Small Business Vulnerability in the Face of Natural Disasters:
The Case of Hurricane Sandy and New York City

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Updated May 26, 2017

Abstract

The density of urban areas is what makes them productive, but it is also what makes them particularly vulnerable in the face of natural disasters. This is all the more true as the threat of, and damage from, natural disasters becomes more severe, especially for coastal cities like New York. In this paper, we consider small businesses, a critical part of the urban economy, and the nature of their risk, in the context of Hurricane Sandy. Specifically, what share of businesses, and the economic activity that they represent, is vulnerable to extreme flooding? What are the characteristics of the businesses, and the nature of their economic activity, in the areas of highest estimated risk, compared to those in areas of lower risk? And did Hurricane Sandy affect the economic activity of these businesses?

To answer these questions, we rely on a combination of several rich micro-datasets on business activity, employment, and property characteristics in New York City. We currently have data for five to ten years leading up to the storm and, in some cases, several years following the storm. We overlay these data with spatial information on locally determined evacuation zones to capture pre-storm risk estimations, and then inundation zones that show us exactly where, and to what height, the flood waters surged. We analyze businesses before Hurricane Sandy and employment, both before and immediately following Sandy, across these zones in order to understand the pre-storm vulnerability of small businesses and the very immediate repercussions from Hurricane Sandy. We find that while a small share of businesses is located in evacuation zones, many are located in older buildings and are small operations that provide services to the local community. Preliminary regression results show significant post-Sandy job declines, of about 4.5 to 6 per census block, for the retail sector only. On average, across all job types, the impacts from Sandy are noisy and largely insignificant.

Acknowledgments: We thank Xioadi Li, Pooya Ghorbani and Rachel Marie Atkins Brooks for excellent research assistance. We thank the New York City Mayor's Office of Recovery and Resiliency and the New York City Department of Small Business Services for providing critical data. This project is supported by the National Science Foundation's program on Infrastructure, Management and Extreme Events.

I. Introduction

The density of urban areas is what makes them productive, but it is also what makes them particularly vulnerable in the face of natural disasters. This is all the more true as the threat of, and damage from, natural disasters becomes more severe, especially for coastal cities like New York. In this paper, we consider the risks the city's small businesses face from natural disasters and offer some preliminary estimates of how Hurricane Sandy affected them.

We hypothesize that retail businesses will be most vulnerable to flooding risk, largely because they rely on local customers, who may be displaced by the storm and/or suffer reductions in income. Further, disruption in transportation networks and closure of nearby businesses may also reduce the number of visitors and workers in the neighborhood who might shop at local stores. Finally, retail businesses also tend to be small businesses that may not have many resources to cover damage and to survive a temporary (if extended) hit to demand. Specifically, we examine three research questions. First, what share of the city's businesses, and the economic activity that they represent, is vulnerable to extreme flooding? What are the characteristics of the businesses, and the nature of their economic activity, in the areas of highest estimated risk, compared to those in areas of lower risk areas? And did Hurricane Sandy affect the economic activity of retail and non-retail businesses located in the areas hit hard by the storm?

To answer these questions, we rely on a combination of several rich micro-datasets on business activity, employment, and property characteristics in New York City. We currently have data for five to ten years leading up to the storm and, in some cases, several years following the storm. We overlay these data with spatial information on locally determined evacuation zones to capture pre-storm risk estimations, and then surge zones that show us exactly where, and to what height, the flood waters rose. We analyze businesses before Hurricane Sandy and employment, both before and immediately following Sandy, across these zones in order to understand the pre-storm vulnerability of small businesses and the very immediate repercussions from Hurricane Sandy.

Preliminary results indicate that 5 percent of businesses and 10 percent of jobs in the city are located in an evacuation zone. While it is somewhat reassuring that these percentages are relatively low, this still represents a meaningful share of economic activity in the city. We find no association between locating in an evacuation zone and the business's size, age and organizational structure. The businesses in evacuation zones, however, tend to be located in older, low-rise buildings that were constructed before the city building code adopted stricter flood-protection requirements, and many are small businesses that target local consumers, making them especially vulnerable to potential storms. but as hypothesized, we find non-negligible declines for retail sector jobs. Our current analysis, however, relies on a limited number of post-Sandy observations.

II. Small business resilience and recovery

Small businesses are a critical part of the urban economy. Firms with fewer than 250 workers make up 46 percent of employment in the United States (BLS, 2016). And research consistently finds that small firms contribute disproportionately to employment growth (Haltiwanger, Jarmin, and Miranda, 2013; Neumark, Wall and Zhang 2011).[1] Certain kinds of small businesses, like restaurants, bars, and specialty stores, also help to generate the street traffic essential to neighborhood vitality and safety (Jacobs 1961) and to attract residents who value the consumption opportunities they offer (Glaeser, Kolko, and Saiz 2001;). In many communities, neighborhood businesses also provide important services and often act as important centers of social gathering and cultural identity (Hyra, 2015; Hyra, 2008).

Yet, small, independent businesses may be highly vulnerable to natural disasters. Typically operating off of tight margins (in good times), they do not have the financial cushion of other, larger establishments. When hit by power outages, flooding and other storm damage, they are less likely to have access to the capital needed to continue to pay fixed costs and to make any needed repairs. As a result, they may be more likely to cut back on staff to save on expenses or even to shut down entirely.

Further, retail and other neighborhood-based businesses may be especially vulnerable as they draw their customers disproportionately from the surrounding community. Thus, when disasters displace residents of the surrounding neighborhoods, they lose a very large share of their customers. Further, disruption in transportation networks and closure

[1] Haltiwanger et al (2013) argue that small businesses disproportionately contribute to job growth because they tend to be relatively young.

or contraction of commercial activity in the area may also reduce the number of visitors and workers in the neighborhood who might shop at local stores, even those aimed at a broader set of customers. Past research has shown that neighborhood-based businesses are strongly affected by crime in the surrounding area, due to a decline in street traffic (Fisher, 1991).

Finally, it's also worth noting the potential for spatial spillovers. The contraction of small businesses not only eliminates important jobs for city residents but also harms neighboring businesses and residents. Small businesses typically cluster together, and benefit from the shared street traffic they generate. If one small business contracts, that means fewer potential customers for its neighbors. Further, city residents often choose neighborhoods based partially on the vitality of nearby commercial strips. Thus, if the businesses in those strips start to falter, demand for nearby residential properties may decline in response.

The vulnerability of small businesses is an increasing concern as storms and other natural disasters have become more common and intense in urban settings (New York City Planning on Climate Change, 2010, 2013, Intergovernmental Panel on Climate Change, 2012). Despite this growing risk, there has been little research on the vulnerability and resilience of small businesses in the face of natural disasters.

Hurricane Sandy offers a unique opportunity to study this question. In October of 2012 the eastern seaboard of the United States was hit by one of the strongest storms it had seen in recent history. New York City residents and businesses were hit particularly hard by the storm surge and are still recovering to this day. The storm surge reached almost nine percent of all residential units in the city, and nearly four percent of all households registered with the Federal Emergency Management Agency (FEMA) for post-disaster assistance (Furman Center, 2013). Data on the impact of the hurricane on businesses are scarce, but media reports indicate that many businesses struggled with their operations for months following the storm (Birch, 2013, Eha, 2013). Hurricane Sandy is estimated as the second-costliest hurricane in U.S. history, after Hurricane Katrina in 2005.

New York City presents a compelling case for disaster inquiry. The sheer scale of the city offers an enormous number of small businesses and neighborhoods to explore. Further, even within its relatively small landmass, New York City experienced highly divergent impacts, so there is a lot of variation to explore. For instance, FEMA estimates indicate that the surge covered 39.6% of Lower Manhattan. Yet, even within this district, the Bowling Green neighborhood saw 58.1% of its land surface flooded while the Church Street neighborhood faced a much lower incidence at 19.6%.

Empirical literature

Research on the economic consequences of natural disasters has received much less attention than the “broader social dimensions” of disaster repercussions (Webb 2006). A compelling, but relatively small, body of work has investigated the impacts of various natural disasters on business operations. The literature covers a range of disaster types, including tornadoes, hurricanes, flooding, and earthquakes. Many of the studies unite around common findings: (i) businesses are as vulnerable to indirect damages, such as lifeline utility outages and consumer base attrition, as they are to direct physical damages (Tierney 1997a and 1997b, Alesch and Holly 2002, Wasileski et al. 2011, Corey and Dietch 2011) and (ii) the extent of physical damage, preparedness and post-disaster governmental aid do not consistently predict business loss, resilience or recovery (Kroll et al. 1990, Dahlhamer and Tierney 1998, Webb et al. 2000, Change and Falit-Baiamonte 2002).

More recently, LeSage et. al. (2011) look at the variation in these post-disaster outcomes over time and space, and find that immediate effects often differ from longer term impacts. In the short term, severity of the disaster (flood depth) reduces the probability of businesses re-opening post-disaster; ownership structure (specifically, sole proprietorship) and local household income increased the probability. Based on post-disaster observations only, the authors find that all of these effects diminish over time. This is consistent with findings from Baade et al.'s study (2007) of the impacts of Hurricane Andrew on taxable sales in south Florida: they report an immediate drop in the taxable sales for affected areas (relative to unaffected areas), but a recovery to pre-storm levels within 18 months.

The research to date convincingly shows that the characteristics of the businesses matter, supporting the notion of "differential recovery" (Cutter et. al. 2000 and 2003, Smith and

Wenger 2007, Cutter and Finch 2008, Finch et. al. 2010, Van Zandt et. al. 2012). Communities and individuals, that is, possess different characteristics that make them more or less vulnerable to negative disaster impacts. A number of studies find that larger businesses, and those that were performing relatively better prior to the disaster, cope better in post-disaster circumstances (Tierney 1997b, Dahlhamer and Tierney 1998, Wasileski et al. 2011). Indeed, some commercial enterprises can actually benefit from disasters since they end up providing goods and services to aid the recovery process or benefit from serving a captive market (Dahlhamer and Tierney 1996).

In general, businesses that rely on more diverse or geographically broader income streams can fare better under disaster shocks than neighborhood businesses that are more reliant on local consumers. Xiao and Van Zandt (2012) find that the return of businesses to a community is dependent on the return of residents (and vice versa) and Chang and Falt-Baiamonte (2002) deduce from interviews that the disrepair of the surrounding commercial district matters for the degree of business's loss. Therefore, differential recovery is not solely determined by the characteristics of businesses themselves, but also by the vulnerabilities and assets of the surrounding community. (Findings from Dietch and Corey (2011) also support this idea.)

The response of institutions also matters. For example, Haynes et al. (2011) find that while governmental aid does not increase the likelihood of survival, it does predict revenue increases for the businesses that endure. That said, Runyan (2006) finds that government assistance was a significant impediment to recovery, as reported by small businesses in the Gulf Coast post-Katrina. In addition, prior research (Asgary et al. 2012, Yoshida et al. 2005) and a more current assessment of the insurance market (Dixon et al. 2013, New York City Mayor's Office of Recovery and Resiliency) both indicate that small businesses have minimal access to flood insurance.

