Rising Waters, Falling Taxes: The Impact of Hurricane Sandy on Property Tax Assessments in New York City*

Wei Guo[†] Qing Miao[‡] Yusun Kim[§] Yilin Hou[¶]

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Abstract

Climate disasters pose fiscal challenges for local governments by increasing recovery costs and demand for property tax relief. Homeowners with or without property damage face tax burdens that may not match changes to their property value. This study examines the impact of Hurricane Sandy on property values and tax assessments in New York City. Using a difference-in-differences approach and comprehensive property-level data, we find that (1) inundated properties faced greater tax burdens due to limited declines in taxable value; (2) unaffected properties in flood zones saw tax burden increases due to declining market values and unchanged taxable values; and (3) higher-valued homes bore larger tax burden hikes. These uneven consequences stem largely from constrained assessment caps and selective tax relief measures, with strong implications for reforming property tax administration and design.

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[†]CMCC Foundation - Euro-Mediterranean Center on Climate Change, Italy. RFF-CMCC European Institute on Economics and the Environment, Italy. University of California, Riverside. wei.guo@cmcc.it.

[‡]Rochester Institute of Technology. qxmgla@rit.edu.

[§]Seoul National University. yusun.kim@snu.ac.kr.

[¶]Syracuse University. yihou@syr.edu.

1 Introduction

Climate disasters, such as hurricanes and floods, are becoming more frequent and intense, causing extensive damage to the built environment and social well-being. Homeowners in affected areas often suffer substantial losses not only from direct physical damage but also from property devaluation due to heightened risk perceptions in disaster-prone areas (Abadie and Dermisi 2008; Ortega and Taşpınar 2018). These natural disasters not only disrupt local economies and trigger negative market shocks, but also pose significant fiscal challenges for local governments. Concerns are mounting that increased disasters may erode local tax bases and diminish property tax revenues (Shi and Varuzzo 2020; Congressional Research Service 2023), which are critical to funding essential public services like education, infrastructure, and emergency services.

Disasters can influence property taxes through multiple intersecting pathways. Housing market disruptions, such as reductions in housing stock, depreciation in market values, outmigration of local populations, and declines in homeownership, collectively shrink the property tax bases (Boustan 2013; Groen and Polivka 2010; Hornbeck and Naidu 2014; Landry et al. 2007; McCoy and Walsh 2018; Sheldon and Zhan 2019).[1] More importantly, the extent to which disasters influence property tax revenues is shaped by the response of local tax administration. While disaster-induced damage typically calls for property reassessments and tax relief, many local governments struggle to implement these measures promptly.[2] If reassessments fail to accurately capture post-disaster changes in property values, affected homeowners may face disproportionate tax burdens, with their property values being assessed at a higher rate relative to market value. Disasters may further trigger increased demand for public spending on disaster recovery, which in turn impacts local budgets

[1] However, property tax revenues may eventually recover or even increase in the long run, as post-disaster housing redevelopment and renovation gradually restore housing stock and enhance property value (Deryugina 2022; Jerch et al. 2023).

[2] One major concern is that an immediate reassessment after a disaster could reduce tax base and local revenues, jeopardizing the funding of essential public services unless affected localities receive additional aid from higher level governments.

and property tax rates (Noy 2009). Thus, how local governments administer property taxes and post-disaster tax relief plays a crucial role in shaping the distribution of local tax burdens (Ahmadu and Nukpezah 2022; Manolakas 2019). However, empirical literature to date has provided little evidence on how property tax administration responds to disasters, particularly regarding whether and how disaster impacts are reflected in assessed values, tax bases, and the distribution of tax burdens.

This study addresses this critical gap by empirically examining the impacts of Hurricane Sandy on property values and property tax assessments in New York City. Hurricane Sandy, which struck the East Coast in October 2012, was one of the most destructive and costliest hurricanes in U.S. history. In response, the City government provided tax relief for affected properties by directly adjusting the assessment rolls. Using data around Hurricane Sandy, we examine the response of property tax administration to natural disasters and the combined effects of disaster and post-disaster relief policy on property-level market values and tax assessment, to shed light on the distribution of tax burden. Property tax inequity arises when assessed values are not adjusted, timely and adequately, to keep pace with changed market values; inequity also results from unfair relief policies (Moore 2008; McMillen and Singh 2023), outdated property assessments (Hou et al. 2023; Kim and Hou 2024), and and underassessment due to assessment caps (Borg and Borg 2023).[3] Our analysis explores three aspects of tax (in)equity: 1) whether Sandy-induced property damage was proportionately and promptly reflected in assessments and tax levies; 2) whether market price changes for undamaged properties within flood zones, driven by updated risk perceptions, were reflected in their tax assessments over time; and 3) whether the storm impacts on tax assessments varied across property value segments. These investigations offer critical insights into both horizontal equity (i.e., similar tax burdens for properties of similar value) and vertical equity (i.e., higher-valued properties bearing higher effective tax rates).

[3] Other sources of property tax regressivity include data and modeling limitations during assessment (Berry 2021), intentionally inaccurate assessments in a declining real estate market (Hodge et al. 2017), and possible assessment bias against minority and low-income homeowners (Avenancio-León and Howard 2022; Holz et al. 2024; Ihlanfeldt and Rodgers 2022).

For the empirical analysis, we compiled a comprehensive dataset of residential house sales and assessment rolls from 2007-2020 in NYC, combining it with FEMA geocoded data on Sandy-induced inundation and structural damage. We exploy a difference-in-difference approach, leveraging the temporal and spatial variations from Sandy-induced inundation to compare affected (inundated) properties with unaffected ones in their assessment variables, before and after the storm. This approach exploits the exogenous nature of Sandy's impact path, as whether a property was inundated by the storm surge was largely random when compared to nearby properties that were not flooded. Notably, the affected properties were not only "treated" by Sandy *per se*, but also could be subject to the City's tax relief policy which directly adjusted the assessor-estimated market values. Beyond the directly affected properties, we also examine whether undamaged, high-risk properties received adjustments in property tax assessments that aligned with their post-Sandy market dynamics. To assess changes in tax burden and tax equity, we use the taxable-to-sales ratio ("taxable ratio"), which is the proportion of taxable values (i.e., assessed values minus exemption) to sales prices. Since all properties examined in this study belong to the same tax class and are subject to a uniform tax rate each year, the taxable ratio effectively captures the effective tax rate (i.e., tax payment relative to house price), which is a common measure of property tax burden.

Our study yields three major findings. First, we find that Hurricane Sandy caused significant declines in the sale prices of inundated homes in the short term, whose assessor-estimated market values, assessed values, and taxable values also dropped due to various tax relief measures. While their sale prices gradually recovered after the storm, their taxable values remained low for an extended period, resulting in reduced property tax payments for homeowners of inundated properties. However, the drops in taxable values were less than the post-Sandy declines in sale prices, leading to a disproportionately higher taxable ratio and, consequently, a greater tax burden for owners of inundated homes compared to non-inundated properties.

Second, we find that non-inundated properties within high-risk flood zones were also indirectly affected by Sandy. Specifically, these properties were mostly ineligible for direct tax relief but experienced a persistent decline in sale prices, likely due to the updated risk perception post-Sandy. However, the assessed or taxable values of these unaffected yet at-risk properties did not significantly change after Sandy, resulting in an even greater and sustained increase in their taxable ratio compared to both inundated properties and unaffected properties outside flood zones. This pattern suggests that post-storm housing market dynamics are not fully captured in the subsequent property reassessment.

Third, our heterogeneity analysis across property value segments indicates that Sandy's inundation led to a relatively greater reduction in the sale prices of high-valued properties relative to low- and middle-valued properties. However, more expensive and inundated properties experienced negligible reductions in taxable values, resulting in a larger increase in taxable ratio for their homeowners, relative to owners of similarly high-valued but non-inundated properties. In contrast, the taxable ratio remains unchanged for lower-valued inundated properties, compared to their non-inundated counterparts in the same price segment.

Overall, our findings highlight that Sandy's impact on property tax burdens was shaped by a combination of hazard exposure, post-storm tax relief and reassessment, and existing tax policies. This study offers one of the first systematic investigations into local property reassessment and tax administration in response to disasters, and contributes to the existing literature on disasters and public finance in several ways. First, this paper connects with the broad economics literature on the socio-economic impacts of natural disasters, including effects on housing markets (Contat et al. 2024), migration and locational choices (Boustan et al. 2012; Boustan et al. 2020; Kocornik-Mina et al. 2020; Mahajan and Yang 2020; Sacerdote 2012), business activities (Boustan et al. 2020; Hsu et al. 2018), public transfers and infrastructure investment (Del Valle et al. 2020; Brennan et al. 2022; Balboni 2025), household finance and resource transfers (Deryugina et al. 2018; Gallagher and Hartley 2017;

Deryugina and Marx 2021). Specifically, this literature extensively documents a negative effect of disasters on property values, in either the short term or the long term (Hallstrom and Smith 2005; Atreya and Ferreira 2015; Bakkensen and Barrage 2017; Bin and Polasky 2004; Bin et al. 2008; Zhang 2016).[4] However, much less is known regarding whether the private housing market response is reflected in property assessment, whether disasters trigger a comparable effect on assessed values and how this, in turn, affects the distribution of the tax burden in affected localities.

Second, as one of first studies examining local tax relief in response to disasters, our study contributes to a growing body of research examining disaster assistance, which has predominantly focused on federal disaster aid including recovery funds (Davlasheridze and Geylani 2017; Gallagher et al. 2023; Del Valle et al. 2020), disaster insurance (Wagner 2022), and mitigation grants, for example, for managed retreat (Balboni 2025; Miao and Davlasheridze 2024; Guo et al. 2023). Our paper is particularly relevant for studies examining the effects of post-disaster aid on household finance (Deryugina et al. 2018; Gallagher and Hartley 2017; Gallagher et al. 2023; Billings et al. 2022). For example, Deryugina et al. (2018) and Gallagher and Hartley (2017) found that while disasters negatively impact household finances, post-disaster aid can help mitigate these burdens or even provide financial benefits. Billings et al. (2022) highlighted the uneven distribution of disaster aid, which may exacerbate financial inequality. Our paper differs from these studies by examining local property taxation policy and its distributional impact on household property tax burdens after disasters.

Third, our study extends the existing research examining the fiscal impact of natural disasters on state and local governments (Deryugina 2017; Miao et al. 2018; Miao and Davlasheridze 2024; Chen 2020; Liao and Kousky 2022; Jerch et al. 2023; Barrage 2020; 2024). These studies generally find that disasters increase government spending and intergovernmental transfers but provide mixed evidence on their effect on local own-source

[4] It should be noted that some studies also found that disasters may result in a temporary increase in housing prices due to the limited housing supply (Zivin et al. 2023).

revenues. Specifically, Miao and Davlasheridze (2024) and Jerch et al. (2023) found limited effects of climatic disasters on property tax revenues, while Liao and Kousky (2022) showed that municipal property tax revenues in California increased markedly after a major wildfire.[5] However, we note that these studies mostly focus on disaster-induced changes in aggregate fiscal accounts. They often overlook how property tax administration responds to disasters, and fail to disentangle changes in tax base (assessed and taxable values) from changes in tax rates. Our paper fills these gaps by dissecting various tax mechanisms and presenting causal evidence on the disaster's impact on property assessment and tax base, relative to changes in market values.

Fourth, our study also makes a unique contribution to the literature on property tax administration and its equity implications. Property taxes constitute both the primary source of local government revenue and a substantial share of individual tax payments (Nathan et al. 2025; Koster and Pinchbeck 2022; Poterba and Sinai 2008). Existing research has explored the relationship between housing markets and property taxation in non-disaster contexts, particularly through mechanisms related to business cycles and economic shocks (B. F. Lutz 2008; Lutz et al. 2011; Coen-Pirani and Wooley 2018), new home construction (B. Lutz 2015), tax law change (İmrohoroğlu et al. 2018; Bishop et al. 2025), and mortgage interest deductions (Poterba and Sinai 2008; Horton 2023). Public finance studies have also examined various aspects of assessment practices, including regularity, uniformity, frequency and size of office (Hou et al. 2023; Kim and Hou 2024; Kim et al. 2023), institutional factors such as tax or assessment caps (Eom et al. 2017; Kioko and Zhang 2019; Nguyen-Hoang and Zhang 2022), and property tax protest (Nathan et al. 2025), with a focus on their implications for property tax inequity or regressivity (Avenancio-León and Howard 2022; Amornsiripanitch 2020; Berry 2021; Hodge et al. 2017; McMillen and Singh 2020; 2023; Hou et al. 2023). However, little research has explored the interplays among property taxa-

[5] They attributed this to increased housing turnover following wildfires, triggering reassessments of more properties due to California's Proposition 13, which suppresses property assessments till time of sale. Their study highlights how the interplay between disasters and tax institutions can reshape local property tax revenues and the broader fiscal landscape.

tion, assessments, and housing markets following major disasters, or how disaster-triggered tax relief measures interact with existing policies to redistribute tax burdens. Our study fills this gap with empirical evidence, highlighting how disasters and policy responses shape tax burdens across affected communities.

The remainder of the paper is organized as follows. The next section discusses the background related to Hurricane Sandy and its economic impacts (as evidenced in empirical research), property taxation policy in New York City and NY state, and the Sandy-specific tax relief policy. Section 3 describes the data and presents descriptive statistics, and Section 4 outlines our empirical strategy. We report our main findings in Section 5, and conclude with discussion of relevant policy implications in Section 6.

2 Background

2.1 Hurricane Sandy and Its Impacts

Superstorm Sandy struck the East Coast in late October 2012, caused an estimated $74 billion in direct damages (adjusted to 2020 dollars), led to major disaster declarations across 12 states and the District of Columbia, and resulted in over 120 fatalities (Painter and Brown 2017; Government Accountability Office 2020). A total of 13 New York counties were declared as disaster areas by the Federal Emergency Management Agency (Federal Emergency Management Agency 2013). New York City, in particular, experienced severe flooding and widespread damage that impacted both residential and commercial properties, as well as transportation and other critical infrastructure along the coast. The housing damage in New York City alone totaled $4.2 billion (Aerts et al. 2014).

Empirical studies have extensively documented the adverse effects of Hurricane Sandy on housing markets (Ortega and Taşpınar 2018; Gibson and Mullins 2020; Meltzer et al. 2021; Comes and Van de Walle 2014; Barile et al. 2020; Lin et al. 2016). Notably, a key finding is that Sandy had a significant negative impact on property values, which was unevenly distributed. Ortega and Taşpınar (2018) found that damaged properties in New York City experienced an initial sharp drop in value followed by partial recovery, and undamaged properties in flood zones also saw a persistent value decline, highlighting the role of updated risk perception. Similarly, Gibson and Mullins (2020), Cohen et al. (2021) and Ellen and Meltzer (2024) found that Sandy had a negative impact on both damaged and undamaged properties, with larger impacts observed in areas outside flood zones and lower price recovery occurring in lower-income neighborhoods. Beyond residential properties, research has also shown that Hurricane Sandy had significant negative impacts on commercial real estate (Addoum et al. 2024; Holtermans et al. 2024). Furthermore, the impact of Sandy extended beyond the immediate disaster zone. Fang et al. (2021) observed a temporary price drop for homes in Miami-Dade County, Florida, and Addoum et al. (2024) documented longer-term price reductions for commercial properties in Boston.

