Neighborhood Demographics and the Hazard Resilience of Local Small Businesses

A Directed Study Project

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ABSTRACT

The ability of local businesses to withstand and recover from severe weather events is an important part of community hazard resiliency. Following a hazard event local businesses that reopen help restart the local economy, are an important source of goods and services for residents who are moving back and trying to recover, provide a space for people to congregate, eat, use restrooms, and charge electronic devices, and restore a sense of normalcy, hope, and identity within the local community (McKay, 2018; Kim, 2018). Businesses can also be an important safe haven during hazard events; if the event damages homes, cuts power, or interrupts other utilities and services, residents may choose to relocate to a local business to weather the storm.

Most businesses, however, do not survive being impacted by a natural hazard event. According to FEMA, forty-percent of small businesses affected by a natural disaster never reopen, and 25% of those that do reopen fail within a year (McKay, 2018; climatechange.ri.gov). It is essential, therefore, to consider the resiliency of local businesses when working towards community resilience.

In this study, rather than look only at the resilience of community residents, I investigate the resilience of small businesses in the context of the neighborhoods within which they are located. Specifically, I explore correlations between the demographic characteristics of neighborhoods and the ways in which businesses located in those neighborhoods relate to natural hazards. Marginalized communities (such as those consisting predominantly of people of color, Hispanic people, or poor people) have been found to be the most susceptible to natural disaster impacts and the least able to take risk-reduction actions (see the Literature Review section of this report). Such communities, therefore, should be a focus for intervention from planners and municipal administrators interested in social justice and equity. Through this study I hope to determine whether businesses located in marginalized communities follow similar patterns.

To accomplish this, I review two datasets. The first was collected in 2018 by the State of Rhode Island over the course of a project titled "Risk Reduction for Small Business Resilience." Through that initiative, one hundred business owners or managers were interviewed about their experiences with, preparations for, and concern about natural hazards; additionally, site vulnerability assessments were conducted for each participating business. Checklists completed during the site visits were previously digitized and de-identified, and are analyzed in this study. The second dataset was collected by the community development nonprofit ONE Neighborhood Builders in early 2018 from residents of the Olneyville neighborhood of Providence. Respondents for that study filled out checklists, which were digitized, deidentified, and provided for this study.

The natural hazards addressed in this study are severe winter weather, high wind, and flood events (including storm surge, riverine, and urban or poor-drainage flooding. The level of concern of businesses toward hazards and the degree to which businesses have implemented risk-reduction measures are the two features of interest with regards to the relationship between businesses and hazards. Demographic characteristics used in the analysis are extracted from 2010 Decennial Census block-groups and include race, ethnicity, country of birth, and income level. A variety of factors, including hazard exposure and vulnerability, were also included in the analysis for comparison purposes.

My expectation prior to the start of this study was that relative population of marginalized individuals within a census block-group (CBG) would correlate positively with the level of hazard concern and negatively with the level of hazard preparedness of the businesses located in that CBG, regardless of actual hazard exposure. In other words, I expected that a business located in a neighborhood with a relatively large population of people of

color, immigrants, Hispanic people, or low-income individuals would be more concerned about and less prepared for natural hazards than a business located in a whiter, wealthier CBG.

In fact, what I find is that businesses in neighborhoods with higher percentages of marginalized populations tend to take more risk reduction steps than those located in whiter and wealthier CBGs. The seems to run contrary to the results of other studies (discussed in the Literature Review Section) and represents an important potential for building community resiliency into marginalized communities. The results show that small businesses can counteract expected trends in the general population, and therefore focus should be put on increasing resiliency of those businesses to increase resiliency of the community.

This report begins with a literature review that presents the results of similar studies conducted in the past and puts this effort into a larger context. It then presents the methodology, results, and analysis of this study. The discussion section interprets results and proposes a number of explanations for observed trends. The ultimate goal of this report is to contribute to efforts to incorporate social justice and equity concepts into community resilience building by adding the consideration of small businesses resiliency.