III. Data and analytical strategy

The U.S. Census defines a "small business" as an entity with fewer than 100 employees. In our sample of businesses in New York City, 99 percent of the establishments have fewer than 100 employees and thus meet the definition of a small business. While we have not omitted larger businesses from our sample, our analysis essentially pertains to small businesses.[2]

Data

We compile a number of datasets, from both public and private sources. First, we obtain information on the location and activity of businesses from the National Establishment Time Series (NETS), a longitudinal, establishment-level database that is constructed by Walls and Associates from the Dun & Bradstreet business register. We use data from 2002 through 2011.[3] Unlike publicly available government data on establishments, the NETS dataset provides full street addresses for each establishment, and it is more likely to capture businesses that have no paid employees (typically self-employed individuals operating sole proprietorships) than other public records (Neumark et al. 2005). The

[2] The analyses that follow have all been replicated, where possible, including only small businesses and the findings do not change substantively.
[3] We are in the process of accessing more recent NETS data so that we can use it to estimate post-Sandy impacts. For now, we use the data to explore pre-Sandy exposure to risk.

dataset reports industry at the 6-digit North American Industry Classification System (NAICS) level to allow for a fine-grained distinction across establishment types.[4] The dataset also provides the age of the businesses and distinguishes between chains and stand-alone businesses. Most importantly for this analysis, because the NETS data are longitudinal and establishment-specific, we can track the movement of businesses into and out of very precise locations, i.e. single city blocks. Specifically, the establishments are identified by a unique ID (a DUNS number), which stays with the establishment even as it changes addresses over time.[5]

Second, we obtain employment information from the LEHD Origin-Destination Employment Statistics (LODES) dataset, which is publicly available from the Census Bureau. The LODES data contains information on annual employment counts for every census block in New York City dating from 2002 to 2014. The LODES data is derived from state unemployment insurance records, which means that the employment counts, while reliable, are likely undercounts of actual employment on the ground (i.e. they do not capture the jobs for which unemployment insurance is not reported). Furthermore, they do not include information on sole proprietorships, which is captured by the NETS

[4] NAICS is a classification system for U.S. businesses, which identifies the industry for the establishment's primary activities. NAICS are self-declared by the business and exist "for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. economy" (https://www.sba.gov/contracting/getting-started-contractor/determine-your-naics-code).

[5] We recognize several limitations with using NETS. Other studies have advised against using it to identify very short-term changes in firm characteristics (Neumark et al., 2005); therefore, we triangulate all NETS-based analyses with those using alternative data sources, like LODES and New York City Department of Finance sales tax revenue data (which we are in the process of acquiring). Furthermore, we note that the NETS data is less adept at capturing within-city moves (Kaufman et al., 2015); since we are not following businesses across space, and only within single fixed locations, this limitation should not affect the current analysis. Finally, since employment numbers in NETS are often rounded to an even number or even imputed, identifying changes (especially short-term) in employment is difficult (Neumark et al., 2005). NETS are better suited for identifying employment levels and changes over longer periods of time (a few years or more). We instead rely on the LODES data set for more reliable employment numbers.

data. We use the variable that records jobs based on the location of employment (i.e. not based on the location of the employee's residential location).

We augment the above datasets with information on the boundaries of local evacuation zones (defined by New York City officials) in effect at the time of Hurricane Sandy together with information on the water surge heights in the flood zones. The evacuation zones are used to proxy for the pre-storm vulnerability of businesses, as well as access to information about pre-storm evacuation alarms. The surge maps, on the other hand, capture the storm's actual impact (from water inundation). The evacuation zone maps were obtained from the New York City Mayor's Office of Recovery and Resiliency and can be seen in Figure 1. We obtain the surge zones maps from the FEMA Modeling Task Force (MOTF), which uses statistical modeling and on-the-ground surge sensors and field observations to regularly update flood impacts. As described by the MOTF, "[a]ll products are created from field-verified High Water Marks (HWMs) and Storm Surge Sensor data from the USGS through 14-February 2013. HWMs and Surge Sensor data are used to interpolate a water surface elevation, then subtracted from the best available DEM, to create a depth grid and surge boundary by state."[6] Since the MOTF's reported surge levels are based on interpolated values, we collapse the raster-level surge heights to block-level averages. We classify a city block with any degree of water level as part of the surge zone, but surge heights within the zone vary widely.

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

Finally, we include building characteristics, like age, height and size, from the New York City Department of City Planning's Primary Land Use Tax Lot Output (PLUTO) dataset. These variables are useful for understanding the physical structures in which businesses operate in the city and to control for land-use constraints that could affect the clustering of certain types of businesses. We have this information from 2004 through 2014.

Analytical strategy

Our analysis aims to answer two questions. First, how vulnerable are small businesses in the face of flood-inducing natural disasters? And, second, what are the short-term effects on economic activity in the flooded areas? To answer these questions, we rely on different time frames and therefore different datasets. We also employ two different analytic methods. For the first question, we conduct a descriptive analysis that provides a set of stylized facts about businesses' pre-storm vulnerability and how it varies by characteristics of the businesses themselves and the built environment. For the second question, we conduct a multivariate regression analysis to estimate the impact of Sandy on jobs; due to data limitations, we are able to focus only on this outcome for now.

Identifying Small Business Activity

Our dependent variable of interest is business activity. We operationalize this outcome in two ways for the current analysis.[7] First, we use the NETS dataset to calculate a simple count (or share) of businesses to capture the presence of economic activity. Second, we use the LODES dataset to measure employment (specifically, the number of jobs) to

[7] Future iterations will use information on sales tax revenues as another dimension of business activity; these data are still being processed.

capture a more substantive measure of what the business activity contributes to the local economy.

We then disaggregate these metrics in several ways in order to better understand how resiliency varies with the characteristics of businesses and the services they provide. First, we identify the broad industrial classification of the economic activity (whether it be the business or the firm at which the jobs are held) to differentiate across businesses that provide direct services versus wholesale goods. We combine businesses into six industrial groupings: retail, professional services, entertainment, social and educational services, goods-producing and other (which includes utility, transportation and warehousing businesses).[8] In certain analyses we collapse these six groupings into two broader classifications: retail and non-retail. The broader retail grouping corresponds with the retail classification referenced above; non-retail includes the remaining sectors (professional services, entertainment, social and educational services, goods-producing and other). We do this to regain some precision in our estimates (since there are a number of cases where the finer industrial classifications result in small cell sizes) and to test directly whether or not retail services are more affected by localized flooding. We also create additional sub-categories for retail and food-related businesses that capture, in

[8] These broader groupings are constructed by combing several 2-digit NAICS classifications in the following way: "retail"= 44 (Retail) + 45 (Retail) + 81 (Other services); "professional services"= 51 (Information) + 52 (Finance & Insurance) + 53 (Real Estate etc..) + 54 (Professional, scientific etc.. services) + 55 (Management etc..) + 56 (Admin support etc..); "social and educational services"= 61 (Educational services) + 62 (Health care, social services); "entertainment"= 71 (Arts, entertainment) + 72 (Accommodation, food services); "goods-producing"= 31 (Manufacturing) + 32 (Manufacturing) + 33 (Manufacturing) + 23 (Construction) + 11 (Agro) + 21 (Mining etc..); "other"=21 (Utilities) + 48 (Transportation & Warehouse) + 49 (Transportation & Warehouse) + 42 (Wholesale). We collapse the data to these broader categories to create more intuitive classifications of goods and services, but also to maintain consistency across the various datasets (unlike the NETS data, which goes down to the 6-digit NAICS level, the LODES data is reported only at the 2-digit NAICS level). We omit from the analysis Public Administration (NAICS 92), because it includes governmental agencies and constitutes a relatively small share of the establishments in our analytical sample.

a more nuanced way, the types of services they provide (in terms of how often they are used or how necessary their goods/services are); these finer groupings are described in more detail in the discussion of the findings.

Second, we can identify the size and organizational structure of the businesses derived from the NETS dataset. To be specific, we proxy for the size of a business by the number of reported employees. As noted above, the existing literature suggests that size has a mediating effect on recovery and resilience (Tierney 1997b, Dahlhamer and Tierney 1998, Wasileski et al. 2011). For certain industries, like retail or professional services, larger businesses might provide a more diverse set goods and services to the community and cater to customers who live outside of the neighborhood (Meltzer and Schuetz 2012), which could make it easier for them to recover. We also classify businesses as either chains or stand-alone establishments, based on whether or not they are linked to at least one other establishment through a common headquarters. Again, research indicates that businesses could have differential recovery patterns depending on whether or not they have other establishments (in unaffected areas) to buffer against the storm's impact (LeSage et al. 2011).

Addressing selection bias

In our estimation, we are concerned with two types of selection bias. First, the location decisions of businesses, prior to the storm, could sort certain types of businesses into the riskier areas of the city. For example, less capitalized businesses could sort into flood-prone areas if the rents are lower there; businesses of a particular industry (i.e.

manufacturing) could cluster in flood-prone areas if that is also where land use is zoned to support their activities. We are confident that we can control for these factors with the data at our disposal, mitigating against selection bias due to business sorting. In addition, conversations with emergency management officials indicate that prior to Sandy there was little awareness around severe flood-risk, suggesting that it would not play a prominent role in the location decision of businesses. The second source of selection bias relates to the businesses' differential preparation for the storm. Specifically, closer to the onset of Sandy, the city did actively issue alarms and evacuation plans for areas at highest risk. It is possible that businesses located in the evacuation zone (the areas targeted in pre-storm evacuation plans and warnings) differentially prepared for the storm's landfall, such as moving inventory to avoid flooding and reinforcing windows and levee-type structures. It is this selection issue that we are most concerned with, since we do not have information on the businesses' activities and idiosyncratic preparedness leading up to the storm. We are able to identify whether or not businesses were located in the evacuation zone (and specifically the area that was told to evacuate), and we use this to proxy for access to pre-storm information on elevated risk (which, we assume, would induce businesses to differentially prepare for the storm compared to those not located in the evacuation zones). Therefore, we assume that all areas of the evacuation zone were perceived as subject to relatively equal risk levels (controlling for other location-specific and business-specific characteristics).

We take advantage of the fact that the impacts of the storm were uneven within the evacuation zone. Some areas of the evacuation zone were hit hard by the storm surge, while others experienced little or no flooding. Similarly, some areas outside the evacuation zone were hit by the storm surge, and other areas were unaffected (by both evacuation pressures and flooding). Since we do not have information on the actual flood-induced damage experienced by businesses, we assume that location in a surge zone meant some degree of water damage.[9]

To operationalize the differences between flood risk and actual flood exposure, we assign city blocks to four categories of zones: those that (i) fall in the evacuation zone and did not experience any flooding (*Evacuation_only*), (ii) fall in the evacuation zone and did experience flooding (*Evacuation_surge)*, (iii) fall in the flood zone, but not in the evacuation zone (*Surge_only)*, or (iv) are not in an evacuation or flood zone (*None*). Figure 2 shows a sample geography where the four zones co-exist within the same larger Sub-Borough Area. The pink blocks are in the *Evacuation_only* zone*,* the yellow blocks in the *Evacuation_surge* zone, the green blocks in the *Surge_only* zone, and the purple blocks are outside of both (*None*).

While we conduct analyses comparing outcomes across these four zones, we prioritize the comparison within evacuation zones, but across surge and non-surge zones (i.e. across pink and yellow blocks). This within-evacuation analysis constitutes our cleanest estimation of the Hurricane impact, since all of the businesses in the evacuation zones

[9] We also exploit variation in surge levels to distinguish between minor and more severe flood-induced damage. We are working to incorporate information on observed damage, as reported by FEMA. For now, we are not accounting for indirect sources of damage, such as electrical outages or transportation interruptions. We intend to include these variables in future analyses and therefore expect our current estimates to be imprecise and likely underestimates of the flood-induced impact from the storm.

presumably had access to the same notification of risk prior to the storm, but only a subset were actually affected (i.e. flooded) by the storm.