In addition to property values, research also suggests that the impacts of Hurricane Sandy extended to homeowner behavior and government finances. McCoy and Zhao (2018) found that Sandy-affected homeowners in flood zones are more likely to invest in capital improvements of their damaged properties, in part due to the heightened risk perception. Miao et al. (2024) found that Sandy increased government expenditures and intergovernmental transfers in the affected municipalities and school districts, with limited effect on property tax revenues.

2.2 Property Taxation in New York

In New York State, property tax is the largest single revenue for municipal and education services. Property tax administration across the State is highly decentralized, with mostly townships and cities responsible for property assessment. Property tax in New York City (NYC) is administered by the City Department of Finance (DOF), which makes annual assessment updates for all properties (approximately 1,045,000) within the City. These assessments establish key financial recordings, including assessor-estimated market values, assessed values, exemptions and abatements, and exempt values. Properties in NYC are divided into four classes with distinct treatment and assessment criteria under the City's ordinances. In this paper, we focus on properties in Tax Class 1, which include primarily one- to three-unit residential properties and constitute the majority of taxable properties in the City.[6]

For Class 1 properties, the DOF estimates market values through statistical modeling that uses sales prices of similar properties in the same neighborhood sold during the prior three years. The assessed value is then set at 6 percent of the estimated market value. Meanwhile, to prevent sudden spikes in property tax, the City's ordinance caps annual assessed-value increases for Class 1 properties to 6% and limits cumulative increase over five years to 20 percent, unless the value increase results from new construction or renovations (New York Tax Law § 1083, New York State Department of Taxation and Finance 2021). As a result, the final assessed value is determined as the lower of either 6% of the estimated market value or the maximum allowable value under the caps.[7] The assessment caps cause most Class 1 properties to be assessed at less than 6% of their estimated market value. We observe that approximately 80% of all properties in NYC were capped pre-Sandy (bottom-right panel of Figure 3). While designed to stabilize property taxes and limit homeowners' tax burdens, these caps have sparked debates about their regressive impacts, as they disproportionately benefit higher-value properties which typically experience larger increases in market value during economic boom years than lower-value properties (Hayashi 2014; Berry 2021).

The City's fiscal year runs from July 1 to June 30. The DOF releases tentative assessment rolls by mid-fiscal year (on January 5th) to allow a window for potential appeals and disputes

[6] As of 2015, the share of class 1 (one- to three-unit residential) properties' aggregate market value accounted for 46% of the market value of all taxable properties in New York City. In terms of taxes paid, class 1 homeowners paid approximately 15.5% of the City's total property tax payment (New York City Department of Finance 2015).

[7] For example, consider a Class 1 property with an estimated market value of $100,000 in the current year, an assessed value of $5,000 in the previous year, and an assessed value of $4,500 five years ago. Without the assessment caps, the assessed value would be $6,000 (6% × $100,000 = $6,000). However, the maximum allowable assessed value under the caps is $5,300—the lower of $5,000 × (1 + 6%) = $5,300 (annual cap) and $4,500 × (1 + 20%) = $5,400 (five-year cap). As a result, the final assessed value is $5,300.

from taxpayers (deadline on March 15th). The final assessment roll, published at the end of May, is the basis for property tax bills for the upcoming tax year beginning on July 1.

2.3 Sandy Tax Relief in New York City

Hurricane Sandy occurred in the middle of the 2012-2013 tax year, prior to the release of the tentative assessment roll for the following tax year. New York State enacted the legislation of "The Superstorm Sandy Assessment Relief Act" (A.39 and A.2294) one year later, authorizing taxing jurisdictions in counties that received presidential disaster declarations to provide property tax relief to owners of damaged properties.[8] This law allows assessors to estimate the percentage reduction in assessed values based on the extent of property damage, upon request by property owners.

New York City opted into the State's relief program but implemented the policy with some modifications. According to our interview with DOF personnel, the agency directly adjusted the estimated market value of affected properties in the 2013 assessment roll (released in mid-2013), based on owner-reported property damage and estimated neighborhood-level damage. The DOF first used geographic coordinates to identify neighborhoods severely impacted by the storm and applied a blanket reduction in estimated market values for properties within these neighborhoods, by 15 percent for Tax Class 1 and 10 percent for Tax Classes 2 and 4. The DOF also adjusted the estimated market values at property level through a demolition change for properties that sustained structural damage (changes to the existing building envelope) based on homeowner's self-reported damage. These two components are inclusive: properties that met both criteria–located in damaged neighborhoods and with

[8] The policy can be adopted by eligible counties, as well as cities, towns, villages, school districts or special districts within the eligible counties. The policy applies only to municipalities that are eligible and choose to offer the relief. Even if a county adopts the program, it does not automatically extend to other local governments within the county; each municipality, school district, or special district must pass a resolution individually. Additionally, eligible municipalities may choose to extend relief to property owners whose buildings and improvements have lost less than 50% of their value. Property owners could only be eligible to receive property tax relief if their jurisdiction opted into the relief program.

structural damage–could receive reductions in estimated market value for both factors.[9]

Given the tax relief policy, we expect properties directly damaged by Sandy to have lower estimated market values and, for those not constrained by the assessment caps, proportionally lower assessed values. We note that the adjustment in estimated market values does not necessarily translate into a proportional change in assessed values, because the latter is simultaneously subject to the assessment caps. As discussed later in this paper, in areas where housing prices had risen rapidly before the storm, assessed values may have significantly lagged behind estimated market prices due to the assessment caps. Even if market prices declined immediately after the storm, 6% of the estimated market value could still exceed the capped value, causing assessed values to increase by 6% over the previous year. The assessment caps may also suppress the growth of assessed value after the storm.[10] In addition, nearby properties exposed to flood risks but not directly damaged may also experience price changes due to the updated risk perceptions affecting housing markets (Ortega and Taṣpınar 2018; Gibson and Mullins 2020; Cohen et al. 2021). Although these undamaged properties should not be eligible for direct tax relief, it is unclear whether their assessed values were adjusted accordingly to reflect post-storm market trends during subsequent reassessments. Thus, for both damaged and undamaged properties, the degree to which their assessed values and after-exemption taxable values were adjusted in line with market values

[9] The tax relief policy also provided rebate and abatement to real property taxes. For the 2012 assessment cycle, the DOF provided a one-time property tax rebate to owners of properties severely damaged by Sandy, as determined by damage classifications provided by the City's Office of Emergency Management. The rebate was determined after reduction for any amount from which the property is exempt. Specifically, the amount of rebate for eligible real property is equal to two-thirds of the annual tax, multiplied by a fraction, the numerator of which is equal to that portion of the assessed valuation of the eligible real property that is attributable to the improvements on the property, and the denominator of which is equal to the total assessed valuation of the eligible real property. In 2014, the New York State government issued a partial property tax abatement for certain properties that had sustained damage from Sandy but faced higher property taxes due to post-storm repairs and reconstruction (A.9578-A/S.7257-A). Following the state authorization, the City government enacted a local law in the same year to provide relief to the City's residents. This applied to those whose tax bill in City Fiscal Year (CFY) 2015 was greater than their corresponding tax liability from CFY 2013.

[10] In areas where market prices rebound quickly, assessed values remain constrained by the 6% increase cap. As a result, if assessed values drop significantly in the aftermath of the storm, their recovery might be slower than that of market prices.

is an empirical question.[11] If their taxable values were not adequately adjusted to reflect post-storm declines in market values, property owners could face disproportionately higher tax burdens after Sandy.

3 Data

To conduct empirical analyses, we construct a comprehensive property-level dataset including real market values from house transactions, assessed values and property taxes from assessment rolls, exposure to Sandy-induced inundation and damage, and housing locational attributes. Next, we describe the sources of NYC data.[12]

3.1 Property Assessment Rolls and Housing Transactions

We collected historical property tax data from annual assessment rolls released by NYC's DOF, including the assessor-estimated market values, assessed values, and exemptions. We included only residential properties in Tax Class 1 of one-to-three-family dwellings, as multi-family homes (e.g. cooperatives and condominiums) are subject to different assessment rules. Based on these financial recordings, we calculate taxable values–defined as assessed values minus exempt values–to obtain the portion of assessed value that is subject to taxation. Taxable value is proportional to property tax levy as property tax rate is uniform across Class 1 properties. To measure actual property tax burden and gauge equity, we compute the taxable ratio (taxable value-to-sales price ratio), which is the share of taxable value relative to market value, as indicated by transaction price. Since the property tax rate is uniform for all Class 1 properties, the taxable ratio is directly proportional to the effective

[11] For instance, assessed values are often suppressed by the assessment cap, and reduced assessed values may lead to reductions in exempt values, since many exemption categories are calculated as a proportion of assessment values. This imbalance undermines the fairness of the tax system and could counteract other policies aimed at aiding storm-affected homeowners.

[12] Since a substantial portion of Sandy's damage occurred in New York City, our primary focus is on property data from the City. In the appendix, we also discuss the data together with the results for another two New York State counties, Nassau and Suffolk, that were also affected by Hurricane Sandy.

tax rate (ratio of property tax payment to market value.)

We obtained data on all property transactions in NYC from DOF's Automated City Register Information System (ACRIS). The deed records thereby contain detailed information on each transaction, including sale price, sale date, sale type flags, and a unique tax identifier (BBL code) that corresponds one-on-one with the assessment rolls. We obtained comprehensive property details from assessment rolls for each sold property, including tax class, building class code, number of total and residential units, number of stories, living area, lot size, and year of construction and renovation.

We dropped duplicates from repeated reporting, defined as having the same sale price and sale date for the same property. To avoid comparing properties with extensive expansions, we limited our sample to properties with no more than five actual residential units and no more than five stories. Additionally, we excluded non-arm's-length transactions and outliers that had prices below $10,000 or above $5 million, or those with estimated market values exceeding $10 million. The records removed represent less than 1% of the entire sample.

3.2 Inundation and Damage by Superstorm Sandy and Flood Zones in NYC

Since properties in different locations were affected differently by the storm, it is crucial to measure Sandy's impact at finer granularity. We used geospatial data from FEMA's Modeling Task Force, which provides structure-level inundation and damage assessments. This data set contains damage estimates for all Sandy-affected states, including a total number of 147,702 buildings that were either inside the inundation zones or outside where aerial imagery was used to determine damage. We observed their geo-referenced locations, inundation depth, cause of damage (wind, surge, or both), and damage category (affected, minor damage, major damage, or destroyed), which represents the actual damage levels verified by FEMA's and USGS's field teams.[13] Unlike FEMA's storm surge map that provides

[13] FEMA's Modeling Task Force utilized common methods from US Army Corp of Engineers and FEMA's Hazus program to develop damage estimates for Sandy. During Hurricane Sandy, these inundation and

geographic boundaries of flooded areas, the building-point assessments allow us to track the specific intensity of Sandy's surge and damage for each structure.

We followed the approach in Ortega and Taşpınar (2018) to define flood zones in NYC based on the hurricane evacuation zones, using the geospatial data obtained through a Freedom of Information Law (FOIL) request to NYC's Emergency Management Department. In the event of a major hurricane, the City government may enact evacuation orders in certain zones depending on the hurricane's projected track and surge. Therefore, it is ensured that all city residents are well informed of their evacuation zone. Another advantage of using the hurricane evacuation zones is that they are typically updated after major storms to reflect new flood risks, making them more current than flood maps delineated by FEMA. The hurricane evacuation zone map we use in this paper was released before Sandy and was active during the storm.

The evacuation map divides NYC into three evacuation zones with decreasing flooding risk. Figure 1 shows the evacuation zones relative to Sandy's surge area with properties having experienced inundation. Zone A indicates the highest risk area, which mostly overlaps FEMA's 100-year floodplain (Figure C1) and includes all low-lying coastal areas and other regions that could experience storm surge from any hurricane near NYC. Throughout our analysis, we focus on Zone A, defining it as the high-risk flood zones of NYC.

3.3 Descriptive Statistics Before and After Sandy

We combined property transactions with assessment rolls, using the tax identifier and the sale date relative to the fiscal calendar to construct our final sample. This unbalanced panel consists of 225,138 properties with 295,178 transactions over the period of 2007-2021, representing more than 40% of residential properties in NYC. It is important to note that

damage assessments were obtained in coordination with the U.S. Geological Survey, utilizing surge sensors and field verification. These data, combining aerial imagery with observed inundation depths, are considered by FEMA as the best measures of inundation events such as Sandy, which were used in other studies (Guo et al. 2023; Ortega and Taşpınar 2018).

we limit our sample to home sales, as they presumably reflect the true market value of each property and are used to calculate the taxable ratio.[14] For each property, we identified its inundation status and damage level of Sandy's impact by matching it with the nearest building point within 100 meters for which the damage assessments were determined.

Table 1 reports the summary statistics of main variables. While our analysis primarily focuses on transacted properties, we observe that they constitute a representative subsample of the full property stock in NYC, with no systematic differences in estimated market value, assessed value, property size, evacuation zone designation, or exposure to Sandy's inundation.

Table 2 presents the pre-storm differences between properties by storm inundation and flood risk exposure. Column (1) shows that Sandy-inundated properties on average have lower market values, smaller living areas (measured by the number of residential units and stories), and lower quality (as indicated by fewer renovations) compared to non-inundated properties. Interestingly, inundated properties have a relatively higher taxable ratio, suggesting a pre-existing assessment gap before the storm. While these differences likely reflect broader community characteristics, as non-inundated properties tend to be located in lower-risk areas farther from the coast, comparing properties in similar communities still indicates that inundated properties exhibited smaller sizes, lower assessed values, and higher assessment ratios pre-storm.[15] Column (2) compares non-inundated properties inside and outside of evacuation Zone A, to highlight pre-storm differences between high-risk and low-risk areas. Non-inundated properties within Zone A showed lower assessed values and higher exempt values, and their taxable ratio was lower than that of properties outside the flood zone. This indicates that these higher-risk properties faced lower tax burdens compared to other

[14] We also use the data of entire assessment rolls, which is a more balanced panel, for robustness checks to compare the changes in assessment outcomes.