LITERATURE REVIEW

DEMOGRAPHICS AND HAZARD IMPACTS

The degree to which an individual or a community is impacted by a natural disaster is influenced by a variety of factors, including the following:

1. Exposure: the frequency with which the community or individual is exposed to a disaster, and the severity of that disaster
2. Vulnerability: the existence of vulnerabilities to a disaster, or of "weaknesses" that will allow a disaster to cause damage. Preexisting hardships that will exacerbate the impacts of a disaster are also vulnerabilities.
3. Capability: the ability of a community or individual to reduce risks (either by mitigating exposure or removing vulnerabilities) before a disaster occurs, to act and respond once the disaster is occurring, and to recover and restore after the disaster has ended. An important sub-category of capabilities is the ability to access social and institutional services for assistance.

Disparities in hazard exposure, vulnerabilities, and capabilities lead to disparities in the degree to which communities or individuals are impacted by disasters. These disparities are not necessarily random. As Bolin (2018) points out, "disasters are produced and shaped by normal operations and material expressions of politics and economics in a place and thus have to be understood in that context." In other words, disparities in hazard exposure, vulnerabilities, and capabilities are influenced by socioeconomic and political forces.

Much research has been done to investigate the connection between these disparities in hazard risk and socioeconomic class. Bolin, 2018, presents a history of such research, describing an evolution of research from simply recognizing disproportionality in hazard even impacts between communities of color and white communities, to identifying cultural differences in how different communities prepare for and respond to disasters, to understanding the political, social, and cultural marginalization that has systematically disadvantaged minority groups, including with regards to housing assistance, political representation, and the failure of federal assistance programs.

In the following literatures review, I summarize a selection of studies that identify connections between demographic features and hazard exposure, vulnerability, and capabilities.

Hazard Exposure

Past studies suggest that marginalized communities tend to have higher exposure to natural hazards than other communities, though the findings are not conclusive. Proximity to a hazard source has been shown to be correlated with property values (Masozera et al, 2007; Bin et al, 2008; Yang Zhang, 2010), and lower income populations tend live in more at-risk areas (Masozera et al, 2007; Bin et al, 2008; Yang Zhang, 2010; Walker & Burningham, 2011). This trend does not always hold true in flood zones, as the disamenity of exposure to risk may be balanced by the amenity of proximity to water (Bin at al, 2008; Yanh Zhang, 2010). Bolin (2018) did not find strong correlation between racial and economic marginalization and location in natural hazard risk zones.

Hazard Vulnerability

Research has shown that lower-income or other socially marginalized communities are more vulnerable to hazards than the overall population (Masozera et al, 2007; Yang Zhang, 2010; Bolin, 2018). Marginalized communities are more likely to experience pre-existing hardships that exacerbate the effects of a hazard event, and are more likely to live in lower-quality housing that is more susceptible to damage (Walker & Burningham, 2011).

Hazard Capabilities

Socially marginalized communities tend to have fewer hazard mitigation, preparedness, or response capabilities, both in terms of personal capabilities and access to community or government assistance.

Implementation of Risk Reduction Measures

Marginalized communities tend to have less awareness of risk reduction options, may have less knowledge and financial capacity to implement them, and may not be able to afford disaster insurance (Masozera et al, 2007; Yang Zhang, 2010; Walker & Burningham, 2011). Lower-income areas may also be underserved with regards to larger-scale hazard-protection infrastructure and capital-improvement projects (Walker & Burningham, 2011).

Access to Resources

Marginalized communities tend to have less access to institutional and social services that can help with mitigation or recovery efforts. Low-income areas are frequently underserved with regards to public transit, while also having fewer cars per household; during emergency evacuations, this may leave residents without transport out of the risk areas (Masozera et al, 2007). Immigrant populations may experience language barriers that interfere with their ability to request support, or even to learn about an impending disaster (Masozera et al, 2007). Political capital is diminished in marginalized communities (Corbin, 2015), meaning such communities are less likely to garner political support that can lead to implementation of large-scale risk reduction projects or help funnel money to aid the community.

Social capital is the ability of a community to support itself through interpersonal relationships. Underserved communities that may suffer from higher crime rates often report lower levels of interpersonal trust, indicating lower social capital to call on during a disaster. On the other hand, those same communities report higher rates of neighbor interaction and stronger interpersonal networks. While these two opposing phenomena make it difficult to make overarching conclusions about the social capital of marginalized communities, lower-income areas, at least, are generally thought to have less social capital than higher-income areas (Walker & Burningham, 2011).