To capture these impacts, we estimate a model in which the dependent variable is the number of jobs per census block *i*, observed on an annual basis (*t*). The regression model takes the following general form:[10]

$$Jobs_{it} = \beta\, \boldsymbol{Zone}_i + \lambda Sandy_t + \gamma\, \boldsymbol{Zone}_i * Sandy_t + \partial Built_i + \delta N_s + \theta D_{b,t} + e_{it}$$

Here, ***Zone*** includes dummies for the census block's location in the four flood risk and exposure zones: *Evacuation_only*, *Evacuation_Surge*, and *Surge_only* (*None* is omitted). If a census block is located in one of these zones the dummy takes on the value of 1 and 0 otherwise. Therefore, β captures average differences across census blocks located in the various zones, relative to the reference category of *None*. *Sandy* takes on the value of 1 starting in 2013, and γ captures the post-Sandy response in jobs; we also include a *Sandy* dummy to capture that effect for the reference category.[11] *Built* captures characteristics of the localized built environment, such as the total amount and composition of building square footage (i.e. residential, commercial, industrial), the total number of units and parcels and the typical heights of the buildings. *N* is a vector of indicator variables (capturing Sub-borough Areas), and $D_{b,t}$ is a vector of borough-year dummies to control for more macro changes over time.

[10] We also run log-linear models and the results are substantively the same.
[11] Hurricane Sandy hit New York City on October 29th, 2012 and the LODES data reports jobs as of April of the calendar year; therefore we use data from LODES as of 2013 to capture post-Sandy conditions.

We also run two alternative specifications. First, instead of identifying off of four zones, we collapse them into two zones: *Surge* and *Non-surge*, and then distinguish across "high" and "low" surge areas within the *Surge* zone. We classify areas as "high" *Surge* if water levels rose three feet or higher; "low" *Surge* areas experienced flooding (i.e. greater than zero feet) up to three feet.[12] This specification allows us to test for storm effects relative to an alternative comparison group and to test for "dosage" effects from the degree of flooding. Second, we stratify the sample by industrial sector and estimate models for jobs located in retail and non-retail establishments separately.[13] As discussed above, we hypothesize that the storm will have differential effects on businesses that serve the local community or rely on retail patronage, compared to businesses that either serve a wider market or that do not rely on foot traffic as much.

IV. Findings

We present the findings from two distinct analyses. First, we describe the landscape of vulnerability for small businesses in New York City in order to answer how vulnerable small businesses are in the face of flood-inducing natural disasters. We consider how their exposure to flood risk varies based both on their spatial locations and on their

[12] We use three feet as the cut-off for "high" surge, because we assume that businesses with at least three feet of water would incur severe damages to their inventory and operations. Three feet falls at about the 85th percentile of surge heights, across all blocks in the city that experience some degree of flooding. See Appendix A for a distribution of the surge heights across blocks that experienced any level of flooding. In future analyses we will test for sensitivities around other surge heights.

[13] Here, "retail" includes general retail food services and accommodation businesses.

business-level characteristics. Second, we present preliminary findings from regression models estimating the impact of Hurricane Sandy on jobs.

What share of New York City businesses, and the economic activity that they represent, is vulnerable to extreme flooding?

First we map out (see Figure 3) commercial activity across the five boroughs, in order to understand how businesses are distributed across space (regardless of their flood-related vulnerability). We use information on the building classification, and specifically whether or not it is classified as commercial; therefore the map captures where businesses is permitted to locate and not the actual activity (i.e. any number of these spaces could be vacant).[14] The map shows that commercial use is dispersed and uneven. There is, however, noticeably denser commercial activity in the middle and southern parts of Manhattan, the borders of which are all water. Indeed, much of the map shows more commercial towards the waterfront, compared to the landlocked parts of the boroughs.

Other heavily commercial areas are located in central Queens and Staten Island (although, we note that none of these commercial shares is very large—the top quintile of commercial space starts at 14 percent). We see from Table 1 that jobs are not evenly distributed either. Manhattan has the lion's share of jobs (about 60 percent), and Queens has the second highest share at around 16 percent. This relative concentration of jobs remains fairly constant over time.

[14] We replicate the map using industrial space and mixed used space and the general pattern holds; industry tends to be more concentrated on the waterfront and at eastern Brooklyn/western Queens.

The geography of risk is much more uneven than the distribution of commercial activity: Manhattan boasts the highest share of commercial square footage in the evacuation zone, while Queens has one of the lowest. The disproportionate share of vulnerable commercial space in the Manhattan is driven largely by the borough's relative density (and building heights). For example, Manhattan has one of the smallest evacuation coverage areas in terms of the property or building footprint shares. With respect to properties and building footprints, Staten Island, Brooklyn and Queens have the largest shares in evacuation zones.

Next, we drill down more and explore how business activities are distributed relative to their flood risk. We look at the shares of businesses (and employment) located inside the evacuation zones and compare them to those located outside of any evacuation zone.[15] Figure 4 displays the business shares as of 2011 (which is slightly less than one year preceding Hurricane Sandy's landfall), separated by borough.[16] We can see that the vast majority (i.e. about 95 percent) of city businesses are located outside of the evacuation zones. Staten Island, a borough that is disproportionately exposed to flood risk, has the highest share of businesses that are vulnerable; but even there, the share is only 17 percent. Employment follows similar trends (see Figure 5), where over 90 percent of the jobs are located in areas outside of any evacuation zone. This distribution of businesses and jobs across evacuation zones is consistent with how properties are situated (about 96 percent of properties are located outside of an evacuation zone).[17] However, compared to

[15] Future analyses will restrict the sample to only include Sub-borough areas with some portion of their land area in an evacuation zone.
[16] We replicate the chart for other years prior to 2011 and the same pattern persists.
[17] This pattern is persistent regardless of the size of the firm at which the jobs are located.

the distribution of building footprints and commercial-oriented building space (especially that classified as mixed-use and industrial), businesses are disproportionately less exposed to risk.[18] From a planning perspective, these findings are somewhat optimistic: it appears that, relative to where commercial space is situated, business activity is more concentrated in areas that are less vulnerable to flood-induced interruption. However, this aggregate snapshot could obscure important variation among the kinds of businesses that are more or less likely to face flood risks. We consider this variation next.

What are the characteristics of the businesses, and the nature of their economic activity, in evacuation zones, compared to those in areas outside of any evacuation zone?

We now look at the characteristics of the businesses, including the services they provide, to better understand whether particular types of businesses are differentially exposed to risk.

First, we consider the size of a business (as measured by the number of employees); these statistics are displayed in Figure 6.[19] We first confirm that 99 percent of the businesses are considered "small" (i.e. with fewer than 100 employees). Furthermore, the distribution of businesses, based on their size, is not significantly different in the evacuation zones than in other parts of the city that are in areas perceived to be lower risk. Therefore, business size does not appear to be correlated with increased exposure to risk.

[18] To be specific: 19 percent of building lot area is located in an evacuation zone; while 6.5 percent of building area (and 9 percent of commercial building area) is located in an evacuation zone, 63 percent of mixed-use and 18.5 percent of industrial space is located in an evacuation zone.
[19] We disaggregate all of the statistics presented here by borough, and the patterns are no different than those exhibited in the citywide figures.

Second, we look at the distribution of businesses relative to their age. This distinction is important, if younger businesses face more challenges to recovery; they might, for example, have had less time to build up reserves, to develop robust operations, and to build a loyal customer base, all of which could facilitate post-storm resilience. The statistics on business shares, by age, are displayed in Figure 7. Similar to business size, there is no meaningful difference between the evacuation zones and other parts of the city perceived to be lower risk, suggesting that younger businesses are no more vulnerable to flooding than more established businesses.

Next, we classify the businesses based on their organizational structure, and specifically whether or not they are part of a multi-establishment chain or a stand-alone enterprise. Again, this distinction could be important if multi-establishment businesses have other income streams to cushion the interruption to businesses at the affected location. In addition, should post-storm operations resume, a network of related establishments could facilitate in maintaining continuity in supplies (which could be cut off or delayed for the affected location). For similar reasons, stand-alone businesses could be disproportionately more vulnerable to storm-induced business interruption and damage. Once again, the patterns are largely indistinguishable across evacuation zones and other parts of the city (see Figure 8). However, there is a small difference in the share of chains: chains are somewhat more prevalent in evacuation zones than in other areas. This is consistent with the expectation that multi-establishment businesses are more able to withstand storm-induced interruptions (and are perhaps more likely to locate in higher-risk areas because of this expectation).

Finally, we consider the services provided by the businesses and explore whether or not they are differentially exposed to risk. As discussed above, small businesses not only generate livelihood and assets for the owners, but they also provide services and goods to the local community. Each business has a unique NAICS classification, which describes its primary type of activity; we use these codes to classify the businesses into several categories, representing not just the nature of their goods or services, but also the degree to which they serve the immediate community. We expect that the temporary closure or shut-down of businesses that more directly serve the local community will have a greater impact on residents in the neighborhood.

We identify establishments classified broadly as retail or food service as those providing neighborhood services (this is consistent with Bingham and Zhang, 1997, Stanback et al., 1981, Meltzer and Schuetz 2012, Meltzer and Capperis 2016). We then further classify these neighborhood-based establishments as providing (i) either necessity or discretionary goods/services and (ii) either frequently or infrequently consumed goods/services. Necessity businesses are those that fulfill more ‘everyday’ needs or are providing for the ‘immediate needs of people’ (Bingham and Zhang, 1997; Stanback 1981), like grocery, household goods or drug stores.[20] Discretionary establishments, by contrast, provide more luxury or recreational services or goods that are not considered basic, but certainly enhance quality of life (for example, restaurants and beauty salons).

[20] For more motivation and technical details on these categories see Meltzer and Capperis (2016).

Frequently and infrequently consumed goods and services are identified by their presumed regularity of patronage. Examples of frequently visited businesses include grocery stores, banks, drug stores, and discount and department stores; infrequently visited ones include such retail categories as furniture, sporting goods and media stores. There is a high correlation between necessity and frequency, but some discretionary services are consumed frequently (nail salons), while some businesses sell necessity goods that are less frequently consumed, such as clothing.

For comparison, we also track three other broad categories of businesses, all of which should draw fewer of their customers from the local community: Goods-producing, Finance/Insurance/Real Estate (FIRE) and Educational/Social Services (the latter of which should be more likely to serve local clients than the first two).[21]

Figure 9 and 10 displays the shares for businesses, across the retail sub-categories described above.[22] We see that there are no differences in the share of businesses delivering frequently consumed services and goods between the evacuation zones and other parts of the city. Thus businesses in evacuation zones are just as likely to offer goods and services that are consumed frequently as those in other areas, and the share of businesses offering these services ranges from 60 to 65 percent. When we disaggregate

[21] Goods-producing includes Manufacturing (NAICS 31, 32, 33) Construction (NAICS 23), Agriculture (NAICS 11) and Mining (NAICS 21); In addition to Finance, Insurance and Real Estate, FIRE also includes Information (NAICS 51), Professional services (NAICS 54), Management (NAICS 55) and Administrative support services (NAICS 56).