[15] To minimize the community-level differences, Columns (1) and (2) of Table C2 focus on properties within 2 kilometers of the coastline and those within high-risk flood zones (zone A), respectively. After limiting to properties in similar communities, inundated properties still exhibited smaller sizes, lower assessed values, and higher assessment ratios before the storm, compared to those not inundated by Sandy.

undamaged properties in lower-risk areas.[16]

Figure 2 presents the annual sample means of sale prices and various assessment indicators for both inundated and non-inundated properties before and after Sandy. In the top panels, we observe similar patterns between sale prices and assessor-estimated market values, suggesting that local assessors effectively captured property values and adjusted storm damage for affected properties. Prior to the storm, inundated properties had lower prices and assessed values than non-inundated ones, and the two groups exhibited overall parallel trends. After the storm, non-inundated properties showed no significant changes in sale prices or assessment records, both continuing to increase over time. In contrast, inundated properties experienced immediate declines in sale prices and estimated market values, with the latter showing a sharper decrease. As shown in the bottom panels, the assessed and taxable values of inundated properties also declined immediately after the storm, though to a lesser extent, then gradually increased over time, mirroring the recovery process in market values. This figure offers clear supporting evidence of the negative effect of Sandy's inundation on property values and tax assessments.

3.4 Illustration of Tax Relief and Assessment Cap

While DOF's assessment roll data does not specify which properties are eligible for the Sandy tax relief, we examine properties that got at least 15% reductions in estimated market values (i.e., corresponding to the neighborhood-level relief) immediately following Sandy (comparing assessed values for 2013 and 2012) to infer the scope of tax relief. As shown by the dashed lines in the top-left panel of Figure 3, the major spike in reduced estimated market values occurred in roll year 2013, coinciding with the one-time relief granted that year. In 2013, 50% of inundated properties received over 15% reductions in estimated market values, while non-inundated properties show no increase in this share. This suggests that

[16] In Column (3) of Table C2, we compare all sold properties inside and outside of evacuation Zone A, and find that properties within Zone A, regardless of inundation status, had overall lower taxable ratio than those outside Zone A.

the neighborhood-based tax relief was targeted at the areas impacted by the storm so that non-inundated properties were mostly ineligible for the relief.[17]

As shown in the top-right panel of Figure 3, half of the inundated properties got lower assessed values post-Sandy. Meanwhile, over 90% of inundated properties saw reduced estimated market values in 2013, as shown by the solid lines in the top-left panel. In addition, comparing the assessed and taxable values in Figure 2, we observe that these values for inundated properties declined less than their estimated market values post-Sandy. We attribute these discrepancies to the assessment caps, which restrict the growth of assessed values to 6% annually or 20% over five years. Specifically, when a property's market value increases rapidly, the caps often keep its assessed value below the uncapped level (i.e., 6% of its estimated market value). Even when a property's estimated market value drops sharply (e.g., due to Sandy tax relief), its capped value (6% above the prior year's assessed value) may still stay below the uncapped value. As a result, the assessed value may continue to rise as it adjusts to prior market increases.

To further illustrate the influence of the assessment cap, the bottom-left panel in Figure 3 shows the average assessed values in solid lines alongside their uncapped assessed values (6% of the estimated market value) in dashed lines. Before the storm, the assessed values for both inundated and non-inundated properties were suppressed by the cap. After the storm, the average assessed value of inundated properties declined but did not drop as much as their estimated market values, still below their uncapped values. Additionally, the bottom-right panel of Figure 3 displays the share of inundated and non-inundated properties with uncapped assessed values by year. Only 20% of all properties were not capped pre-storm. This share rose to 60% for inundated properties immediately after the storm, which saw their assessed values align with the reduced market values (6% of estimated market value).[18] The remaining 40% of inundated properties had their assessed values capped and

[17] In 2013, more than 90% of inundated properties and almost half of non-inundated properties saw reduction in estimated market values (solid lines in the top-left panel of Figure 3), likely driven by the declining market trends over this period.

[18] Even among the 60% of inundated properties uncapped due to reduced estimated market values, some

increased in 2013, relative to the previous year. Therefore, the assessment caps largely explain why declines in assessed values for inundated properties were moderate relative to those in estimated market values. We also provide a numeric example in the Appendix to illustrate the effect of the assessment caps in this case.

4 Empirical Strategy

4.1 Estimating Sandy's Impacts

To estimate the impacts of Hurricane Sandy, our primary estimation model employs a difference-in-differences (DID) specification, leveraging the spatial and temporal variations induced by the storm:

$$\ln(Y_{it}) = \beta \text{Post}_t \cdot \text{Sandy}_i + \alpha X_i + \alpha_{ym} + \alpha_{fy} + \alpha_b + \alpha_A + \epsilon_{it} \tag{1}$$

Each observation corresponds to a transaction of residential property i in date t. The outcome variables of interest, Y_{it}, include sale price, estimated market value, assessed value, exempt value, taxable value, and taxable ratio. The treatment indicators, Post_t and Sandy_i, represent whether the transaction occurred after Sandy and whether the property was affected by the storm, respectively. Throughout our analysis, we define a property as Sandy-affected if it incurred any storm inundation.[19] The control group thus consists of the properties that were not inundated by the storm. Our key identifying assumption is that the spatial and annual variations in storm inundation status is plausibly random and not directly correlated with our outcomes of interest (Bertrand et al. 2004). We validate this assumption by demonstrating that the treatment and control groups exhibit parallel pre-trends, as shown in an event study (Figure 4), which we will discuss later in Section 5.

of their assessed values may continue to rise over the year before Sandy (less than 6%).

[19] In robustness check, we also use actual damage level as an alternative to measure Sandy's impact intensity.

Coefficient β for the interaction term, $\text{Post}_t \cdot \text{Sandy}_i$, compares the differential impact on Sandy-affected properties relative to unaffected properties post-storm. The treatment effect, as capitalized into sale price, captures both the storm damage and the influence of post-Sandy tax relief and reassessment policies on assessment variables. Additionally, we control for property characteristics, X_i, including number of residential units, number of stories, living area, lot size, and property age (measured as the difference between the transaction year and the most recent year of building or renovation). We incorporate several fixed effects to control for potential confounding factors. The sale-year-month fixed effects, α_{ym}, account for macroeconomic dynamics and market seasonality. The fiscal-year fixed effects, α_{fy}, capture broader fiscal trends and the influence of policy changes on tax assessments. [20] The tax block fixed effects, α_b, control for differences in the housing market as well as demographic and socioeconomic conditions specific to each community at the city block level. [21]

Identification of this model relies on the exogenous nature of Hurricane Sandy. A possible concern is that properties differ in their preparedness for hurricanes, leading to varying pre-storm resilience levels and post-storm recovery capabilities. We noted that the primary information source for NYC homeowners in formulating flood risk expectations is the map of hurricane evacuation zones. Therefore, we include an indicator for whether a property is located within the high-risk evacuation Zone A, denoted by α_A. [22].After controlling for the census-block fixed effects, our estimation exploits the within-community variation–specifically, whether a property was actually affected by the storm, as determined by its precise location relative to the storm's impact area–which is relatively exogenous.

[20] The sale-year-month fixed effects are included for sales-related variables, such as sale price and taxable ratio. The fiscal-year fixed effects are only included for assessment-related variables, such as estimated market value, assessed value, exempt value, and taxable value.

[21] Tax blocks are roughly equivalent to city blocks. There are 39,039 tax blocks in NYC, with 22,076 covered by our transaction sample.

[22] Since Zone A does not align perfectly with city block boundaries, it is necessary to include Zone A fixed effects in addition to block fixed effects.

4.2 Estimating Differential Effects by Flood Risks

In addition to examining inundated properties as the treatment group, we estimate the impact of Sandy on non-inundated properties that are also located in high-risk flood zone and may endure market-price shocks from updated risk perceptions. These non-inundated properties were generally undamaged by the storm.[23] To estimate the effects on these properties, we introduce the spatial variation in high-risk flood zones, measured by Zone A on the hurricane evacuation map:

$$\ln(Y_{it}) = \beta_1 \text{Post}_t \cdot \text{Sandy}_i + \beta_2 \text{Post}_t \cdot \text{ZoneA}_i + \alpha X_i + \alpha_{ym} + \alpha_{fy} + \alpha_b + \epsilon_{it} \quad (2)$$

Building on model (1), we incorporate an additional treatment indicator, ZoneA_i, which identifies whether the transacted property is located within Zone A but was not inundated by Sandy. The coefficients β_1 and β_2 respectively capture Sandy's impacts on inundated properties and unaffected properties within the flood zone, relative to unaffected properties outside the flood zone. To avoid double-counting Sandy's effects, we do not differentiate Sandy-affected properties located within Zone A from those outside. In a robustness check, we incorporate a triple-difference interaction term, $\text{Post}_t \cdot \text{Sandy}_i \cdot \text{ZoneA}_i$, to capture the differential effects on properties within Zone A compared to those outside for Sandy-affected properties. The outcome variables of interest, Y_{it}, and all other controls are analogous to the previous specification.

[23] While non-inundated properties may have experienced other types of storm damage, such as wind, less than 0.6% of non-inundated properties in our sample had minor or major damage from Sandy, according to FEMA's classification.

5 Results and Discussion

5.1 Sandy's Impact on Property Value and Assessments

We begin by estimating the average effect of Sandy's inundation on property-level market value and assessment outcomes, including estimated market value, assessed value, exemption value, after-exemption taxable value, and taxable ratio. Panel A of Table 3 presents the results from model (1), using the indicator for whether a property was inundated as the treatment variable.

Column (1) indicates that the storm led to a significant reduction in property values: the sales price of inundated properties declined by 10% relative to non-inundated properties after the storm. This result aligns with previous literature on the housing market impact of Sandy (Cohen et al. 2021; Ortega and Taṣpınar 2018). Column (2) shows that the assessor-estimated market values of inundated properties declined by 17% post-storm, 7 percentage points lower than their market prices, which was mostly due to the tax relief policy following the storm and partly to the updated assessments post-storm when assessors referred to recent house sales in estimating market values. Column (3) shows that assessed values of inundated properties decreased by 10% post-storm, smaller than the decrease in assessor-estimated market values. This discrepancy may have risen from the interactions of the statutory assessment caps, which limit the extent to which assessed values can change each year and over each five-year window, as discussed in Section 3.4.

There is also a reduction in the exempt values, though with considerable noise, as shown in Column (4). This is probably because many exemptions are calculated as a percentage of the assessed value. Further analysis using a balanced panel from assessment rolls (Panel B) shows that the shrinkage of exemptions is almost two thirds smaller in magnitude.[24] With

[24] Figure C3 shows an increase in Sandy-inundated properties with zero exemptions post-storm, suggesting that some exemptions became inapplicable after the damage. This likely reflects certain exemptions no longer applicable after the storm-induced damages. For example, additional constructions that had previously qualified for exemptions may have been destroyed during the storm, rendering those exemptions invalid. The increased zero exemptions may also be driven by out-migration and sorting effects caused by disaster-related damage and risk.

reductions in both assessed and exempt values, we observe a 6.5% decrease in the (after-exemption) taxable value of inundated properties after Sandy. Using this estimate along with the property tax rate, we infer that, an averageinundated properties experienced a 3.15% decrease in tax levies post-Sandy, while non-inundated properties had a 3.35% increase due to the rising tax rate.[25]

We should point out that the decrease in taxable value was smaller than that of sale price. Consequently, the post-storm taxable ratio for inundated properties increased by 3.9% relative to unaffected properties (Column 6). This suggests heavier property tax burdens for affected homeowners after Sandy, because their taxable values were not reduced in proportion to the fall in market values. In other words, they were taxed at a higher percentage of their property values. This finding highlights an unintended consequence of the assessment caps the City faces post-Sandy: although the tax relief lowered the estimated market values more than the actual price declines for inundated properties, the assessment caps limited the changes in assessed values, preventing taxable values from fully reflecting the storm-induced declines in actual market values.[26]

5.2 Differential Impacts by Flood Risk Exposure

Heightened flood risks following drastic events like Hurricane Sandy may lead to depreciation of properties, even for those without direct damage (Cohen et al. 2021; Ortega and Taṣpınar 2018). If property assessments are not adjusted to reflect these housing market dynamics, homeowners in high-risk areas will have to face disproportionately higher property taxes due to over-assessment (i.e., unchanged assessment relative to fallen property value). To explore this, we analyze the impact of Sandy on properties that were located within high-risk flood

[25] The property tax rate for Class 1 properties in NYC was 18.569% in 2012/2013 fiscal year, and increased to 19.191% in 2013/2014 fiscal year.

[26] In Panel B of Table 3, we estimate the storm impact using a balanced panel constructed from the city-wide assessment rolls. While not observing the prices for unsold properties, the complete assessment roll data allows us to examine Sandy's impact on all affected properties rather than sold properties alone. We find that the storm-induced changes in the estimated market, assessed, and taxable values of all inundated properties are highly similar to our estimates based on housing sale samples.

zones (i.e., hurricane evacuation zone A) but not inundated by the storm. The results from Equation (2) are presented in Table 4.

For properties inundated by the storm, we observe significant drops in sale prices, estimated market values, assessed values, and taxable values, which are very close in magnitude to those estimated from our baseline specification (Panel A of Table 3). We observe a consistent increase in the taxable ratio for the inundated properties, reinforcing our previous finding. The interaction term between being within Zone A and the post-Sandy indicator captures the storm's impact on non-inundated properties inside high-flood-risk zones, relative to non-inundated properties outside these zones. We find that the sale prices of these high-risk properties declined by 11% after the storm, and the depreciation effect is similar in magnitude to that of inundated properties. This aligns with the literature on hazard belief update and risk perception (Kozlowski et al. 2020), which suggests that large-scale disasters can prompt people to update their expectation of future disaster risks and devalue properties prone to such hazards.[27]

Interestingly, we show that these non-inundated properties inside Zone A did not experience changes in assessor-estimated market values, assessed values, or taxable values, relative to non-inundated properties outside Zone A. This is primarily because non-inundated properties were less likely to qualify for the City's tax relief, as they typically did not sustain structural damage that would warrant the demolition change. We estimate that fewer than 15% of non-inundated properties within Zone A received tax relief given their lowered estimated market values post Sandy.[28] Many of them may qualify for neighborhood-level tax relief if they were located in neighborhoods classified as damaged. Moreover, reduced market

[27] Households in hazard-prone areas, including those required to pay for flood insurance, may lack up-to-date information on flood risks due to outdated flooding maps and evolving climate conditions. For example, the current Flood Insurance Rate Maps were last significantly updated in 1983, with only minor revisions since then, the most recent being in 2007.

[28] While we cannot observe whether a property received tax relief after Sandy, we examine the properties that got more than a 15% reduction in estimated market values in the 2013 assessment cycle compared to 2012. This includes properties either treated by the tax relief or located in areas with significant depreciation. Among this subsample (13,276 properties), non-inundated properties within evacuation Zone A comprised less than 10% (1,090 properties), representing 13% of all non-inundated properties within Zone A.

prices may not be immediately and fully captured in reassessment, as property assessments in NYC are based on housing sales from the previous three years and may average out short-term market fluctuations.

Consequently, we observe a substantial 24% increase in the taxable ratio for properties in Zone A that were not directly affected by the storm, relative to non-inundated properties outside Zone A. Notably, this increase is much more pronounced than that for inundated properties. This finding suggests that tax burdens increased more drastically for unaffected properties located in high-risk areas, as their market values fell sharply after Sandy due to heightened flood risk, while their assessments remained unchanged since these properties were generally ineligible for storm-related tax reliefs.[29]

We conduct several extensions to examine the robustness and heterogeneity of our baseline findings, as shown in Table C3. First, Panel A examines how the responses vary by the extent of damage sustained by affected properties.[30] We find that properties more severely impacted by Sandy had greater declines in their property market and assessed values, while their taxable values did not fall in proportion, thereby resulting in higher tax burdens. One explanation for the disproportionate change is that exempt values also shrank substantially with the larger reduction in assessed values of more severely damaged properties. Second, we limit our sample to properties with repeated sales to better control for unobserved, time-invariant property characteristics (Panels B and C). The results are largely consistent with baseline findings, except that the change in taxable-to-sales ratio is statistically insignificant for inundated properties.[31] Third, we restrict our analysis to a short window of 2 years

[29] Although undamaged areas did not experience direct property or infrastructure damage, nearby communities may have been flooded by Sandy, potentially triggering broader general equilibrium effects, such as declines in neighborhood amenities (Lee and Lin 2018; Fu and Gregory 2019), damage to nearby infrastructure and disruptions in public services (Ouazad and Kahn 2025; Davlasheridze and Fan 2019; Boustan et al. 2020), or shifts in resident composition (Daepp, Hsu, et al. 2023; McNamara et al. 2024; Wrenn 2024)

[30] We categorize the damage levels based on FEMA's assessment into three groups: Affected, Minor Damage, and Major Damage. Among all sold properties affected by the storm, 56.6% were classified as "Affected", 31.3% as "Minor Damage", and the remaining 12.1% as "Major Damage".

[31] In the repeated sales specification, the sample size is reduced by more than half, leading to increased noise in the estimates. While the increase in assessment ratio for affected properties is not statistically significant, its magnitude is similar to that in the baseline specification in Table 3.

before and after Sandy, to best tease out confounding factors of storm-induced migration and property supply response (Panel D). The results show that the increased tax burdens for both inundated properties and unaffected properties within flood zones remain generally robust. Fourth, instead of grouping all affected properties together, we differentiate between inundated properties within and outside evacuation Zone A, thus extending model (2) into a standard triple-difference specification (Panel E). The results show that the storm-induced increase in taxable ratio is primarily concentrated within high-risk flood zones. Inundated properties outside Zone A had similar reductions in sales prices and taxable values, with no change in their taxable ratio after Sandy. Finally, because all properties in Zone A may have been treated by Sandy through information effects, we restrict our control group to non-inundated properties outside Zone A and re-estimate our baseline model in Equation (1) (Panel F). The results remain largely consistent with our baseline finding. Additionally, we analyze the count of annual home sales for properties in Sandy-inundated areas and those outside the immediate impact zones, with results in Figure C2. Both groups had a decline in home sales following Sandy, but this effect was short-lived, with sales rebounding by the second year after the storm. This pattern aligns with existing literature, suggesting that homebuying responses to climate-related disasters are transitory (Bin and Landry 2013).

In addition to New York City, we also analyze the impact of Hurricane Sandy on Nassau and Suffolk, two heavily affected counties in Long Island, New York. In line with our findings for NYC, properties in high-risk areas but not inundated experienced significant declines in sale prices but no adjustments in their assessments, leading to a disproportionately high tax burden. These results are discussed in Appendix B.

5.3 Dynamic Response in Property Outcomes

Prior studies find that hurricanes have both transient and long-lasting effects on housing values, affecting both damaged and undamaged yet hazard-prone properties (Ortega and Taşpınar 2018; Cohen et al. 2021; Ellen and Meltzer 2024). Property assessments might also exhibit dynamic patterns over time, initially responding to tax relief policies, followed by reassessments that reflect gradually ongoing housing market trends. To understand the long-term response in property tax burden, we further examine the dynamics impacts of Sandy on sale prices and property assessments using an event study framework, where the event is defined as the storm's inundation. To ensure a consistent time scale for comparing market and taxable values, we estimate the event study model using fiscal yearsas Sandy occurred in October 2012 which falls within fiscal year 2012. We set fiscal year 2011 as the baseline, with its effects normalized to zero.[32]

The coefficients from the event study analysis are presented in Figure 4. The left panels show that inundated properties suffered an immediate decline in their sales prices following Sandy, reaching approximately 10% below pre-storm levels one year later. The fallen price persisted for four years, then beginning to attenuate in 2017, and becoming statistically insignificant eight years after the storm. Over time, sale prices for these properties gradually recovered, returning to their pre-storm levels by 2020.

The taxable values of inundated properties remained unchanged in 2012, because the property tax relief policy only took effect in fiscal year 2013. Starting then, their taxable values decreased significantly, exhibiting greater fluctuation over the post-storm period, likely due to a combination of factors such as ongoing reassessments as market recovers, tax relief being phased out, and evolving housing market dynamics. Four years after Sandy, taxable values stabilized at around 5% below the pre-storm level, with no sign of recovery observed within the study period up to 2021.[33]

As a result, the taxable ratios of inundated properties increased sharply right after Sandy, driven by falling sale prices and initially unchanged assessed values. Their taxable ratios remained elevated, particularly in the second and fourth years following the storm, primarily

[32] The data of fiscal year 2012 is omitted due to mixed treatment status–properties sold after Sandy's landfall in October 2012 but before the fiscal cycle's end in May 2013 reflect post-storm sale prices, while their assessments remained untreated by Sandy.

[33] The drop in taxable value observed in 2020 is likely due to noise, as it does not follow the trend seen in adjacent years (2019 and 2021).

due to the assessed values not declining as much as the market values under the assessment caps. Five years after the storm, as the taxable values began to align more closely with the recovery of property values, the tax burdens for affected properties returned close to their pre-storm levels.

The right panels of Figure 4 show distinct patterns in the dynamic responses of non-inundated properties inside high-risk flood zones. These properties experienced a gradual and sustained decline in sale prices, intensifying around three years post-storm, with no sign of recovery throughout the eight-year period. This finding is consistent with the literature, which suggests that the risk updating effect intensifies as flood information is becoming salient over time (Cohen et al. 2021).

Meanwhile, the taxable values of non-inundated properties inside flood zones remained stable following the storm. Consequently, the taxable ratio of these properties experienced a substantial increase after Sandy, more pronounced than the increase of inundated properties. The tax burdens for these non-inundated properties continued to rise over the first three years post-storm and remained elevated than pre-storm levels throughout the research period up to 2021. This highlights a persistent increase in tax inequity, as properties in high-risk areas faced disproportionate tax burdens over a prolonged period due to heightened flood risk perceptions.

5.4 Heterogeneous Effects by Property Value

Disaster resilience varies across neighborhoods and properties, with wealthier communities generally better prepared for disasters and equipped with stronger recovery capabilities (Cutter et al. 2012; Van Zandt et al. 2012; Bakkensen and Barrage 2017). Flood risk preference, perception, and capitalization impacts also vary by household income and property value (Lindell and Hwang 2008; Kellens et al. 2011; Kellens et al. 2012; Mills et al. 2016; Gibson and Mullins 2020). Moreover, property assessment embeds with inequitable practices across factors such as income, housing value and racial composition(Goolsby 1997; Allen and Dare 2002; Avenancio-León and Howard 2022; McMillen and Singh 2020; 2023).[34] Our study yields evidence of regressive assessment even prior to hurricane Sandy, i.e. inundated properties were generally of lower value but had a higher taxable ratio than non-inundated properties prior to Sandy. Overall, we find that hurricane Sandy may have exacerbated the pre-existing inequities in tax burden for storm-affected areas. Particularly, homeowners of inundated properties may have paid lower taxes in absolute amounts after the hurricane, but they faced an increased relative tax burden (i.e., taxable ratio) as a result of the net effects of storm-induced damage, tax relief, and assessment cap.

Hurricane Sandy and subsequent tax relief could affect both vertical equity (i.e. higher-valued properties being taxed at a higher rate) and horizontal equity (i.e., similar-valued properties being taxed similarly), if their impacts on tax burdens for inundated and risk-prone properties differ by property value. To explore this, we divide all sold properties into three sub-groups by their estimated market values in fiscal year 2012 (mid-2012), before the occurrence of Sandy.[35] The top panels of Figure 5 present the share of inundated properties and their pre-storm taxable ratio across the three value segments. Lower-valued properties had a significantly higher likelihood of being inundated relative to higher-valued ones and were more likely to inflict more severe damage from Sandy (Figure C4). Nonetheless, there was no clear pattern of tax regressivity or progressivity by price segments prior to the storm.[36]

To examine how Sandy and subsequent tax reliefs affected property values and assessments across price segments, we expand Equation (2) by incorporating interaction terms

[34] For instance, Avenancio-León and Howard (2022) found that assessment ratios are higher for African Americans. Other studies report systematic errors in market value estimation and assessment bias against low-income neighborhoods (Baar 1982; Goolsby 1997; Allen and Dare 2002).

[35] These groups, representing approximately equal numbers of properties, are labeled "Low," "Middle," and "High," with cutoff values of \$399,000 and \$543,000 (in 2012 dollars).

[36] While middle- and high-valued properties had slightly higher taxable ratios on average, the differences from the lowest price segment are not statistically significant at the 5% level.

between the treatment effects and the value segment indicators:

$$\ln(Y_{it}) = \sum_{g\in\{\text{L,M,H}\}} \beta_{1g}\mathbf{I}\{i \in g\} \cdot \text{Post}_t \cdot \text{Sandy}_i + \sum_{g\in\{\text{L,M,H}\}} \beta_{2g}\mathbf{I}\{i \in g\}\text{Post}_t \cdot \text{ZoneA}_i \qquad (3)$$
$$+ \alpha X_i + \alpha_{ym} + \alpha_{fy} + \alpha_b + \epsilon_{it}$$

where $g \in \{\text{L,M,H}\}$ represents the index segments of property value. β_{1g} and β_{2g} respectively measure Sandy's impact on inundated properties and unaffected properties inside flood zones for each price segment g, relative to unaffected properties outside flood zones in the same price segment. This model allows us to capture the post-Sandy changes of properties in each price segment and compare the impacts across price segments. The effects on sale price, taxable value, and taxable ratio are reported in panels C-F of Figure 5.

Panels C and D of Figure 5 present the estimated impacts on inundated properties and panels E and F report the estimates for non-inundated properties within evacuation Zone A. Sale prices dropped significantly in both treatment groups after Sandy, and higher-valued properties in both groups got larger reductions. This suggest that flood damage and risk perceptions may be more salient among high-income homeowners, leading to greater price discounts for higher-valued properties in the short run, which is consistent with the literature (Barr et al. 2017; Bakkensen and Barrage 2017; Ellen and Meltzer 2024).[37]

For inundated properties, taxable values were reduced across all price segments, but the reduction was relatively smaller and statistically insignificant for the highest-value properties, which led to a marked 7% increase in their taxable ratios relative to high-value, non-inundated properties outside flood zones. In contrast, inundated properties in the low and middle-valued segments got significant reductions in taxable values post-Sandy, yielding insignificant changes in their taxable ratios. For non-inundated properties within the flood

[37] Barr et al. (2017) find that New York City houses in higher-income neighborhoods were more severely hit by Sandy. Bakkensen and Barrage (2017) find that the capitalization of flooding risk is greater among properties that are located in wealthier neighborhoods. Ellen and Meltzer (2024) find that properties in higher-income neighborhoods experienced large initial price shocks post-Sandy but then started to recover, and they attribute the more salient impacts to differences in the resources to rebuild and optimism about the local market's resilience.

zones, changes in their taxable values across price segments were not statistically significant, consistent with the results in Table 4. This pattern, along with the significant declines in sale prices, lead to higher taxable ratios after the storm particularly for the high-value segment.

Several factors may explain the observed disparities in post-Sandy tax burden increase across price segments, especially for inundated properties. First, we find that high-valued properties were more likely to be suppressed by the assessment caps, as only a small share (less than 10%) have uncapped assessed values prior to the storm, as shown in the middle-right panel of Figure C4. This may be because high-value properties are concentrated in rapidly appreciating areas (Gyourko et al. 2013; Brueckner and Largey 2008; DiPasquale and Wheaton 2006). Therefore, their assessed and taxable values may continue to increase after Sandy. Second, low-value properties were disproportionately affected by the storm surge, as shown in Figures 5 and C4.[38] Consequently, neighborhoods clustered by low-value properties were more likely to qualify for tax relief, resulting in greater reductions in estimated market values and aligning assessed and taxable values more closely with post-storm market value declines.[39] As a result, high-value inundated properties had increased tax burdens post-Sandy, relative to unaffected properties in the same price segment.

Overall, our findings highlight the complexity in the redistribution of post-disaster tax burdens, which is influenced by disproportionate risk of inundation, post-storm tax relief and reassessment practices, and the assessment caps. Our results suggest that the net effects of Sandy inundation and tax administration lead to higher tax burden among the affected high-valued properties compared to the lower-valued properties, an outcome that appears to support the principle of vertical equity. However, this outcome may also suggest a compromise in horizontal equity among the properties within the high value segment, i.e., inundated high value properties face disproportionately higher tax burden than non-

[38] The binary indicator of inundation, which shows a larger decline in assessed values within the low-value segment compared to mid- and high-value segments, can also reflect greater value reductions due to the extent of damage sustained in this group.

[39] Lower-valued properties were not only more likely to be inundated but also more likely to experience greater damage from the storm, as shown in the top panels of Figure C4. This may have made these properties also more eligible for the property-level demolition change in the tax relief.

inundated properties of similar value. This observed pattern reflects not only the importance of tax relief policy but also characteristics of the affected properties, including their values and exposure to disasters.

6 Conclusion

This study provides some of the first empirical evidence on the impacts of natural disasters and tax relief measures on property assessments and subsequent redistribution of tax burden, using New York City after Hurricane Sandy as a case study. Our study highlights the role of local tax administration in providing tax relief and moderating disaster impacts on affected homeowners. Our findings reveal the complex interactions among disaster damage, risk perception, housing market dynamics, post-disaster tax relief, and existing fiscal institutions such as the property assessment cap.

We find that Hurricane Sandy directly impacted the market values of both inundated properties and non-inundated properties inside the flood zone, reflecting both the direct effect of storm damage and the indirect effect of updated risk perception. The tax relief lowered the estimated market values of affected properties, but did not proportionally reduce their assessed values, largely due to the assessment growth caps and a delayed reassessment process. Since exempt values are tied to assessed values, the after-exemption taxable values of inundated properties decreased less than their market values, resulting in a higher taxable ratio and a greater tax burden for affected homeowners. The increased tax burden was more pronounced for non-inundated properties inside the flood zone that were ineligible for tax relief, as the reassessment process failed to promptly reflect post-disaster housing market dynamics.