[22] In the LODES data, industry classifications are provided only at the 2-digit NAICS level (which constitute the broad industry categories), and therefore we cannot create the retail sub-categories for the employment data. In addition, employment is overwhelmingly located in non-evacuation zones, even when it is broken down by broad industry categories. Therefore, patterns by industry are not shown for the employment data.

the neighborhood-based services along discretionary and necessity lines, we do see differences. Services considered discretionary are more prevalent in the higher-risk evacuation zones in New York City (and the opposite is true for those considered necessary); these statistics suggest that storm-induced damage would not disproportionately interrupt the delivery of critical goods and services, like supermarkets and drug stores.[23]

For comparison, we display the other broad service categories in Figure 11. Of note, we see that FIRE and professional services and goods-producing businesses are both over-represented in the higher-risk evacuation zones. The concentration of FIRE businesses in the evacuation zone is not surprising, as downtown Manhattan, which is bordered by a continuous evacuation zone, houses a large number of FIRE and professional firms. In addition, goods-producing establishments tend to locate in more industrial areas, many of which are situated on the waterfront.[24] We also note that, while the citywide analysis yields insignificant differences in the share of establishments focused on educational and social services, borough-specific analyses (not shown) indicate that outside of Manhattan, these establishments tend to locate outside of any evacuation zone. Like the retail results, this suggests that in many instances residents are not more likely to lose important services due to storm-induced damage.

Do the buildings where the businesses are located make them more vulnerable?

[23] These patterns are consistent when disaggregated by borough.
[24] The goods-producing patterns are largely driven by businesses in all of the boroughs outside of Manhattan.

Apart from the size and type of the businesses, degrees of risk could be associated with – and even shaped by – the characteristics of the buildings in which they operate. Figure 12 first shows the distribution of businesses according to the age of the building where they reside. The structure's age could be a good proxy for resilient development, such that businesses in older building could be even more vulnerable to storm-induced interruptions (i.e. systems are on lower levels, the building construction itself is more worn). We see that older buildings are more prevalent in evacuation zones (compared to newer built structures), and that businesses in evacuations zones are likely to disproportionately locate into older buildings. This suggests that businesses in higher-risk evacuation zones could face the added challenge of unsustainable physical infrastructure (perhaps making their recovery even more tenuous). Next, we compare the height of buildings in which businesses are located, in evacuation zones and other parts of the city (see Figure 13). Across the entire city, businesses are more likely to locate in shorter structures: about 65 percent of commercial properties have fewer than 3 stories. Moreover, the prevalence of shorter commercial buildings is even more pronounced in the evacuation zones, of which 70 percent have fewer than 3 stories. This trend implies (i) that business' operations are more likely to be on lower floors (especially retail establishments, which rely on street traffic for their business) and (ii) that any damage from flooding could be more acute.

What are the Short-term effects from Hurricane Sandy on neighborhood economic activity?

Thus far, we have established baseline patterns related to business vulnerability. We now present some preliminary results on estimating the impacts of Hurricane Sandy on small business activity, and specifically on employment. Again, while we have data on employment going back to 2002, we currently only have only one-and-a-half years post-Sandy, greatly reducing the power of the model and precision of the estimates. We plan to more robustly estimate these impacts on employment (as well as business closings and sales revenues) when we can build out the dataset over time.[25]

As noted above, we use information on the New York City evacuation zones, which were in place at the onset of Hurricane Sandy, and on the actual surge zones, which represent actual surge levels, to construct our treatment and control groups. Results are presented in Tables 2 through 7. Our first regression (displayed in column 1 of Table 2) includes only dummy variables for the various flood risk and exposure zones (the non-evacuation and non-flood zone is omitted), to estimate average differences in employment across the zones. We see that, on average, census blocks in both evacuation and flood zones have about 6 more jobs compared to census blocks in neither evacuation nor flood zones (although this difference is statistically insignificant). The gap is even larger and negative for blocks in only surge zones: they have about 43 fewer jobs, on average, compared to those in areas outside both the surge and evacuation zones, and this difference is highly significant. The difference in employment for blocks in exclusively evacuation zones

[25] We also note that while the LODES data is limited in its disaggregation of jobs by the size of the firms (this is only available for certain years), we have replicated our analyses, (i) using separate regressions for jobs in large versus small firms and (ii) dropping geographies where large firms tend to locate (i.e. Downtown Manhattan and Brooklyn), and the results are substantively consistent with the pooled estimates.

(relative to those outside of any zone) is bigger in magnitude than the other coefficients, but statistically insignificant.

Next, we interact the zone dummies with an indicator capturing when Sandy took place (2012) in order to test whether or not Sandy mediated these employment changes; these results are displayed in column 2 of Table 2. First, we notice that the estimated zone differentials observed in the first model persist, with very similar magnitudes and precision. Second, none of the interaction coefficients are statistically significant;[26] but this could be a product of the limited number of post-Sandy year-observations. Therefore, it is still useful to consider the magnitude and the sign of their coefficients. We see that the relative magnitudes are consistent with our expectations. Census blocks in the evacuation zones that suffered flooding saw a smaller increase in employment compared to the increase on blocks that are also located in evacuation zones but did not experience any flooding during the storm. In addition, the coefficient on *Surge_only* * *Sandy* is the smallest in magnitude, indicating that employment on census blocks that experienced flooding, but were not located in evacuation zones, increased marginally compared to the employment on blocks that were not hit by the storm.[27] In the final column of this table, we add in additional controls for features of the built environment (that could affect the composition of businesses in the block and also the vulnerability of those businesses) as well as geographic and temporal controls. While the coefficients on

[26] Wald tests across the coefficients were not completed in time, but will be available by the time of the presentation.

[27] We re-run the models with more restrictive census tract fixed effects, and the signs on the coefficients remain the same. The magnitude on *Both*, however, is now slightly larger than that on *Evacuation_only*. We also run the regressions stratified by type of business (using the 2-digit industry classifications discussed earlier), and, while the signs and magnitudes of the coefficients vary by industry, none of the differences are significant.

the *Sandy* interaction terms are still insignificant, the magnitudes and signs do change. Most notably, the coefficients on *Evacuation_Surge * Sandy* and *Evacuation_only * Sandy* turn negative. These new results run counter to our priors, as those businesses in the *Surge_only* area fare better than those in the *Evacuation_Surge* area; we are hesitant to rely heavily on the *Evacuation_only* estimates, as the very small number of observations that fall into that category make them quite noisy. The unexpected hierarchy of coefficients suggests that the crude categorization of "surge" (i.e. as those blocks with any water surge) could be obscuring important variation in the storm's impact. We test for this heterogeneity in the next set of specifications.

In the next set of results, we identify the storm's impact off of the surge area (regardless of locating in an evacuation zone). We consider the intensity of the storm's effect by classifying census blocks into "high" or "low" surge areas (the balance of blocks without any water inundation comprise the omitted category in the models). First, we estimate the effect of being anywhere in the surge zone (see Table 3). We see that while the coefficient on *Surge* is negative, it is statistically insignificant. In addition, the coefficient on *Surge*Sandy* is statistically insignificant, and positive. Table 4 displays the results for the model where we distinguish between "high" and "low" surge areas, and while the coefficients are still not statistically significant, more nuanced patterns do emerge. We see that the storm's effect on jobs was negative in areas designated as "high" surge and positive in the "low" surge areas. This suggests that any negative impact on jobs could be concentrated in areas with more severe flooding (and therefore more disruptive damage).

To further refine the comparison area, we restrict the sample to include only blocks in the evacuation zone. As we discussed before, this will mitigate selection bias with respect to pre-storm risk, evacuation and preparation. These results are displayed in Table X. We first notice that the coefficients on the "high" and "low" *Surge*Sandy* variables are larger in magnitude, albeit insignificant (we do lose about half the sample when restricting the blocks to only evacuation areas). And although neither of the coefficients is negative, the magnitude of the coefficient on "high" *Surge*Sandy* is smaller than that on "low" *Surge*Sandy*; their difference is not statistically significant either.

Finally, we stratify the models by the business' broad industrial classification (retail versus non-retail) and re-estimate the two models above.[28] This analysis is motivated by the expectation that certain businesses will be more severely affected by flooding, if they rely more heavily on street traffic and in-person patronage; we proxy for this kind of business by grouping together the jobs in the retail sector. These results are displayed in Table 5.[29] There are differences across the sectors; most notably, jobs in retail establishments tend to exhibit declines post-Sandy and, in the case of areas with "high" surges, significant ones. The positive coefficients seem to be driven more by the non-retail jobs and are not significant in the non-retail sub-sample. Specifically, blocks in "high" surge areas (of about 3 feet or more of water) lost just short of 8.5 jobs compared

[28] We also run separate models for each 2-digit industry classification. We observe variation in the sign (and magnitude) of the "high" and "low" *Surge*Sandy* coefficients across sectors, but not with any statistical precision. About half of the sectors exhibited positive coefficients on the "high" *Surge*Sandy* variable, including Wholesale, Transportation, Information, Finance/Insurance, Professional Services, Management, Educational and Health Services, and Arts/Entertainment.

[29] We only display the results for the evacuation-only sample, but have replicated all of the models with retail and non-retail strata. The *Sandy*Surge* estimates are consistently more pronounced (and negative) for the retail sub-sample.

to areas in the evacuation zone and outside of any surge area. This loss is equivalent to a forty percent reduction in jobs in the typical block in the evacuation zone. While the coefficient on "low" *Surge*Sandy* is also negative for the retail sub-sample, it is not statistically significant (and neither is the difference between the "high" and "low" *Surge*Sandy* coefficients). Figure 14 summarizes the effect from Sandy across retail and non-retail sectors.

V. Conclusions and policy implications

This paper explores the degree to which local businesses in New York City are vulnerable to coastal flooding. We find that 5 percent of businesses and 10 percent of jobs in the city are located in an evacuation zone. While it is somewhat reassuring that these percentages are relatively low, this still represents a meaningful share of economic activity in the city. Further, businesses outside of these zones may be vulnerable as well to power outages, and the size of the area at risk may increase over time as storms and other climate-related threats become more common. Moreover, the businesses in evacuation zones tend to be located in older, low-rise buildings that were constructed before the city building code adopted stricter flood-protection requirements, and many are small retail that target local consumers, making them especially vulnerable to potential storms.

We also conduct some very preliminary analyses testing the extent to which Hurricane Sandy disrupted the operation of local businesses and reduced employment. Although we are constrained by the limited number of post-Sandy observations, we do see significant job declines, of about 8.5 per block, for the retail sector only. These findings are consistent with the expectation that the flooding would more severely affect businesses that rely on the patronage of the local community and foot traffic more generally. On average, across all job types, the impacts from Sandy are noisy and largely insignificant. We plan to enrich these analyses with more years of employment data, as well as additional data on sales revenues, commercial property values and post-Sandy business closures. Given the growing risk of climate-related threats, it is critical that we learn more about the vulnerability and resiliency of small businesses in the face of natural disasters, especially in coastal cities like New York.