We also find that the impact of tax burden redistribution varies by property value, with the post-storm taxable ratio rising more substantially for high-valued properties. Specifically, more expensive properties saw a greater decline in their sale prices but smaller reductions in their assessed and taxable values, which may be linked to the pattern of hazard exposure: high-valued properties were generally less affected by the storm and less likely to receive the tax relief. Meanwhile, these properties were more likely located in rapidly appreciating areas, where their assessed values had long been suppressed by the assessment cap. In this context, Sandy and the subsequent tax relief may have provided an opportunity to correct the pre-existing tax regressivity and improve vertical equity of property taxation.

As discussed earlier, the extent to which disaster-induced shock affects property tax revenues hinges on the standard assessment process and the tax relief policies. Property taxation can serve as an important mechanism for providing disaster relief when properly administered. However, disasters can also exacerbate existing tax inequities, if property reassessments are delayed or fail to reflect changes in property values (e.g., by overlooking the capitalization of risks), leading to a disproportionate tax burden on vulnerable groups whose properties are less structurally resilient and more susceptible to damage. Earlier studies show that natural disasters may widen pre-existing inequity among individuals (Howell and Elliott 2019) and fiscal inequity among localities (Ahmadu and Nukpezah 2022), both of which may exert an indirect effect on the distribution of tax burden (Ratcliffe et al. 2020). Even when local tax relief is provided, the design and implementation of such policies can have varying implications. Specifically, in Sandy's case, the City's tax relief policy significantly reduced the estimated market values of inundated properties, but this reduction is not fully reflected in assessed values due to the assessment caps. The cut in taxable values was even smaller due to formulaic exemptions. This outcome raises the question of how the tax relief should be structured and delivered through property assessment in line with existing fiscal institutions.

Our analytical framework of examining disaster-induced housing market dynamics and property tax responses can extend to economic shocks, such as the mixed housing market responses observed during the COVID-19 pandemic (Cohen et al. 2022; Gupta et al. 2022). However, our findings should be interpreted with caution when considering their generalizability. The extent to which our results may apply to other disasters and tax jurisdictions largely depends on the urban/rural context, local political and fiscal institutions, the administrative features of the tax system, and tax relief policies. For instance, Texas recently enacted Tax Code Section 11.35, allowing local jurisdictions to provide disaster relief in the form of property tax exemptions in proportion to reported disaster damage, which may provide immediate relief to homeowners while lowering the administrative burden in conducting post-disaster assessments. More future research is needed to assess the effect of tax relief with varying levels of specificity and design. These institutional differences in the local tax system require more attention when assessing the responses in property tax revenues and tax burdens to disasters and other major shocks.

It is also important to note that after disasters occur, local governments face the challenge of providing immediate tax relief while ensuring sufficient tax revenues to support essential public services and disaster recovery. Responses to disaster shocks can vary across local governments, influenced by factors such as fiscal institutions, demand for public services, administrative capacity, and available fiscal resources. Future research should explore how political and institutional contexts shape tax policy responses to natural disasters.

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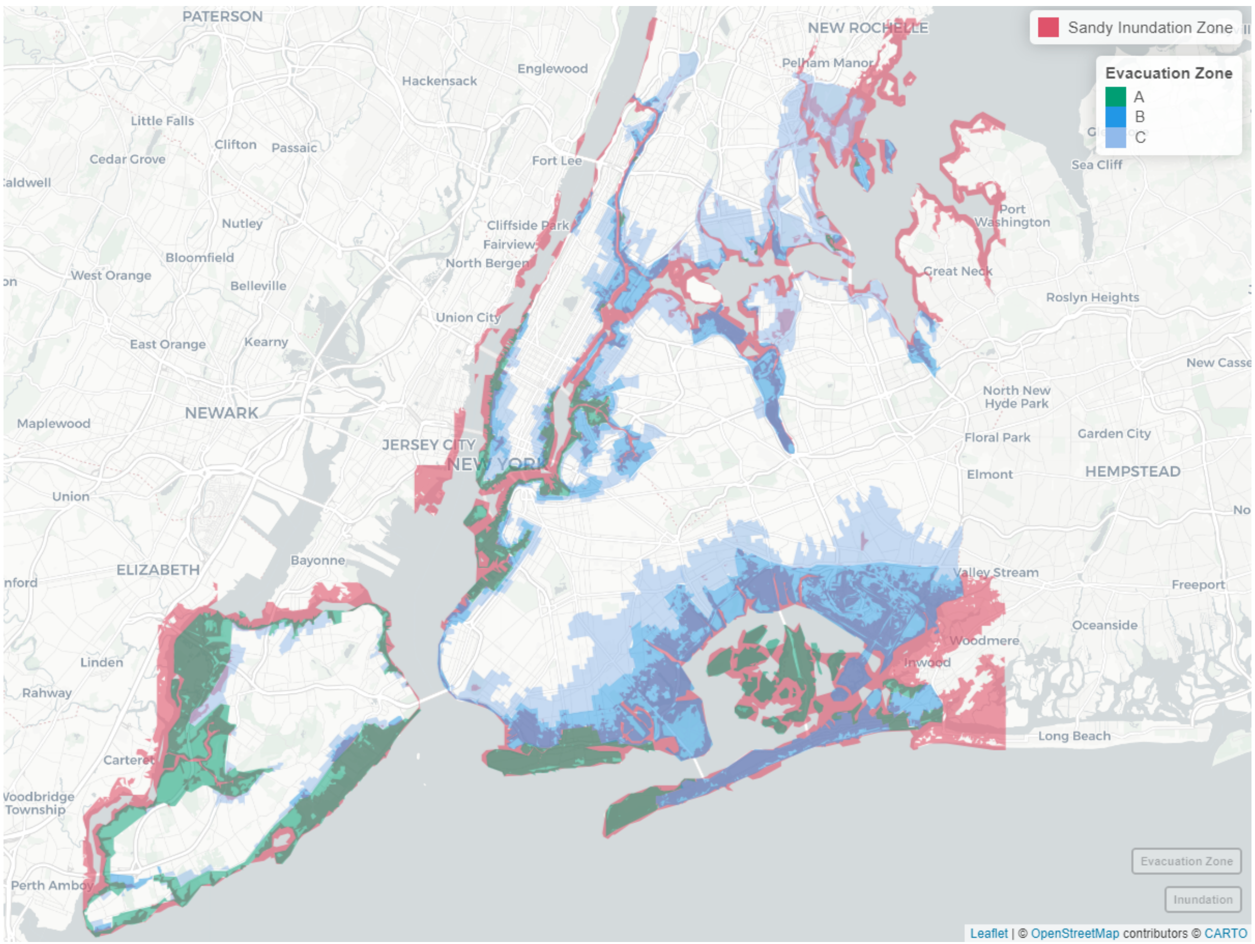
Figure 1: Sandy Inundation Area and Hurricane Evacuation Zones

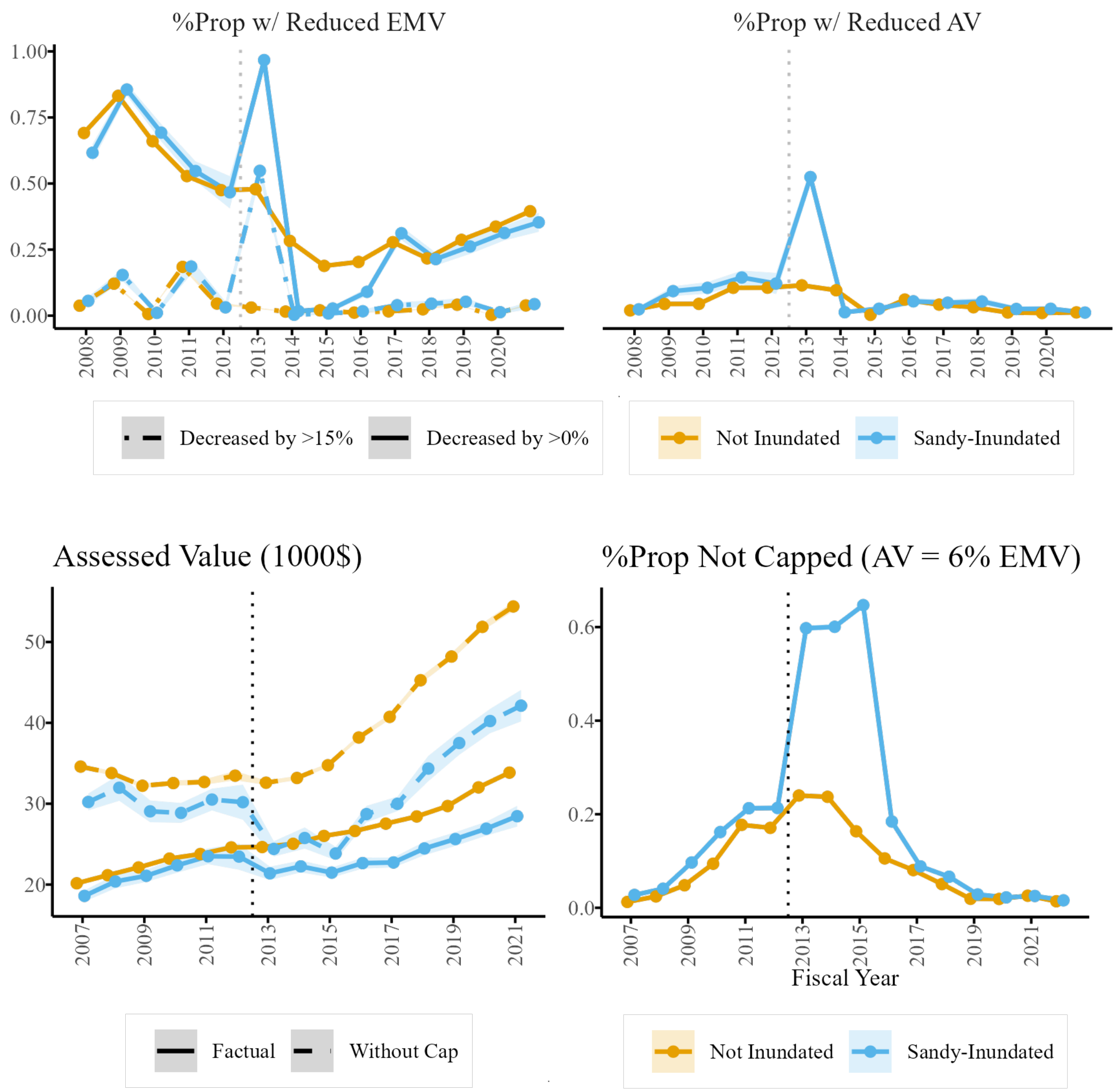


Notes: The figure displays the inundation zone of Hurricane Sandy in red, and the hurricane evacuation zones for categories A, B, and C, represented by varying intensities of green and blue.

Figure 2: Property Values and Assessments Records before and after Sandy

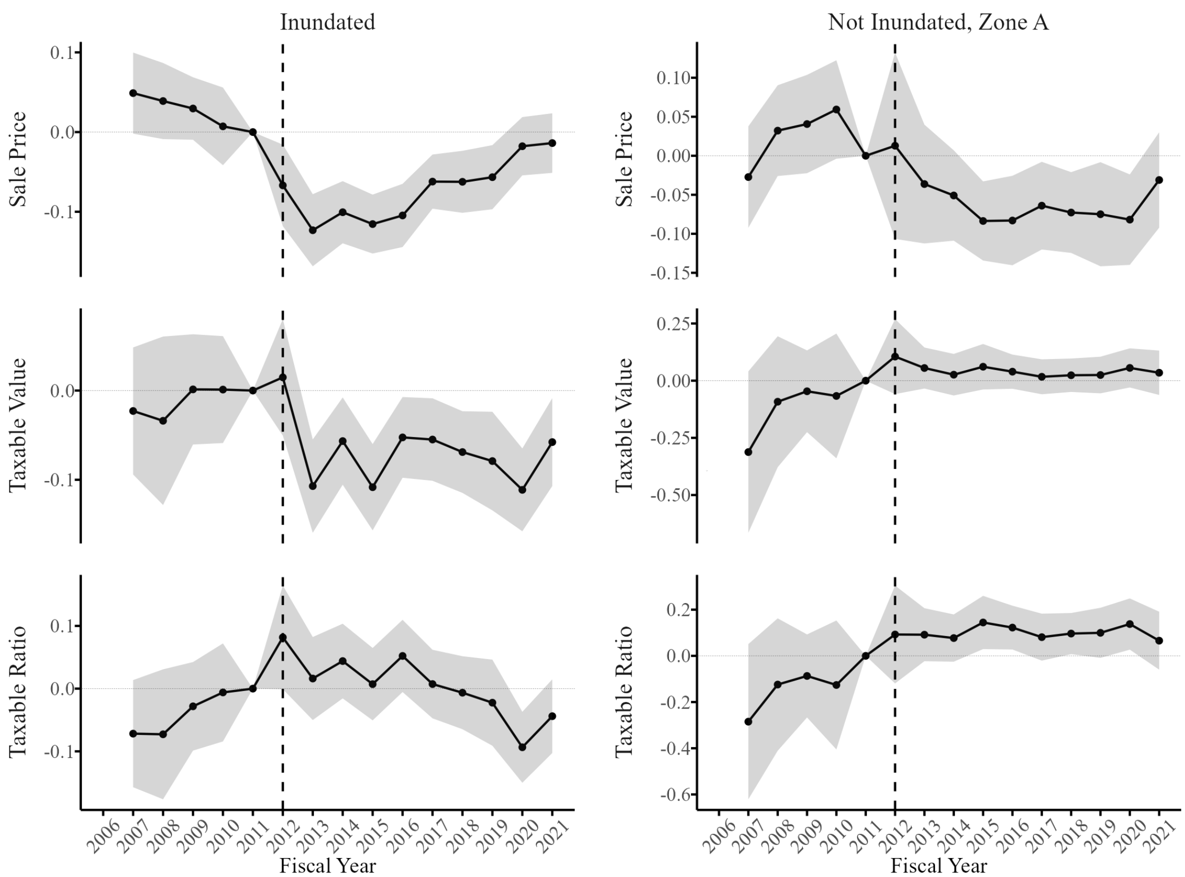
Notes: The panels show the yearly average property outcomes of fiscal years 2007-2021, separately for Sandy-inundated and non-inundated properties. The sample includes all sold properties during this period. The panels display the average property sale price, assessor-estimated market value, assessed value, and taxable value (assessed value minus exempt value), respectively. The shaded areas represent 95 percent confidence intervals.

Figure 3: Assessment Outcomes by Year



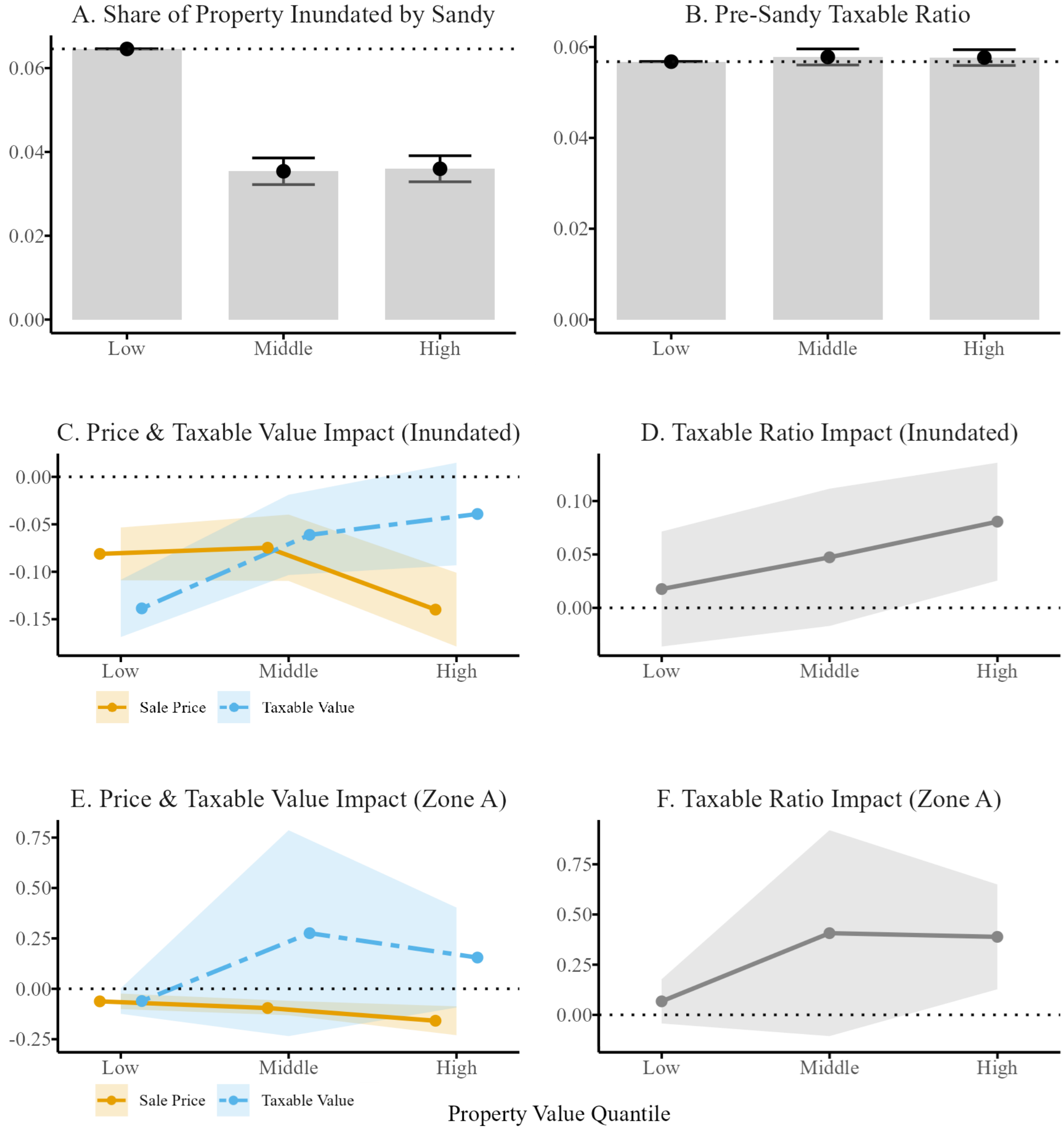
Notes: The top-left panel shows the assessed values for Sandy-inundated and non-inundated properties, with and without the assessment increase cap. The assessed value without the cap is calculated as 6% of the assessor-estimated market value. The top-right panel displays the share of properties that did not reach the assessment increase cap of each fiscal year. A property is determined uncapped if its assessed value equals 6% of the assessor-estimated market value and is less than the maximum allowable capped increase (6% annually or 20% over five years). The bottom-left panel displays the share of properties with estimated market value below the previous year's level in solid line, and properties with more than 15% drop in dashed lines. The bottom-right panel shows the share of properties with assessed value below that of the previous year. The sample includes all tax-class-1 properties from the assessment rolls. Shaded areas represent 95 percent confidence intervals

Figure 4: Dynamic Response in Property Outcomes



Notes: The panels display the coefficients of an event study regression with the event defined as the storm inundation. The left panels show the effects on inundated properties, and the right panels display properties that were not inundated by Sandy but were within the evacuation Zone A. The sample spans fiscal years 2006 to 2021, and the coefficient for fiscal year 2011 is normalized to 0. Shades represent 95 percent confidence intervals constructed using standard errors clustered at the tax block level.

Figure 5: Property Outcome and Sandy Inundation's Impact by Property Value



Notes: The panels show the average property outcomes and coefficients following Equation (3), for each property value quantile. The sample is divided into three terciles, using the 1st ($399,000) and 2nd ($543,000) tercile of the sold properties' estimated market value in fiscal year 2012. Panels A and B display the share of properties inundated and the average taxable assessment ratio, respectively. The points show the mean for each price segment. Panels C and D display the impact coefficients of Sandy on sale price and assessed value, and taxable ratio, for inundated properties. Panels C and D display the coefficients for non-inundated properties within Zone A. The error bars and shaded areas represent the 95 percent confidence intervals.

Table 1. Summary Statistics

Panel A: NYC Transactions and Assessments of Sold Properties

	All Sales (N=295,178)		Not Inundated (N=280,652)		Inundated (N=14,526)	
	Mean	SD	Mean	SD	Mean	SD
Sale Price (1000$)	651.45	462.96	657.40	466.16	537.88	378.89
Est Mkt Value (1000$)	633.48	417.81	639.96	419.83	508.88	354.47
Assessed Value (1000$)	25.63	13.08	25.78	13.06	22.70	13.15
Exempt Value (1000$)	2.33	5.30	2.33	5.31	2.40	5.03
Taxable Value (1000$)	23.30	13.34	23.45	13.32	20.30	13.41
# Residential Units	1.6	0.66	1.6	0.66	1.45	0.61
Land area (sqft)	3003.05	1972.81	3000.24	1987.28	3057.05	1669.57
Living area (sqft)	1978.77	844.86	1988.96	844.05	1782.77	836.63
Age	69.69	32.81	70.34	32.61	57.34	34.24
Inundated Depth	0.18	0.94	0	0	3.7	2.23
Zone A = 1	0.04	0.21	0.02	0.12	0.59	0.49

Panel B: NYC Assessment Rolls of All Properties

	All Properties (N=549,273)		Not Inundated (N=524,075)		Inundated (N=25,198)	
	Mean	SD	Mean	SD	Mean	SD
Est Mkt Value (1000$)	668.61	397.87	673.31	398.98	570.84	360.61
Assessment Value (1000$)	27.48	12.58	27.59	12.47	25.31	14.51
Exempt Value (1000$)	2.52	4.11	2.51	4.12	2.59	3.93
Taxable Value (1000$)	24.97	12.79	25.08	12.68	22.72	14.66
# Residential Units	1.43	0.5	1.43	0.5	1.36	0.48
Land area (sqft)	3187.33	2641.78	3184.29	2193.82	3250.54	7213.12
Living area (sqft)	1894.61	743.45	1899.15	740.96	1799.99	787.4
Inundated Depth	0.15	0.82	0	0	3.32	2.07
Zone A = 1	0.04	0.19	0.01	0.12	0.54	0.5

Table 2. Pre-Sandy Differences in Property Outcomes

	Inund v.s. Non-Inund (1)	Zone A v.s. Outside (2)
Sale Price (2011 1000$)	−57.7***	−63.9***
Est Market Value (2011 1000$)	−46.7***	−80.4***
Assessed Value (2011 1000$)	−1.31***	−0.33
Exempt Value (2011 1000$)	0.23***	1.26***
Taxable Value (2011 1000$)	−1.54***	−1.60***
Taxable Asmt Ratio (2011)	0.00528***	−0.00597**
# Res Units	−0.124***	−0.272***
Living Area (sqft)	−176***	−2.81
# Stories	−0.138***	−0.131***
Lot Size Acerage	99***	623***
Renovated = 1	−0.0119**	−0.0719***
Distance to Coastline (km)	−7.04***	−5.83***
Zone A = 1	0.563***	

Notes: This table presents cross-sectional differences on property outcomes (t-statistics). Column (1) compares between the Sandy-inundated properties and properties not inundated by the storm, by regressing the dependent variables on the sandy inundation indicator, with the sample being all properties that have been sold pre-storm in our research period. Column (2) compares between non-inundated properties inside and outside evacuation Zone A, by regressing the dependent variables on the indicator for being within evacuation zone A, with the sample being all properties that were within the storm's inundation zone and have been sold pre-storm in our research period. The dependent variables are: the sale price converted to 2011 level using the county-level quarterly housing price index from FHFA , the estimated market value of 2011, the assessed value of 2011, the exempt value of 2011, the taxable value of 2011, the taxable assessment ratio of 2011 (taxable value / sale price), the number of stories, the living area, the lot size, the indicator for whether the properties has been renovated, the distance to coastline, and the indicator for being located inside the hurricane evacuation zone A. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

Table 3. The Effects of Hurricane Sandy's Inundation on Property Outcomes

	Sale Price (1)	Est Market Val (2)	Asmt Val (3)	Exempt Val (4)	Txbl Val (5)	Txbl Ratio (6)
Panel A: NYC Sale Sample						
Post × Sandy	-0.10***	-0.17***	-0.10***	-0.18*	-0.065***	0.039**
	(0.010)	(0.010)	(0.013)	(0.010)	(0.015)	(0.019)
N	295178	295178	295178	295178	295178	295178
Adj. R^2	0.49	0.80	0.77	0.14	0.56	0.23
Panel B: NYC Assessment Roll						
Post × Sandy		-0.15***	-0.10***	-0.067**	-0.085***	
		(0.0038)	(0.0042)	(0.030)	(0.0059)	
N		8762583	8762583	8762583	8762583	
Adj. R^2		0.91	0.97	0.68	0.85	

Notes: This table presents estimation results on the average effect of Hurricane Sandy's inundation on property value and assessment, following Equation (1). Panel A uses the sale sample, and Panel B use a balanced panel constructed from the assessment rolls. The dependent variable is the log of sale price in Column (1), the log of estimated market price in (2), the log of assessment value in (3), the log of exempt value in (4), the log of taxable value in (5), and the log of taxable ratio in (6). Each regression in Panel A controls for a full set of property characteristics, the sale-year-by-sale-month fixed effects, the fiscal-year fixed effects, and the census block fixed effects. Each regression in Panel B controls for the fiscal-year fixed effects and the property fixed effects. Standard errors are clustered at the census block level. * p<0.1, ** p<0.05, *** p<0.01

Table 4. The Differential Effects by Evacuation Zone

	Sale Price (1)	Est Market Val (2)	Asmt Val (3)	Exempt Val (4)	Txbl Val (5)	Txbl Ratio (6)
Post × Sandy	-0.11***	-0.17***	-0.10***	-0.18*	-0.063***	0.043**
	(0.010)	(0.010)	(0.013)	(0.11)	(0.015)	(0.019)
Post × ZoneA	-0.11***	0.0294	0.081	0.083	0.14	0.24**
	(0.013)	(0.010)	(0.12)	(0.34)	(0.12)	(0.12)
N	295178	295178	295178	295178	295178	295178
Adj. R^2	0.49	0.80	0.77	0.14	0.56	0.23

Notes: This table presents estimation results on the differential effect by whether the property is located inside Zone A of NYC's hurricane evacuation zones, following Equation (2). The dependent variable is the log of sale price in Column (1), the log of estimated market price in (2), the log of assessment value in (3), the log of exempt value in (4), the log of taxable value in (5), and the log of taxable ratio in (6). Each regression controls for a full set of property characteristics, the sale-year-by-sale-month fixed effects, the fiscal-year fixed effects, and the census block fixed effects. Standard errors are clustered at the census block level. * p<0.1, ** p<0.05, *** p<0.01

Appendix

A A numeric example of the assessment cap

As indicated in the DOF's property tax guide, a class 1 property's assessed value can change due to several factors: 1) the property's estimated market value has changed; 2) There is a physical change to the home, such as an addition or renovation, and these physical changes are not subject to the annual or five-year caps on increases to assessed value for that year; 3) homeowners lose a tax exemption or abatement, or these values have changed; 4) assessed values is catching up to prior changes in market values.

Table C0 shows how a residential property's assessed value may increase or decrease in year 3 depending on the extent of the drop in its estimated market value after a natural disaster. First, with a slight drop in the estimated market values, the property's uncapped assessed value is still above the values under the assessment growth cap. In this case, the assessed value will still increase by 6 percent over that in Year 2. When the estimated market value drops to 110,000, its uncapped assessed value is now below the capped value and thus becomes the actual assessed value. But note that the assessed value in Year 3 is still greater than that in Year 2. In the case of a significant drop in the estimated market value, the uncapped assessed value also decreases sharply, falling below the previous year's assessed value.

B Additional Discussions in New York State

B.1 Property assessment and Sandy tax relief in New York State

In New York State, property tax is the largest single revenue for supporting municipal and school district services. Property tax administration across the State is highly decentralized, with townships and cities responsible for local property assessment (except in Nassau, Tompkins, and New York City, where assessment is centralized at the county level.[40] While the State does not mandate a reassessment cycle, taxing jurisdictions follow the guidelines from the International Association of Assessing Officers to conduct mass appraisal at least every six years,[41] and some jurisdictions, including New York City, conduct reassessment annually. The State also encourages regular and frequent assessment through state aid programs (Kim and Hou 2024; New York State Department of Taxation and Finance 2010). Since 2011, all jurisdictions across the State, except New York City, have implemented a property tax cap, which limits the annual growth of property tax levy to either 2% or the rate of inflation.[42] Some jurisdictions, such as New York City and Nassau county, have instituted separate assessment limits for certain property classes that restrict the growth of assessed value (Paquin 2015).

Hurricane Sandy occurred in the middle of the 2012-2013 tax year, prior to the release of the tentative assessment roll for the following fiscal year. In response, New York State enacted the legislation of "The Superstorm Sandy Assessment Relief Act" (A.39 and A.2294) one year later, authorizing taxing jurisdictions in counties that received presidential disaster declarations to provide property tax relief to owners of damaged properties.[43] This policy can be adopted by eligible counties, as well as cities, towns, villages, school districts or special districts within these eligible counties. Thus, property owners could only be eligible to receive property tax relief if their jurisdiction opted into the relief program.[44]

To qualify for the tax relief, property owners in participating jurisdictions across the State

[40] The total number of tax assessing units across New York State was 994 in 2017, including 932 towns and 62 cities.