VI. References

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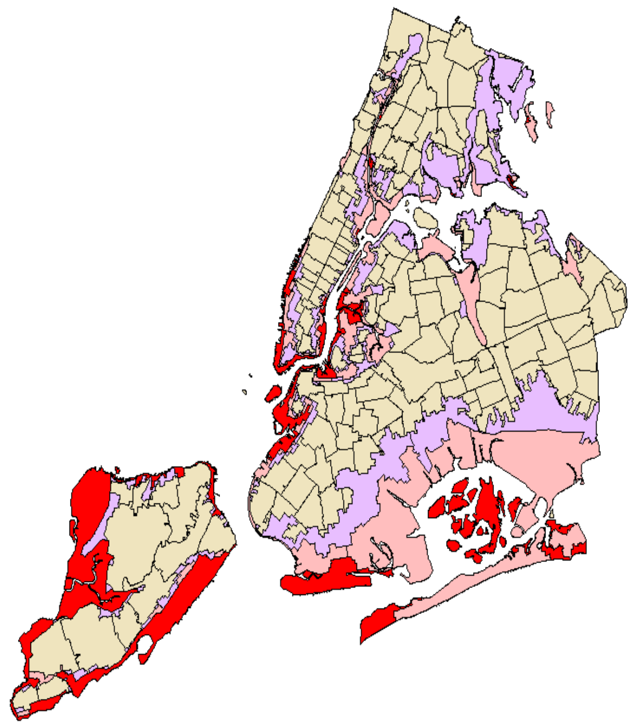
Figure 1: NYC Evacuation Map

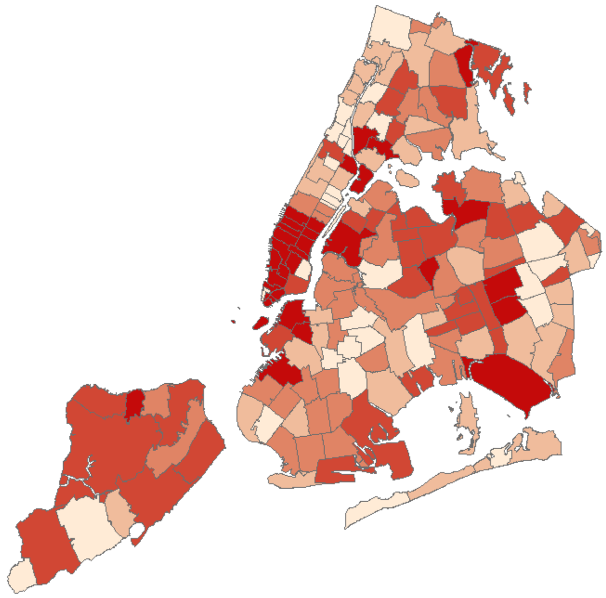


Notes: The dark (red) area is Zone A, the evacuation zone that was instructed to evacuate prior to Sandy. The lighter shaded areas are also evacuation zones, but were not told to evacuate for Superstorm Sandy. We use only Zone A areas to define our evacuation zones in the analysis.

Figure 2: Evacuation and Surge Zones

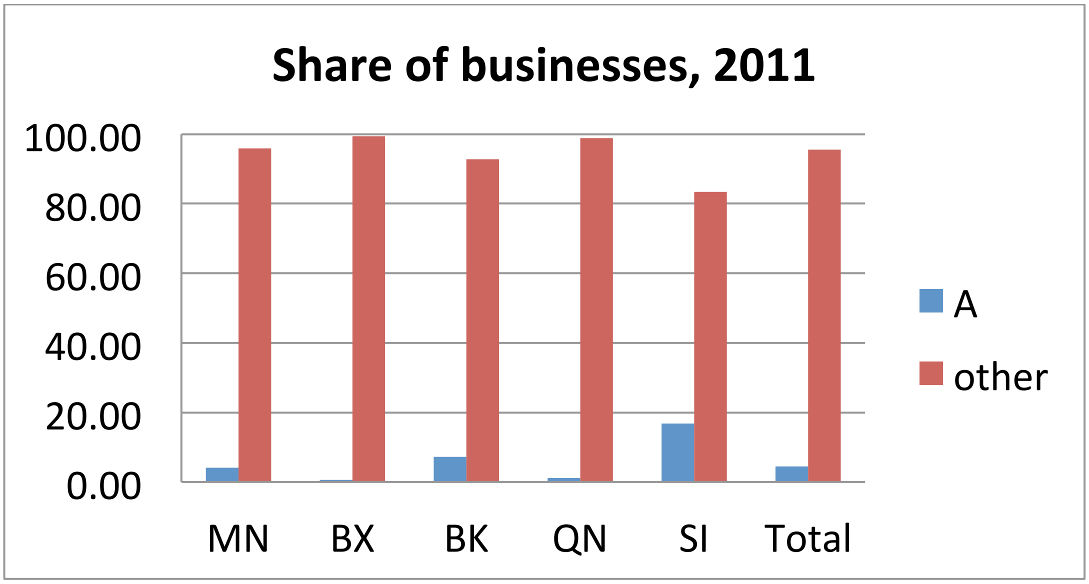
Notes: **Yellow blocks are in both evacuation and surge zones; green blocks are in surge only zones; pink blocks are in evacuation only zones; and light purple blocks are not in any zones.**

Figure 3: Distribution of commercial square footage



Notes: **shaded areas represent quintiles of commercial shares (commercial square footage as a proportion of total building square footage); darker gradations represent higher quintiles. The upper limits of the quintiles are as follows: Q1=.03, Q2=.04, Q3=.06, Q4=.10. The maximum share is .74, with a mean of .12.**

Figure 4: Distribution of businesses across zones



Notes: **"A" = evacuation zone; "other" = outside of any evacuation zone.**

Figure 5: Distribution of employment across zones

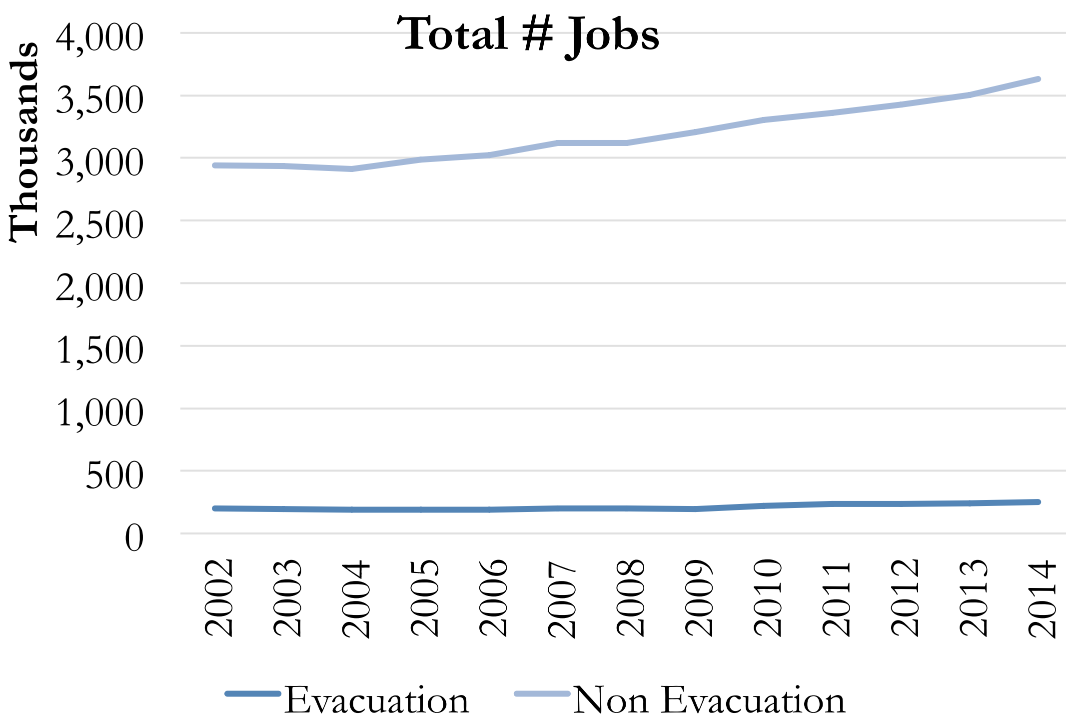
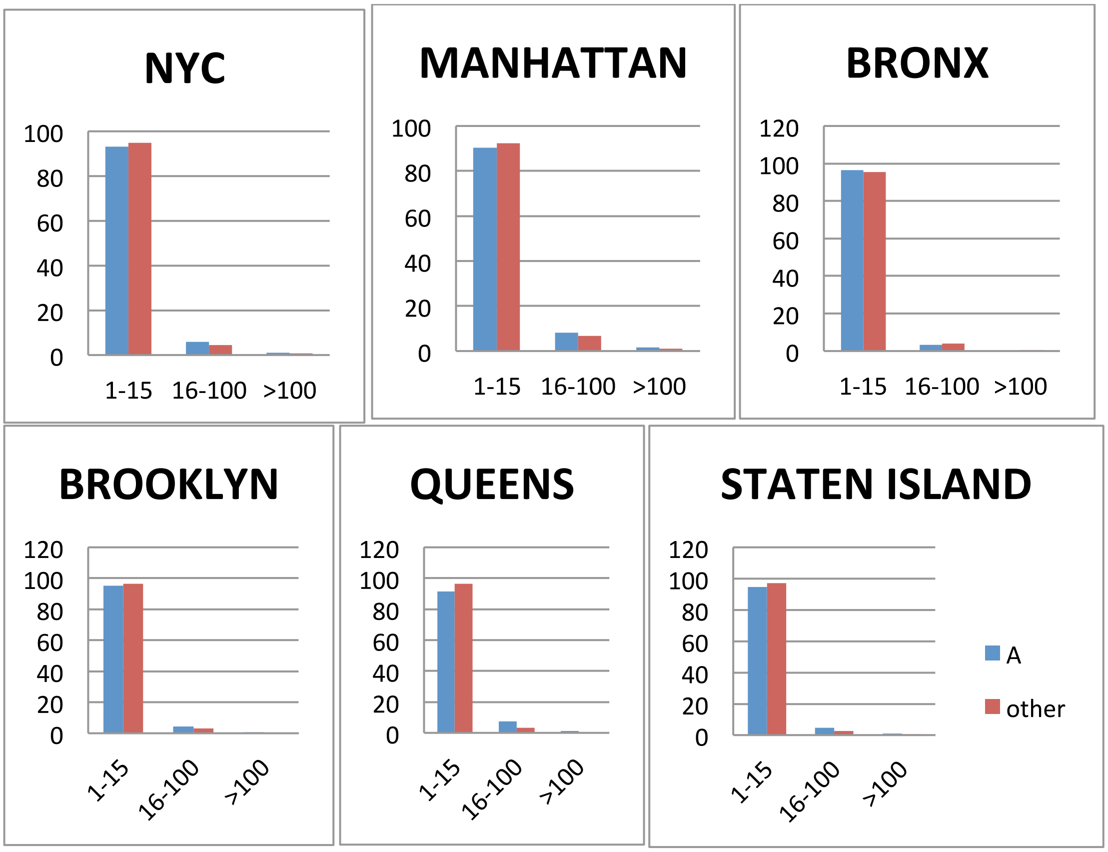
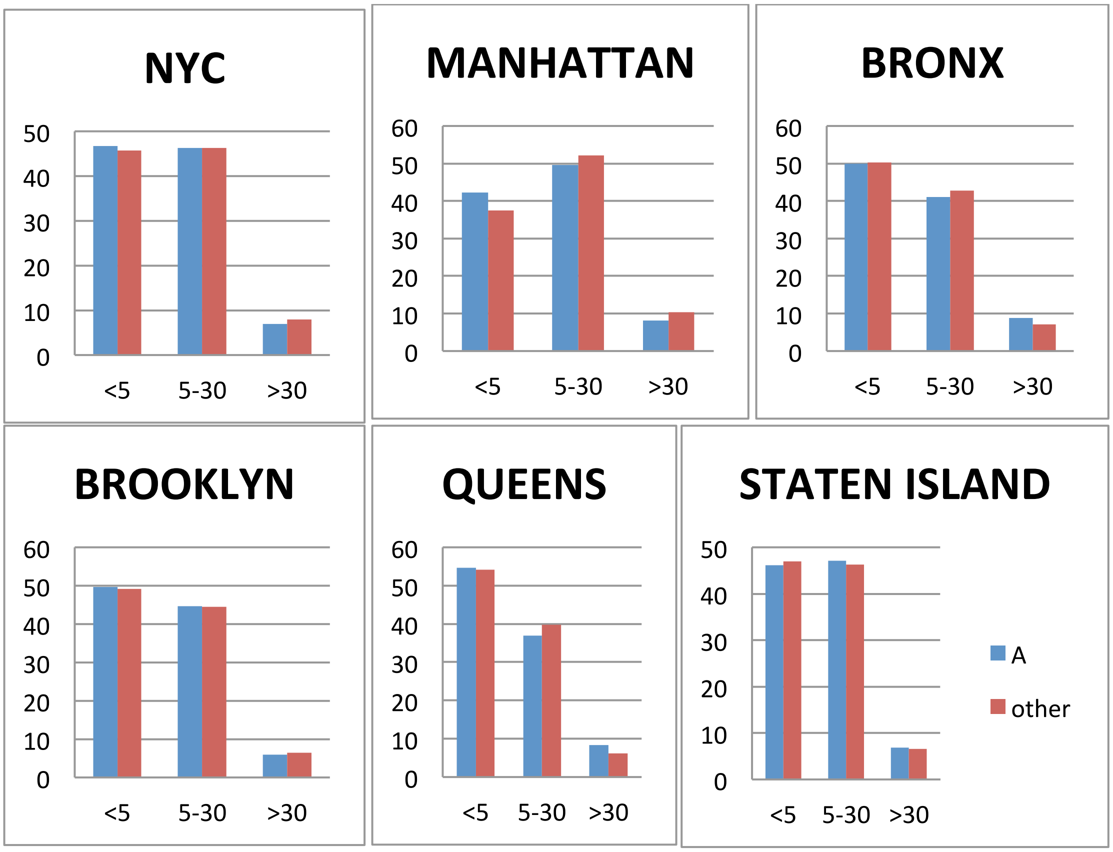


Figure 6: Distribution of businesses, by size, across zones



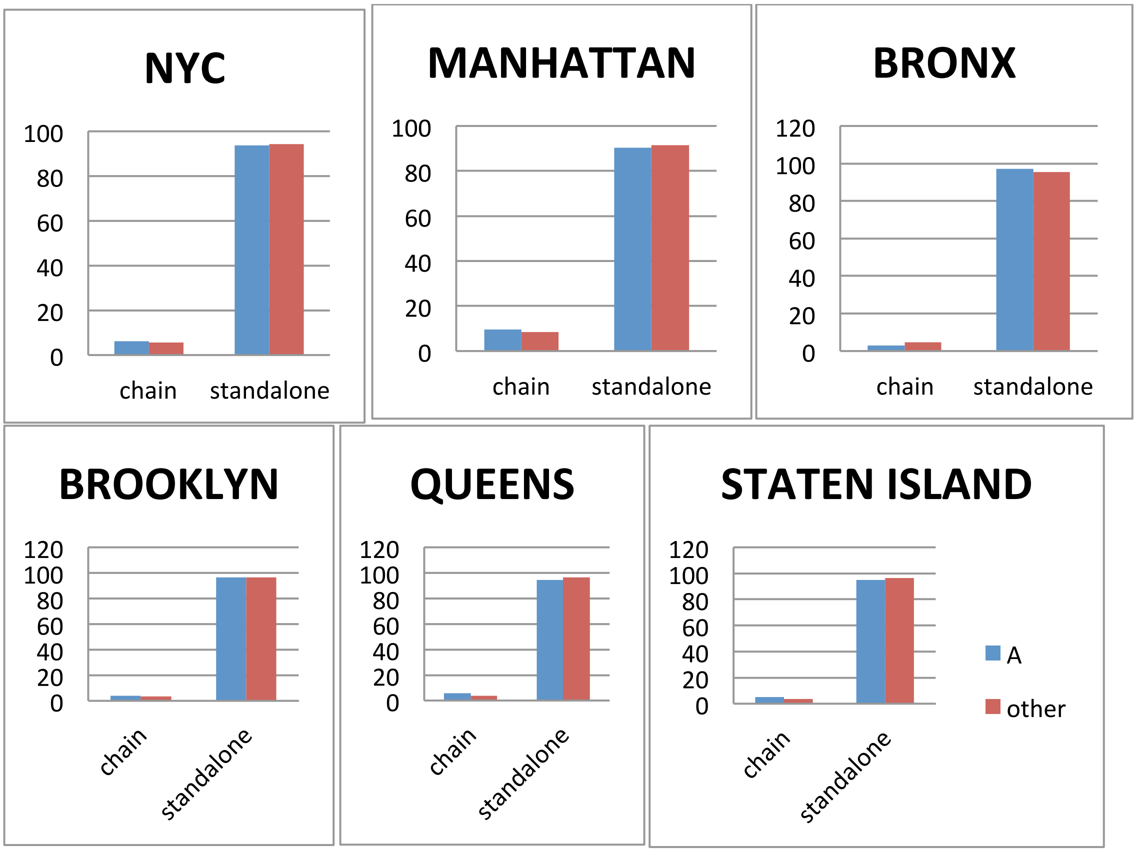
Notes: **"A" = evacuation zone; "other" = outside of any evacuation zone; Y-axis reports shares (%); all data is from 2011**

Figure 7: Distribution of businesses, by age, across zones



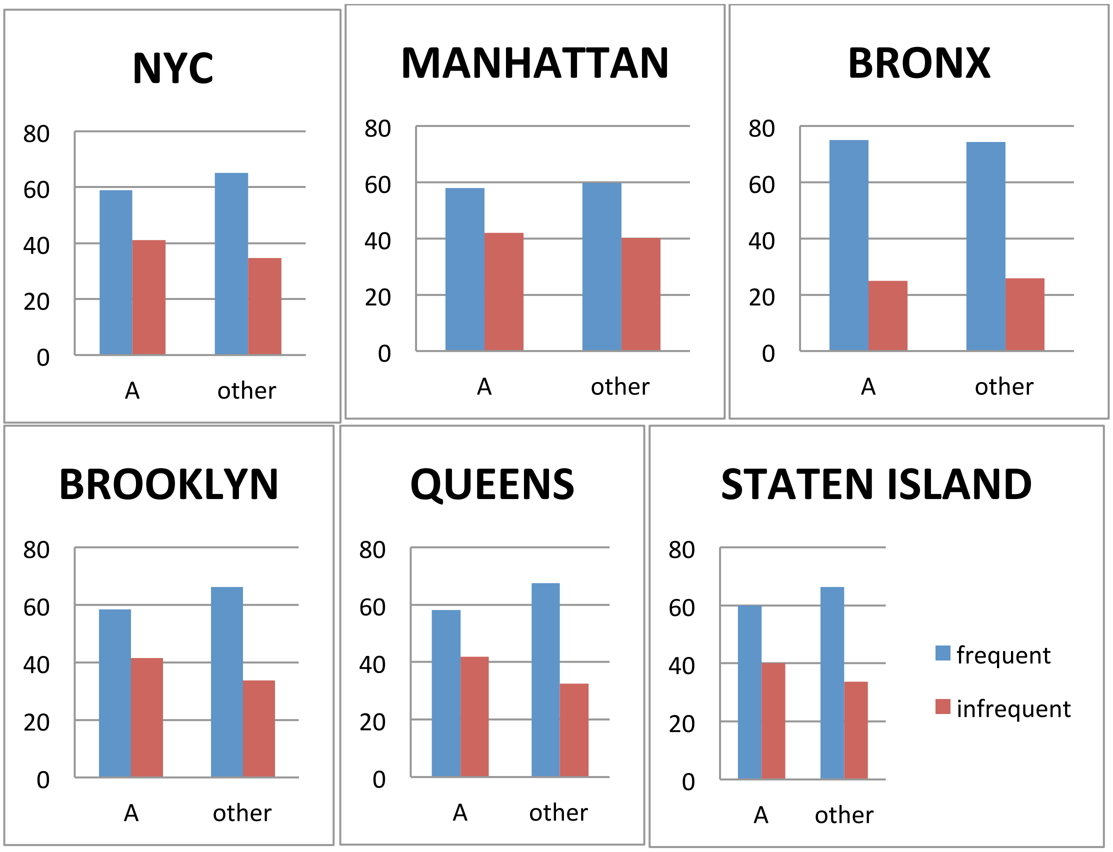
Notes: **"A" = evacuation zone; "other" = outside of any evacuation zone; Y-axis reports shares (%); all data is from 2011**

Figure 8: Distribution of businesses, by firm structure, across zones



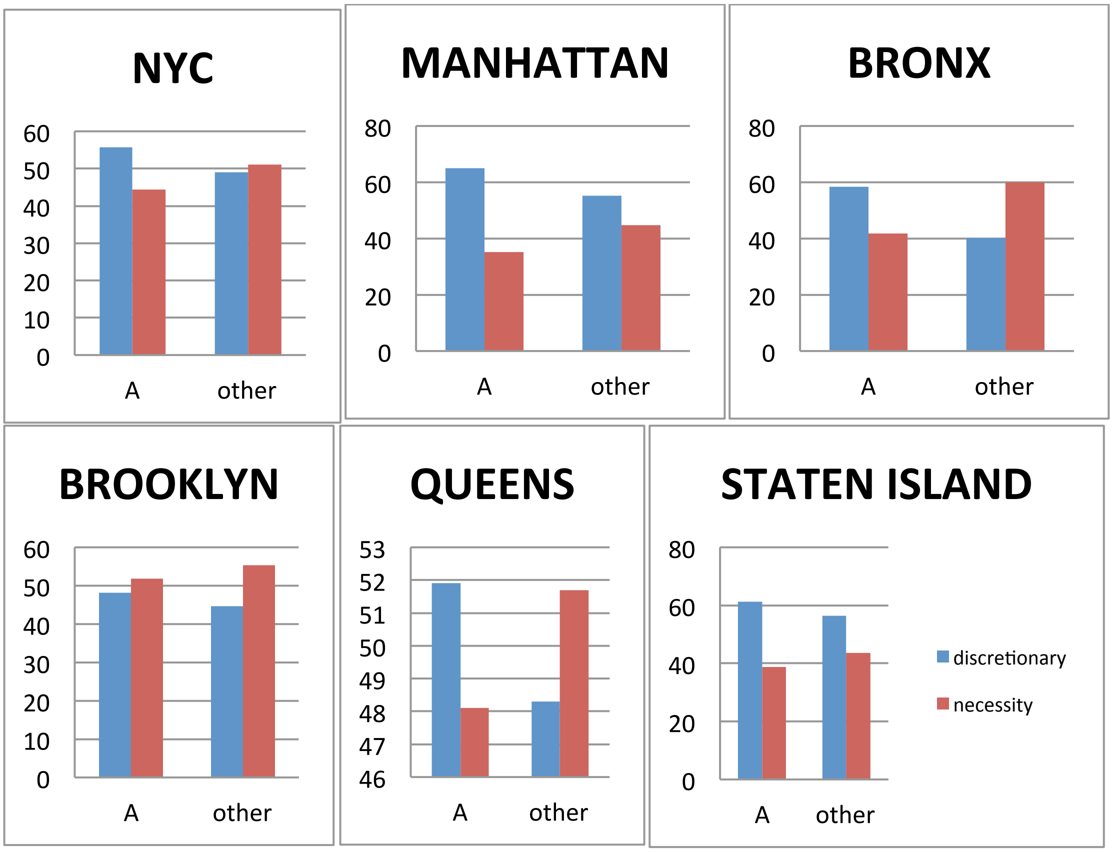
Notes: **"A" = evacuation zone; "other" = outside of any evacuation zone; Y-axis reports shares (%); all data is from 2011**