[41] This is according to Part 190 of the Rules of the State Board of Real Property Tax Services and New York Tax Law § 1083 (New York State Department of Taxation and Finance 2021).

[42] On rare occasions, such tax limitations can vary across jurisdictions since the actual levy may exceed the limit when 60 percent or more of local voters support over-riding the cap.

[43] New York City opted into the State's relief program but implemented it with some modifications. The tax relief policies in the City are discussed in Section 2.3.

[44] The policy is not applicable in municipalities that are either ineligible or eligible but have chosen not to offer this relief. If a county adopts the program, it does not automatically extend to other local governments within that county. Each municipality, school district, or special district must individually pass a resolution to offer the relief to its property owners. Additionally, eligible municipalities that opt in may choose to extend the relief to property owners whose buildings and improvements have lost less than 50% of their value.

had to submit a written request with necessary supporting documentation to their assessor. The assessor estimated the percentage reduction in value, rather than determining the precise value loss, based on the submitted documentation and the FEMA's damage assessments. The loss is then categorized into ten damage ranges, each representing a 10 percent interval, starting with properties sustaining 10%-20% damage and up to properties with 100% damage. The reduction in the assessed value was set in proportion to the estimated damage loss.[45]

B.2 Analysis for Sandy-Affected Counties in New York State

Since a substantial portion of Sandy's damage occurred in New York City, the primary focus throughout the paper is on property data from the City. Here, we discuss the data together with the results for another two New York State counties, Nassau and Suffolk, which were also affected by Hurricane Sandy.

we constructed a property-level dataset of transactions and assessments in Nassau and Suffolk counties spanning the periods from 2007 to 2023. The transaction records were retrieved from the secured New York Real Property-5217 sales data. We also used the local assessment rolls provided by the New York State Department of Taxation and Finance, which include records on assessed value, full market value, property size, owners' name, exemption information for all properties in local jurisdictions across the State (excluding New York City). Since the assessment data contain limited information on housing characteristics, we restricted the sample to properties with repeated sales in our research period, allowing us to control for the property fixed effects in regression. The final sample includes 120,066 transaction records in Suffolk and Nassau counties.

We define the high-risk flood zones as special flood hazard areas (SFHA), also known as the 100-year flood map identified by FEMA. We employ a model similar to (2) to estimate Sandy's impacts on property sale price and assessment outcomes in Suffolk and Nassau

[45] For example, damaged homes within the 10%-20% loss category would have their assessed values reduced by 15%, and destroyed homes with a 100% value loss would have their assessed values reduced to zero.

counties.

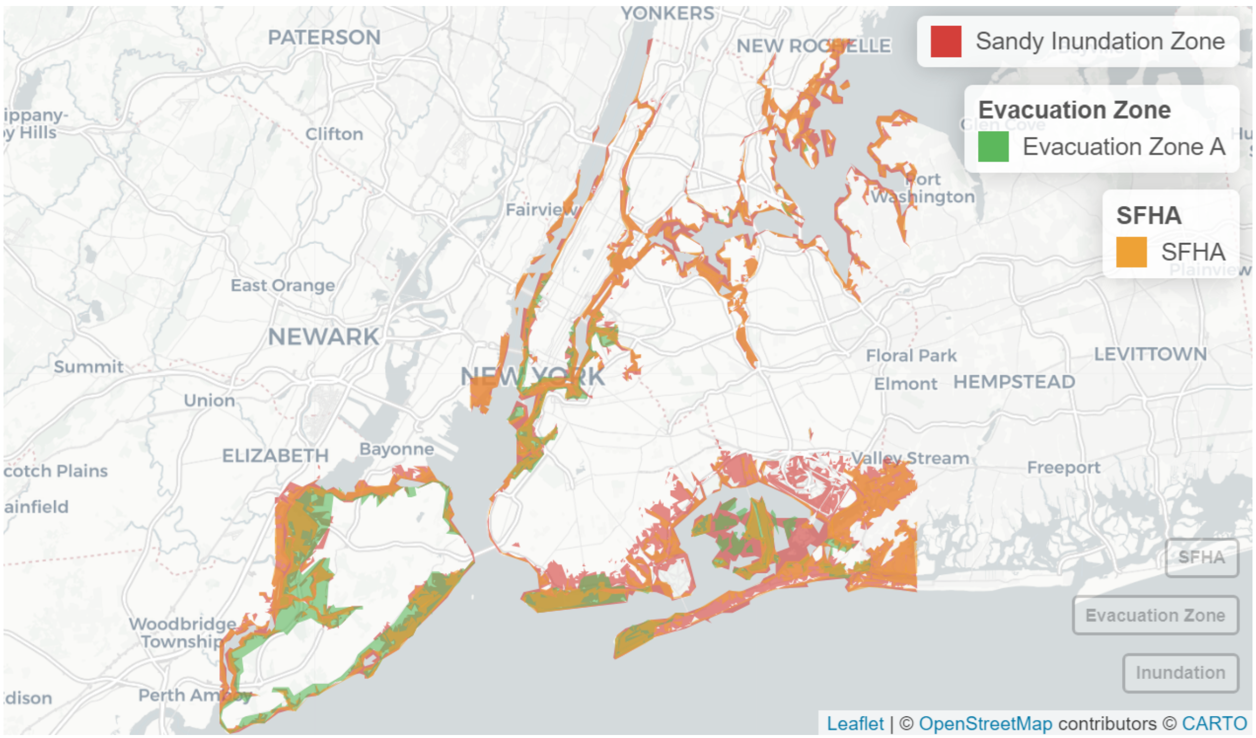
$$\ln(Y_{it}) = \beta_1 \text{Post}_t \cdot \text{Sandy}_i + \beta_2 \text{Post}_t \cdot \text{SFHA}_i + \alpha_{ym} + \alpha_{fy-\text{SWIS}} + \alpha_i + \epsilon_{it} \tag{4}$$

Each observation corresponds to a transaction of residential property i in date t. The outcome variables Y_{it}, and the treatment indicators, Post_t and Sandy_i, are analogous to (2). SFHA_i identifies whether the transacted property is located within SFHA but was not inundated by Sandy. Thus, the coefficients β_1 and β_2 respectively capture Sandy's impacts on inundated properties and unaffected properties within the flood zone, compared to unaffected properties outside the flood zone. We incorporate several fixed effects to control for potential confounding factors, including the sale-year-month fixed effects, α_{ym}, the SWIS-by-fiscal-year fixed effects $\alpha_{fy-\text{SWIS}}$, and the property fixed effects α_i.

The results are summarized in Table C1. In line with our findings in NYC, properties in high-risk areas but not inundated experienced significant declines in sale prices but no adjustments in their assessments, leading to a disproportionately high tax burden.

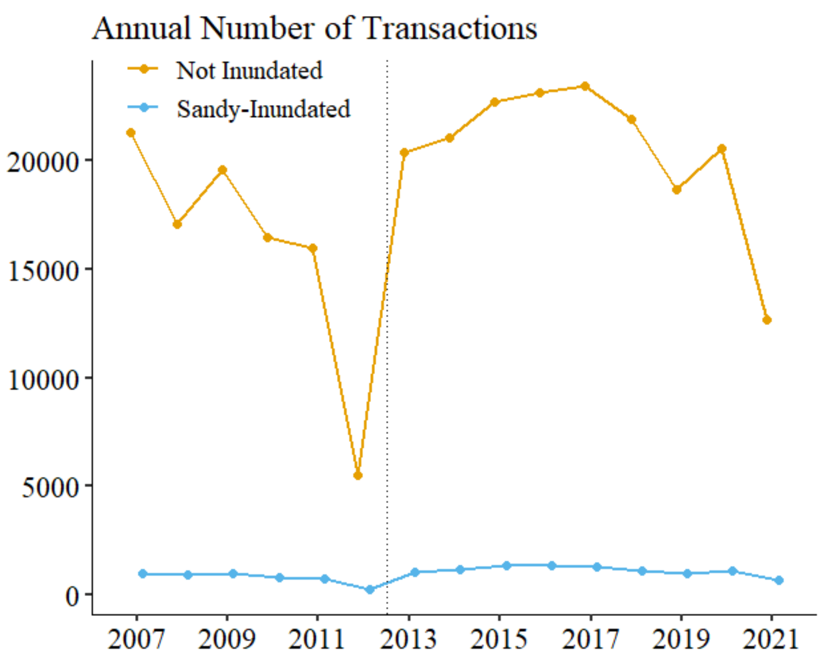
C Additional Figures and Tables

Figure C1: Sandy Inundation Area, FEMA's SFHA, and Hurricane Evacuation Zones A



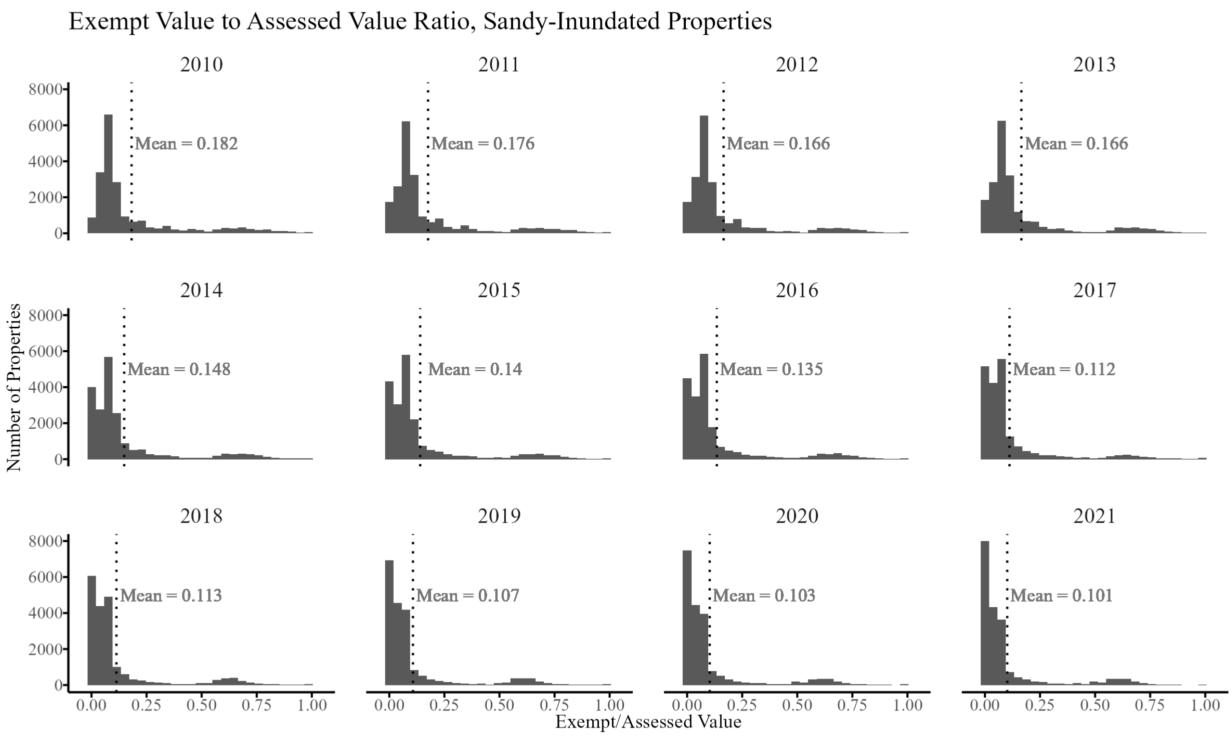
Notes: The figure displays the inundation zone of Hurricane Sandy in red, FEMA's special flood hazard area (SFHA) in green, and the hurricane evacuation zone A in orange.

Figure C2: Annual Count of Housing Transactions



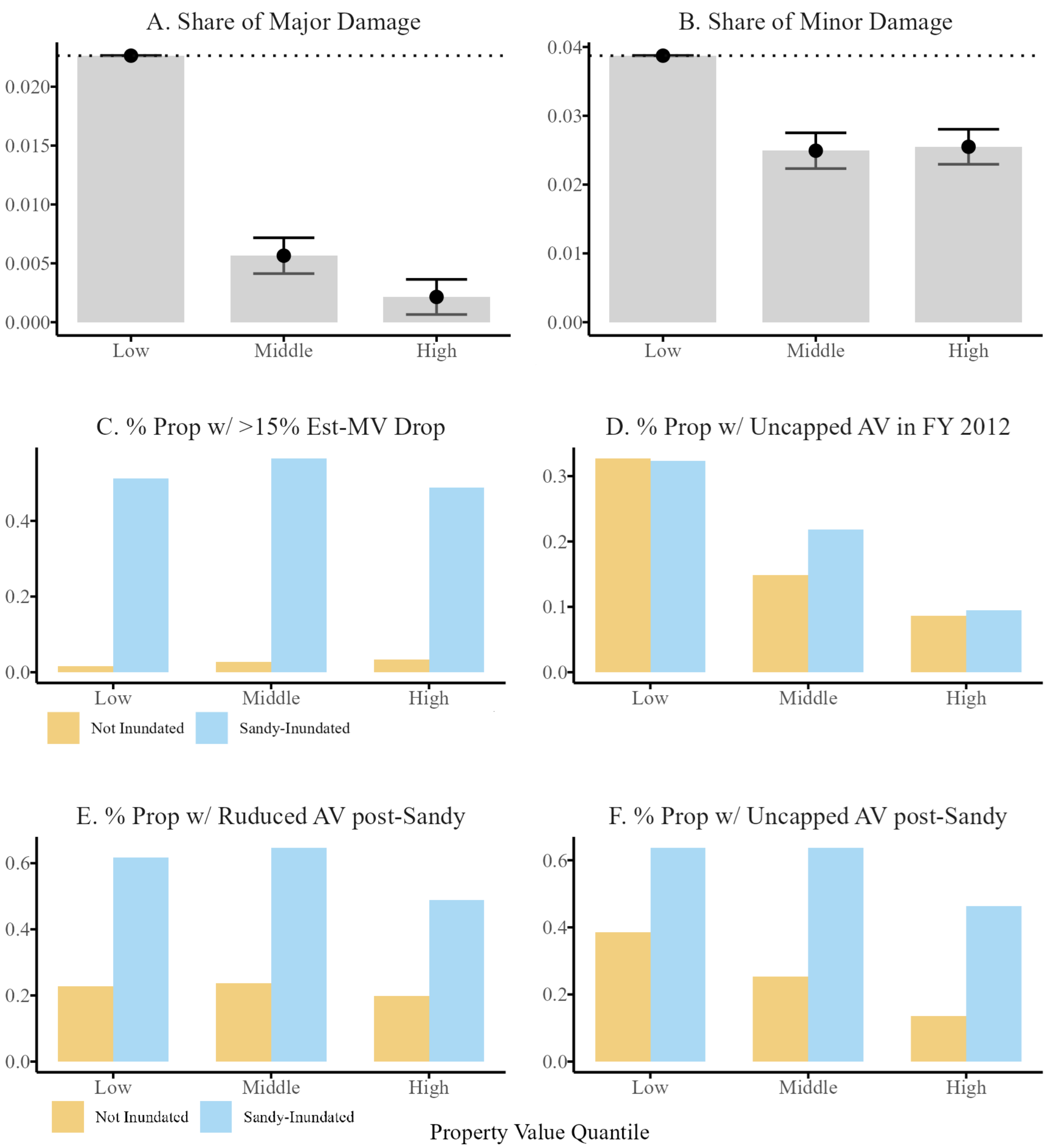
Notes: The figure displays the yearly count of housing transactions of fiscal years 2007-2021, separately for Sandy- inundated and non-inundated properties.