Figure 9: Distribution of businesses, by frequent/infrequent retail, across zones



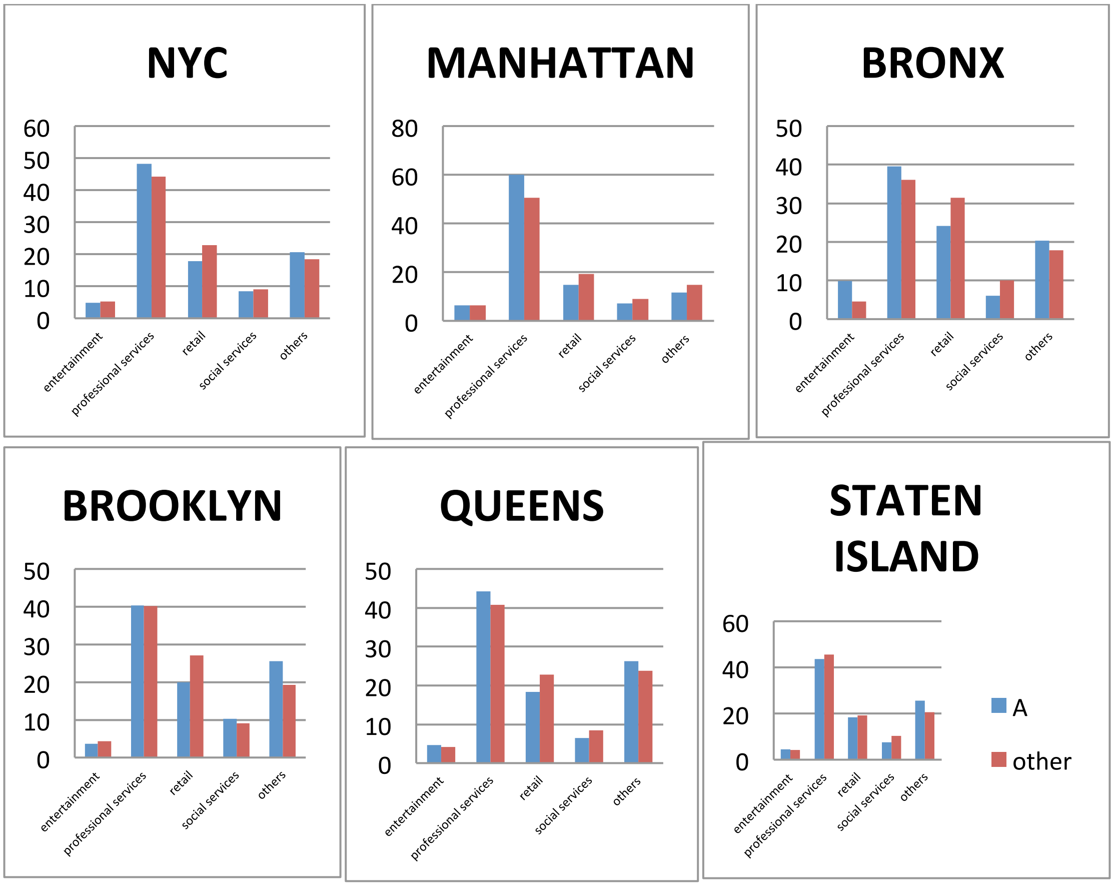
Notes: **"A" = evacuation zone; "other" = outside of any evacuation zone; Y-axis reports shares (%); all data is from 2011**

Figure 10: Distribution of businesses, by discretionary/necessary retail, across zones



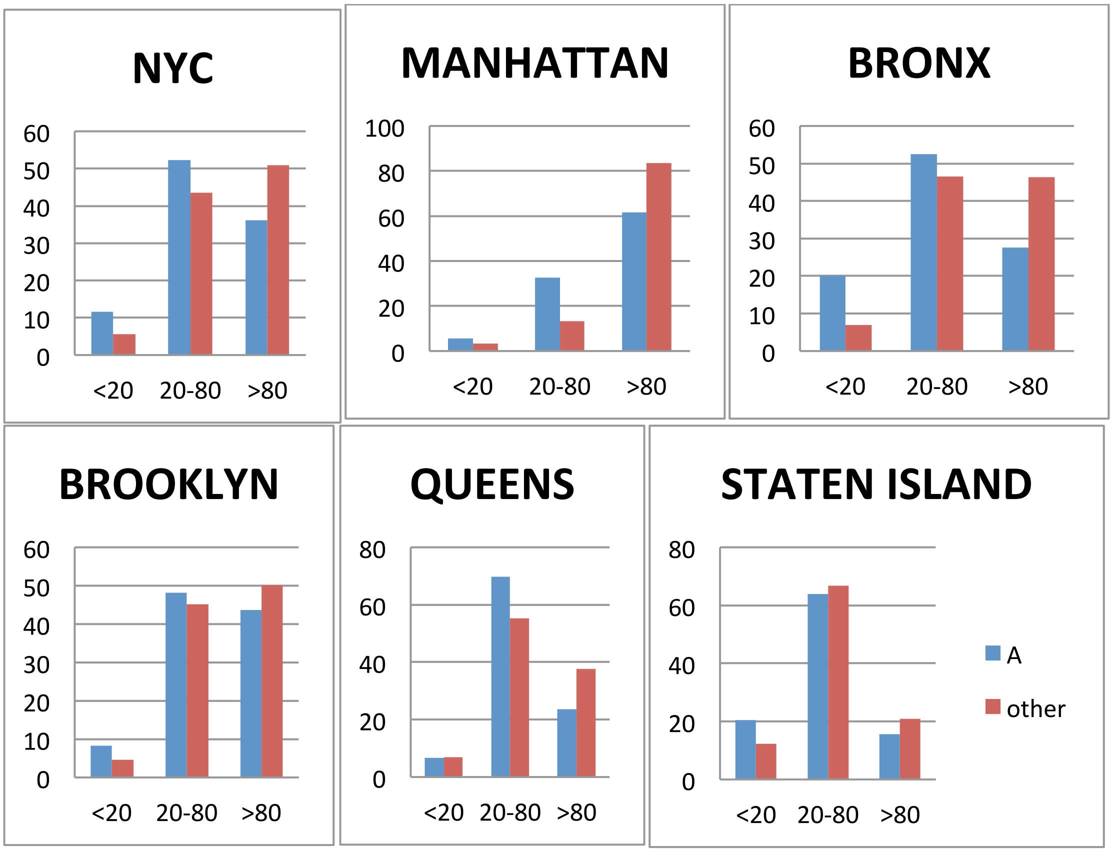
Notes: **"A" = evacuation zone; "other" = outside of any evacuation zone; Y-axis reports shares (%); all data is from 2011**

Figure 11: Distribution of businesses, by NAICS 2-digit industry, across zones



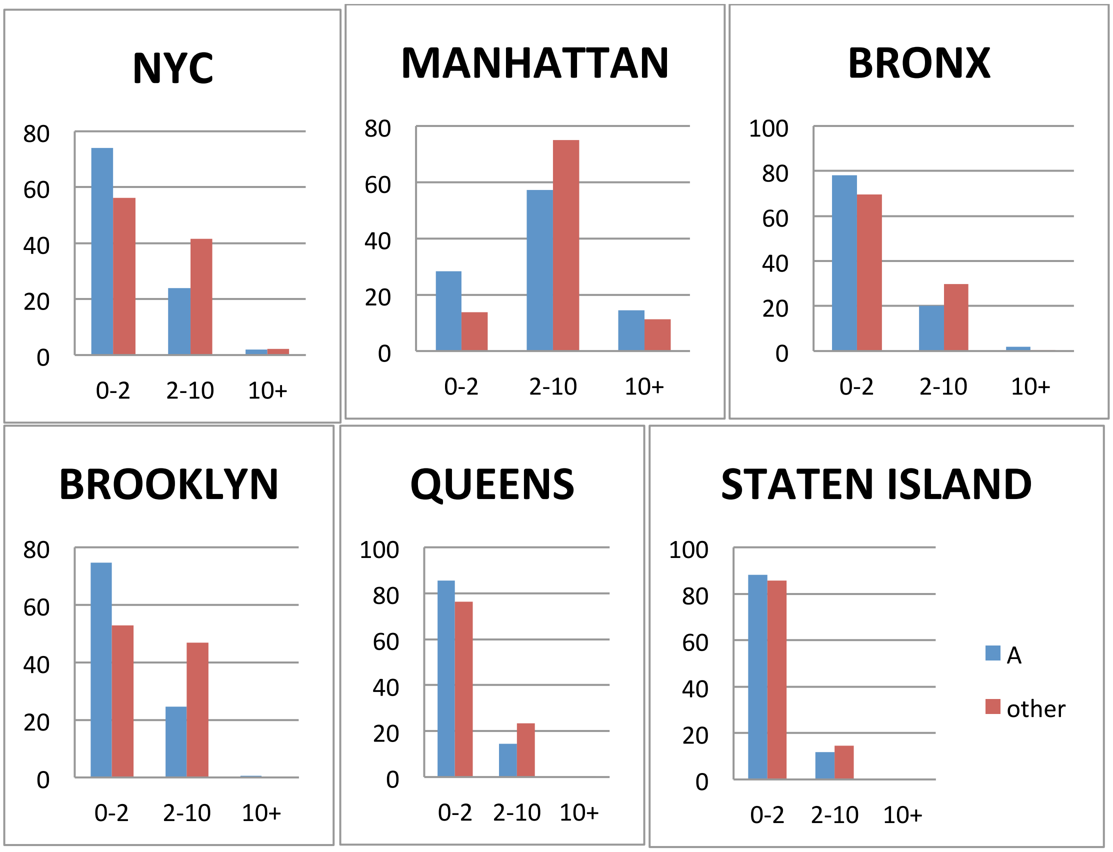
Notes: **“A” = evacuation zone; “other” = outside of any evacuation zone; Y-axis reports shares (%); all data is from 2011**