Figure C3: Exempt Value to Assessed Value Ratio for Sandy-Inundated Properties



Notes: The panels display the distribution of the ratio of exempt value to assessed value for Sandy-inundated properties across the fiscal years 2010-2021. The horizontal axis represents the exempt value as a percentage of the assessed value, while the vertical axis shows the number of properties for each ratio category. The sample includes all tax-class-1 properties with a positive exempt value at any point during the fiscal years 2010-2021, excluding those where the exempt value always equaled the assessed value (i.e., fully exempt properties). Each panel corresponds to a specific fiscal year, with the mean ratio for each year indicated by a dashed line.

Figure C4: Additional Property Outcome by Property Value



Notes: The top two panels illustrate the shares of properties with "Minor Damage" and "Major Damage" from Sandy per FEMA's damage classification. The middle-left panel shows properties with more than 15% reduction in estimated market value from FY 2012 to 2013; the middle-right shows properties with uncapped assessed values in FY 2012 (i.e., the assessed value equals 6% of the estimated market value.) Bottom-left displays the share of properties with reduced assessed value in FY 2013 vs. FY 2012, and bottom-right shows properties with uncapped assessed values in FY 2013.

Table C0. A Numerical Example

	Year 1	Year 2	Year 3	Year 3	Year 3
			slight drop	moderate drop	big drop
Estimated market values	100,000	150,000	140,000	110,000	105,000
Assessed values if increase was not capped	6,000	9,000	8,400	6,600	6,300
Assessed values with cap on increase	6,000	6,360	6,741	6,741	6,741
Final assessed values	6,000	6,360	6,741	6,600	6,300

Table C1. Effects of Hurricane Sandy on Property Outcomes, Suffolk and Nassau Counties

	Sale Price (1)	Est Market Val (2)	Asmt Val (3)	Exempt Val (4)	Txbl Val (5)	Txbl Ratio (6)
Post × Inund	-0.085***	-0.065***	-0.056**	0.0024	-0.074***	0.011
	(0.0071)	(0.021)	(0.026)	(0.0031)	(0.025)	(0.021)
Post × SFHA	-0.075***	0.049	0.0504	0.023	0.026	0.11***
	(0.0087)	(0.030)	(0.031)	(0.023)	(0.025)	(0.022)
N	120066	120066	120066	120066	120066	120066
Adj. R^2	0.69	1.00	0.99	0.27	0.98	0.94

Notes: This table presents estimation results on the differential effect by whether the property is located inside SFHA, for properties in Suffolk and Nassau Counties. The estimation samples are property with repeated sales in our research period. The dependent variable is the log of sale price in Column (1), the log of estimated market price in (2), the log of county assessment value in (3), the log of county exempt value in (4), the log of county taxable value in (5), and the log of assessment ratio in (6). Each regression controls for the sale-year-by-sale-month fixed effects, the SWIS-by-fiscal-year fixed effects, and the property fixed effects. Standard errors are clustered at the SWIS level. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

Table C2. Pre-Sandy Differences in Property Outcomes

	Inundated v.s. Not-Inund		Zone A v.s. Outside
	< 2km of coast	Zone A Only	
	(1)	(2)	(3)
Sale Price (2011 $)	-9.68×10^{4}***	-1.77×10^{4}	-7.48×10^{4}***
Est. Market Value (2011)	-8.38×10^{4}***	3.5×10^{3}	-7.80×10^{4}***
Assessed Value (2011)	-4.57×10^{3}***	-2.52×10^{3}***	-1.97×10^{3}***
Exempt Value (2011)	−354***	-1.05×10^{3}***	580***
Taxable Value (2011)	-4.22×10^{3}***	-1.47×10^{3}***	-2.55×10^{3}***
Taxable Ratio (2011)	0.0045**	0.0068*	−0.00183
# Stories	0.025	0.023	−0.11***
Living Area SQFT	−247***	−220***	−142***
Lot Size Acerage	−702***	−619***	218***
Renovated = 1	−0.0055	0.059***	−0.034***
Distance to Coastline (m)	−42***	-1.9×10^{3}***	-6.91×10^{3}***
Inundation Depth	3.64***	3.96***	2.49***
Zone A = 1	0.49***		
Sandy Inundated = 1			0.63***

Notes: This table presents cross-sectional differences on property outcomes. The first two columns compare between the Sandy-inundated properties and properties not inundated by the storm, by regressing the dependent variables on the sandy inundation indicator. The samples in the first three columns are: all properties that has been sold pre-storm in our research period, the subset of properties within 2km of the coastline, and the subset of properties in evacuation Zone A only. The last column compares between properties inside and outside evacuation Zone A, by regressing the dependent variables on the indicator for being within evacuation zone A. The sample is all properties that has been sold pre-storm in our research period. The dependent variables are: the sale price converted to 2011 level using the county-level quarterly housing price index from FHFA , the estimated market value of 2011, the assessed value of 2011, the exempt value of 2011, the taxable value of 2011, the taxable assessment ratio of 2011 (taxable value / sale price), the number of stories, the living area, the lot size, the indicator for whether the properties has been renovated, the distance to coastline, the inundation depth, the indicator for being located inside the hurricane evacuation zone A, and the indicator for being inundated by Hurricane Sandy. * p<0.1, ** p<0.05, *** p<0.01

Table C3. Robustness Checks

	Sale Price	Est Mkt Val	Asmt Val	Exempt Val	Txbl Val	Txbl Ratio
Panel A: Differential Effect of Sandy by Damage Level ($N = 295178$)						
Affected	-0.023***	-0.039***	-0.022***	-0.070	-0.025***	0.0046
	(0.0069)	(0.0064)	(0.0072)	(0.074)	(0.0076)	(0.010)
Minor Damage	-0.076***	-0.12***	-0.076***	-0.18*	-0.047***	0.029*
	(0.0093)	(0.0081)	(0.0083)	(0.098)	(0.012)	(0.016)
Major Damage	-0.13***	-0.19***	-0.12***	-0.28*	-0.075***	0.055**
	(0.018)	(0.015)	(0.016)	(0.15)	(0.022)	(0.0261)
Adj. R^2	0.49	0.80	0.77	0.14	0.56	0.23
Panel B: Repeated Sales, Sandy's Inundation Effect ($N = 127736$)						
Post × Sandy	-0.0938***	-0.144***	-0.101***	0.0939	-0.0691***	0.0247
	(0.0198)	(0.0202)	(0.0209)	(0.194)	(0.0231)	(0.0293)
Adj. R^2	0.46	0.84	0.89	0.52	0.78	0.37
Panel C: Repeated Sales, Differential Effect by Evacuation Zone ($N = 127736$)						
Post × Sandy	-0.092***	-0.14***	-0.095***	0.086	-0.061***	0.031
	(0.020)	(0.020)	(0.020)	(0.20)	(0.023)	(0.029)
Post × Zone A	-0.11***	0.15	0.21	0.54	0.28	0.39*
	(0.027)	(0.18)	(0.21)	(0.67)	(0.21)	(0.22)
Adj. R^2	0.45	0.84	0.89	0.51	0.78	0.37
Panel D: 2 Years before and after Hurricane Sandy ($N = 66156$)						
Post × Sandy	-0.15***	-0.17***	-0.065***	-0.21	-0.078***	0.067*
	(0.026)	(0.024)	(0.023)	(0.23)	(0.028)	(0.038)
Post × Zone A	-0.15***	-0.083	-0.0053	-0.19	-0.022	0.13*
	(0.032)	(0.056)	(0.065)	(0.58)	(0.069)	(0.074)
Adj. R^2	0.47	0.84	0.81	0.18	0.53	0.25

Notes: This table presents estimation results for the effect of Hurricane Sandy on property value and assessment. Panel A reports the differential effects by damage level. Panels B and C present estimation following models (1) and (2) using the sample of repeated sales. Panels D restricts the samples of transaction and assessment to 2 years before and after Hurricane Sandy.Panels A, B, C, and D follows the specification in Table 3. Standard errors are clustered at the tax block level. * p<0.1, ** p<0.05, *** p<0.01

Table C3. Robustness Checks (Continued)

	Sale Price	Est Mkt Val	Asmt Val	Exempt Val	Txbl Val	Txbl Ratio
Panel E: Triple Difference Specification ($N = 295178$)						
Inund, Zone A	-0.11***	-0.18***	-0.11***	-0.42***	-0.037*	0.076***
	(0.013)	(0.013)	(0.015)	(0.14)	(0.021)	(0.025)
Inund, Outside	-0.094***	-0.16***	-0.092***	0.15	-0.098***	-0.0045
	(0.015)	(0.015)	(0.021)	(0.15)	(0.021)	(0.026)
Unind, Zone A	-0.11***	0.029	0.081	0.083	0.14	0.24**
	(0.013)	(0.10)	(0.12)	(0.34)	(0.12)	(0.12)
Adj. R^2	0.49	0.80	0.77	0.14	0.56	0.23

Notes: This table presents estimation results for the effect of Hurricane Sandy on property value and assessment. Panel E estimates the triple difference specification, incorporating the interaction terms on being inundated and inside Zone A with post-Sandy, being inundated and outside Zone A with post-Sandy, and not being inundated and inside Zone A with post-Sandy. Panel F presents estimation following model (1) using the control group of non-inundated properties outside Zone A. Standard errors are clustered at the tax block level. * p<0.1, ** p<0.05, *** p<0.01

Table C5. Pre-Sandy Property Difference by Property Value Segment

	(1) Middle - Low		(2) High - Low	
Sale Price (2011 $)	1.21×10^5***	(2.49×10^3)	4.35×10^5***	(2.45×10^3)
Estimated Market Value (2011)	1.42×10^5***	(2.16×10^3)	4.81×10^5***	(2.12×10^3)
Assessed Value (2011)	5.51×10^3***	(78.8)	1.65×10^4***	(77.5)
Exempt Value (2011)	404***	(31.9)	1.1×10^3***	(31.4)
Taxable Value (2011)	5.11×10^3***	(81.9)	1.54×10^4***	(80.5)
Taxable Asmt Ratio (2011)	0.00113	(0.000893)	0.00119	(0.000878)
# Res Units	0.323***	(0.00492)	0.459***	(0.00484)
Living Area SQFT	481***	(5.98)	1.02×10^3***	(5.88)
# Stories	0.0371***	(0.00486)	0.128***	(0.00478)
Lot Size Acerage	204***	(14.8)	826***	(14.6)
Renovated = 1	0.0339***	(0.00241)	0.114***	(0.00237)
Inundated = 1	−0.0289***	(0.0016)	−0.0277***	(0.00158)
Inun Depth	−0.157***	(0.00668)	−0.174***	(0.00657)
Zone A = 1	−0.0254***	(0.00152)	−0.0356***	(0.00149)
Dist to Coast	552***	(34)	10.5	(33.4)

Notes: This table presents cross-sectional differences on property outcomes. Properties are divided into three groups with similar sample sizes by their assessor-estimated market value in 2012: low-valued properties are below $399,000, middle-valued properties are between $399,000 and 43,000, and high-valued properties are above $543,000. Column (1) compare between the middle-valued and low-valued properties, and column (2) compares between the high-valued and low-valued properties. The sample is all properties that has been sold pre-storm in our research period. The dependent variables are: the sale price converted to 2011 level using the county-level quarterly housing price index from FHFA , the estimated market value of 2011, the assessed value of 2011, the exempt value of 2011, the taxable value of 2011, the taxable assessment ratio of 2011 (taxable value / sale price), the number of stories, the living area, the lot size, the indicator for whether the properties has been renovated, the distance to coastline, the inundation depth, the indicator for being located inside the hurricane evacuation zone A, and the indicator for being inundated by Hurricane Sandy. * p<0.1, ** p<0.05, *** p<0.01

Table C6. Effects of Hurricane Sandy on Property Outcomes by Property Value Tercile

	Sale Price (1)	Est Market Val (2)	Asmt Val (3)	Exempt Val (4)	Taxable Val (5)	Asmt Ratio (6)
Post × Sandy						
Low	−0.112***	−0.163***	−0.13***	−0.242*	−0.0817***	0.03
	(0.0119)	(0.0113)	(0.0129)	(0.125)	(0.0188)	(0.0226)
Middle	−0.0545***	−0.0961***	−0.0578***	−0.233*	−0.0302*	0.0243
	(0.0119)	(0.0129)	(0.0136)	(0.135)	(0.0175)	(0.0212)
High	−0.0984***	−0.115***	−0.0359***	−0.0681	−0.024	0.0745***
	(0.0162)	(0.0123)	(0.0118)	(0.136)	(0.0159)	(0.0209)
Post × Zone A						
Low	−0.0751***	−0.0275	−0.0215	0.092	0.0326	0.108**
	(0.0177)	(0.035)	(0.0415)	(0.231)	(0.0481)	(0.0502)
Middle	−0.0878***	0.0687	0.123	0.249	0.179	0.266*
	(0.0172)	(0.12)	(0.138)	(0.407)	(0.137)	(0.142)
High	−0.0809***	0.0658	0.182	−0.219	0.257*	0.338**
	(0.0241)	(0.119)	(0.144)	(0.428)	(0.138)	(0.148)
N	295124	295124	295124	295124	295124	295124
Adj. R^2	0.496	0.814	0.774	0.143	0.568	0.235

Notes: This table presents estimation results for the differential effect by whether the property is located inside Zone A of NYC's hurricane evacuation zones, following Equation (2). The sample is divided into three terciles, using the 1st ($399,000) and 2nd ($543,000) tercile of the sold properties' estimated market value in fiscal year 2012. The dependent variable is the log of sale price in Column (1), the log of estimated market price in (2), the log of assessment value in (3), the log of exempt value in (4), the log of taxable value in (5), and the log of assessment ratio in (6). Each regression controls for a full set of property characteristics, the sale-year-by-sale-month fixed effects, the fiscal-year fixed effects, and the census block fixed effects. Standard errors are clustered at the census block level. * p<0.1, ** p<0.05, *** p<0.01