Figure 12: Distribution of businesses, by building age, across zones



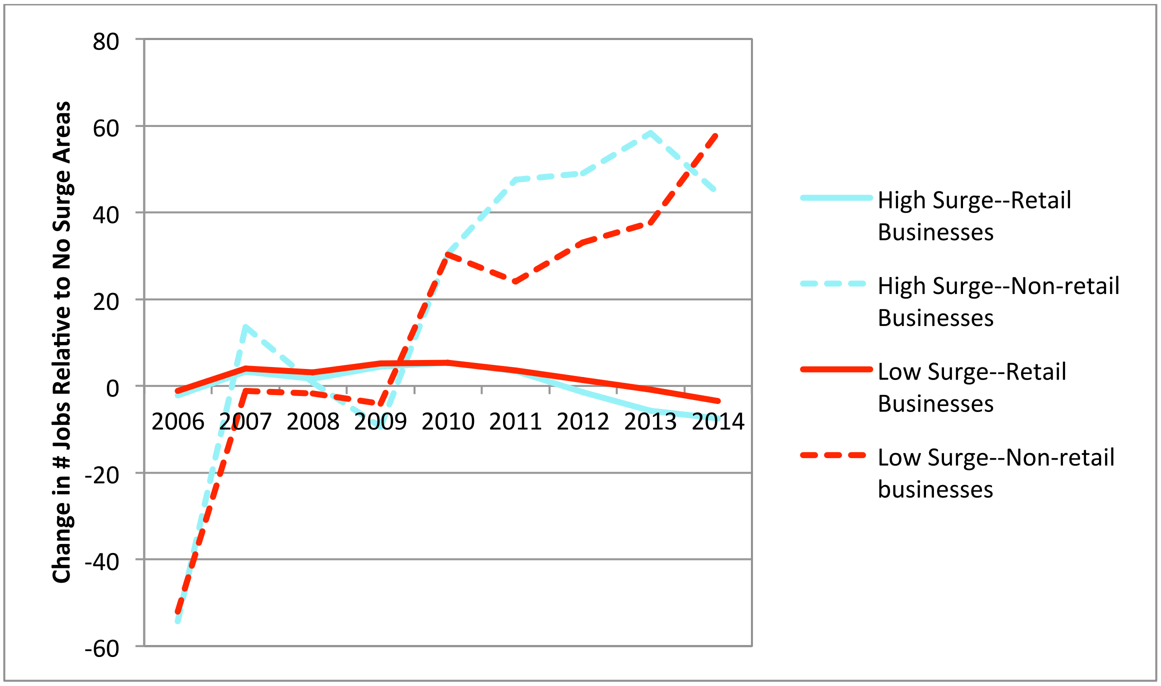
Notes: **"A" = evacuation zone; "other" = outside of any evacuation zone; Y-axis reports shares (%); all data is from 2011**

Figure 13: Distribution of businesses, by building height, across zones



Notes: **“A” = evacuation zone; “other” = outside of any evacuation zone; Y-axis reports shares (%); all data is from 2011**

Figure 14: Retail vs. Non-Retail Jobs, Before and After Sandy



Notes: Plotted points are adjusted values, controlling for land use and structure characteristics, and SBA and borough-year indicators.

Table 1: Employment, by Borough

Total Jobs	2002	2006	2010	2011	2012	2013	2014
Bronx	204,676 6.52%	215,954 6.73%	236,581 6.72%	240,309 6.68%	218,212 5.96%	240,310 6.42%	257,838 6.64%
Kings	458,953 14.62%	484,688 15.10%	571,444 16.23%	587,298 16.33%	595,955 16.28%	602,122 16.07%	633,758 16.31%
New York	1,923,227 61.25%	1,957,692 60.98%	2,128,612 60.45%	2,184,465 60.76%	2,239,127 61.16%	2,290,012 61.14%	2,359,350 60.72%
Queens	469,672 14.96%	470,122 14.64%	495,913 14.08%	497,578 13.84%	520,799 14.23%	523,959 13.99%	545,049 14.03%
Richmond	83,304 2.65%	81,692 2.54%	88,766 2.52%	85,729 2.38%	86,998 2.38%	89,420 2.39%	89,396 2.30%
Total	3,139,832	3,210,148	3,521,316	3,595,379	3,661,091	3,745,823	3,885,391

Notes: source is LODES, jobs based on the location of the place of employment.

Table 2: Regression results, four-zone model

Dependent variable = # jobs			
	(1)	(2)	(3)
Sandy		12.80***	5.946
		(5.62)	(1.58)
Evacuation_Surge	6.260	3.674	-27.81
	(0.18)	(0.11)	(-0.86)
Surge_only	-43.03**	-43.35**	-43.69
	(-2.73)	(-2.80)	(-1.57)
Evacuation_only	89.94	86.67	49.21
	(0.94)	(0.95)	(0.47)
Evacuation_Surge*Sandy		11.49	-4.016
		(0.80)	(-0.36)
Surge_only*Sandy		1.983	4.979
		(0.35)	(0.74)
Evacuation_only*Sandy		18.09	-34.31
		(0.33)	(-0.57)
bldgarea			0.000678
			(1.28)
comarea			-0.000553
			(-1.05)
resarea			-0.000892
			(-1.64)
factryarea			-0.000116
			(-1.05)
floors			24.11***
			(4.34)
units			0.0216
			(0.72)
parcel			-0.168
			(-0.85)
_cons	150.0***	147.4***	56.12**
	(13.51)	(13.50)	(2.73)
N	234,618	234,618	225,150
SBA fixed effects?	N	N	Y
Borough*Year dummies?	N	N	Y

Notes: t statistics in parentheses; * p<0.05; ** p<0.01; *** p<0.001.

Table 3: Regression results, two-zone model

Dependent variable = # jobs			
	(1)	(2)	(3)
Sandy		12.86***	5.996
		(5.65)	(1.59)
Surge	-22.73	-23.99	-38.51
	(-1.18)	(-1.28)	(-1.43)
Surge*Sandy		6.712	3.667
		(1.02)	(0.53)
bldgarea			0.000676
			(1.27)
comarea			-0.000551
			(-1.04)
resarea			-0.000890
			(-1.63)
factryarea			-0.000114
			(-1.03)
floors			24.16***
			(4.36)
units			0.0216
			(0.72)
parcel			-0.172
			(-0.88)
_cons	150.6***	148.0***	55.56**
	(13.59)	(13.58)	(2.70)
N	234,618	234,618	225,150
SBA fixed effects?	N	N	Y
Borough*Year dummies?	N	N	Y

Notes: t statistics in parentheses; * p<0.05; ** p<0.01; *** p<0.001.

Table 4: Regression results, two-zone model, "low" and "high" surge

Dependent variable = # jobs			
	(1)	(2)	(3)
Sandy		12.85***	6.082
		(5.75)	(1.61)
Low_Surge	-39.16*	-42.24*	-47.84
	(-2.18)	(-2.43)	(-1.68)
High_Surge	-2.513	-2.892	-11.08
	(-0.07)	(-0.08)	(-0.34)
Low_Surge *Sandy		15.80	14.60
		(1.54)	(1.24)
High_Surge*Sandy		2.578	-8.140
		(0.28)	(-1.10)
bldgarea			0.000676
			(1.27)
comarea			-0.000552
			(-1.04)
resarea			-0.000890
			(-1.63)
factryarea			-0.000117
			(-1.05)
floors			24.19***
			(4.37)
units			0.0216
			(0.72)
parcel			-0.161
			(-0.82)
_cons	149.9***	147.3***	53.92**
	(13.88)	(13.87)	(2.64)
N	234,618	234,618	225,150
SBA fixed effects?	N	N	Y
Borough*Year dummies?	N	N	Y

Notes: t statistics in parentheses; * p<0.05; ** p<0.01; *** p<0.001.

Table 5: Regression results, "low" and "high" surge, evacuation only sample

Dependent variable = # jobs			
	(1)	(2)	(3)
Sandy		30.88	-68.05
		(0.56)	(-0.96)
Low_Surge	-98.01	-97.98	-73.92
	(-1.05)	(-1.10)	(-0.61)
High_Surge	-67.17	-65.77	-42.98
	(-0.63)	(-0.64)	(-0.30)
Low_Surge *Sandy		-1.416	39.52
		(-0.02)	(0.58)
High_Surge*Sandy		-8.140	32.61
		(-0.14)	(0.49)
bldgarea			0.00176**
			(3.16)
comarea			-0.00189**
			(-3.23)
resarea			-0.00148*
			(-2.25)
factryarea			0.000239
			(1.11)
floors			-1.378
			(-0.19)
units			0.00295
			(0.02)
parcel			-0.957*
			(-2.17)
_cons	239.9*	234.1*	113.7
	(2.50)	(2.56)	(0.89)
N	12461	12461	11156
SBA fixed effects?	N	N	Y
Borough*Year dummies?	N	N	Y

t statistics in parentheses
="* p<0.05 ** p<0.01 *** p<0.001"

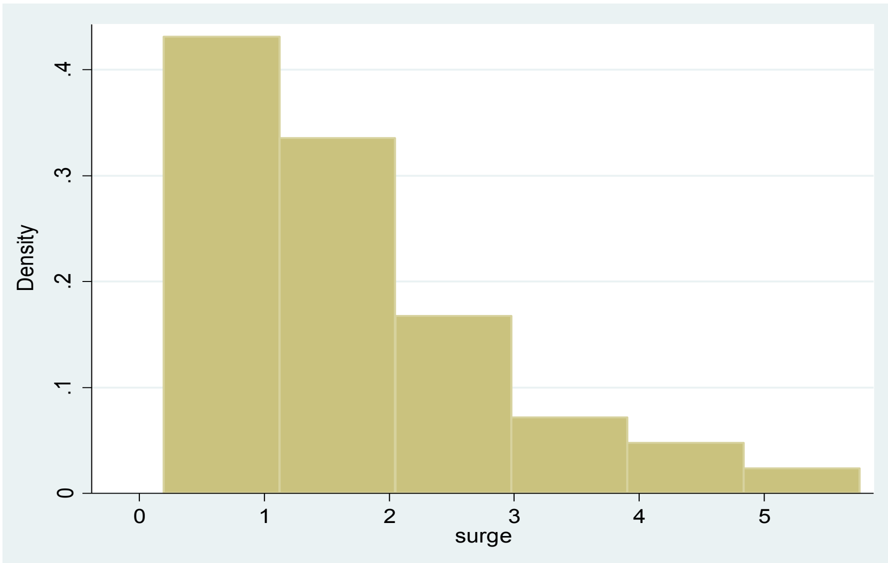
Table 6: Regression results, "low" and "high" surge, evacuation only sample, retail vs. non-retail

Dependent variable = # jobs		
	(1)	(2)
	RETAIL	NON-RETAIL
Sandy	6.031	-74.08
	(1.33)	(-1.06)
Low_Surge	-2.795	-71.13
	(-0.37)	(-0.59)
Low_Surge *Sandy	-4.858	44.38
	(-1.18)	(0.66)
High_Surge	-7.746	-35.23
	(-0.98)	(-0.25)
High_Surge*Sandy	-8.476*	41.09
	(-2.26)	(0.62)
N	11156	11156
Land use & structure controls?	Y	Y
SBA fixed effects?	Y	Y
Borough*Year dummies?	Y	Y

t statistics in parentheses

="* p<0.05 *** p<0.001"

Appendix A: Surge height distribution



Notes: the X-axis represents water levels in feet.

Percentiles	Water height (feet)
1%	0.193697
5%	0.2597921
10%	0.3583701
25%	0.7600582
50%	1.474652
75%	2.251574
90%	3.26084
95%	3.919767
99%	5.762398