Demographics and Risk Perception

Perceptions about hazards drive both personal risk-reduction actions and community risk-reduction policies (Brody et al, 2008, citing Correia, Fordham, Saraiva, & Bernardo, 1998; Slaymaker, 1999; Tierney, Lindell & Perry, 2001). Risk perception is affected by demographics, personal experience, culture, and psychology (Brody et al, 2008, citing Garvin; Jasanoff & Wynne, 1998; Kempton; Krimsky & Plough; Margolis; Savage, 1993).

Brody, et al (2008) found that previous studies have identified a correlation between risk perception and proximity to the risk source (Farley, Barlow, Finkelstein, and Riley, 1993; Lindell, 1994; Brody and Highfield, 2005). Brody, et al (2008) investigated this correlation with their own study and found that people who live in areas that are close to the coastline and are low-lying tend to have higher perceptions of risk (from climate change, specifically) than those living on higher ground or farther from the coast. On the other hand, having personally experienced severe weather events had a limited impact of risk perception, and being located within a 1% annual-chance floodplain actually correlated to a *decrease* in risk perception. Knowing of someone who was killed by a natural disaster was the variable that most strongly triggered increased perception of personal risk.

Studies also show that risks tend to be perceived as higher by women than by men and by non-white individuals than by white individuals (Flynn, 1994; Finucane, et al, 2000). Finucane, et al (2000) suggest that differences in gender and race correlate with differences risk perception because of differences in the following factors:

- Worldview: white males tend to hold more hierarchical and individualistic views, and less fatalistic and egalitarianist views, that non-whites and females.
- Trust: white males tend to be more trusting of technology and experts, and less trusting of government, than other groups.
- Stigma: white males are less concerned about negative public responses from risk exposure.

As Finucane, et al, put it in that paper, “the world seems safer and hazardous activities seem more beneficial to white males than to other groups”. Finucane, et al, also recognize that non-white individuals express a wide diversity of risk perceptions. Additionally, risk perception changes based on the type of hazard being considered.

Savage, 1993, breaks risk perception into three factors:

- Dread: the degree to which contemplation of a risk causes a person distress
- Knowledge: the degree to which an individual is aware of the consequences and likelihood of a hazard
- Personal Exposure: the degree to which an individual believes that they personally are at risk from a hazard

Dread

Individuals who perceive themselves to be personally exposed to a hazard tend to be more fearful of that hazard, or to have a higher level of dread (Savage, 1993). According to the research of Savage (1993), this perception of risk exposure is not necessarily related to the actual level of risk to an individual, and is likely influenced by the way in which risk level has been communicated to that individual. Brody, et al (2008) determined that socioeconomic and attitudinal factors have a larger impact on risk perception that physical vulnerability.

Savage (1993) found that higher dread for a variety of hazard types is expressed by women than by men, by young people than by older people, by black individuals than by white individuals, by those with lower levels of schooling than those with higher education levels, and by higher-income individuals than by lower-income levels.

Brody et al (2008) identified previous studies that found that individuals with lower levels of education, income, and risk knowledge tend to perceive a risk as being a larger concern than other individuals; additionally, women have higher levels of concern than men (Savage, 1993; Bord, Fisher, & O’Connor, 1998; O’Connor et al., 1999).

Knowledge

Savage (1993) found that hazard knowledge and demographic characteristics correlate poorly with one-another, in general. Older people and black people reported higher levels of knowledge about certain risks (not natural hazard risks) than young people and non-blacks, respectively. Notably, Finucane, et al (2000) found that increased education and knowledge about risks did not increase perceptions of *personal* risk.

Personal Exposure

Savage (1993) found that blacks and Women tend to feel more threatened by a variety of hazards (not natural hazards) than other populations. His findings also suggest that low-income individuals tend to feel personally at-risk from certain hazards, specifically fire and cancer.

Other studies found that appreciation of the level of risk in an area tends to be lower among marginalized communities, due to a combination of factors. Immigrant communities may not have access to information in their primary languages, and lower-income residents who move frequently and may rent rather than own are less likely to know about local risks. The latter phenomenon is the result of lack of disclosure when someone is first buying or renting a property, as well as lack of experience in a neighborhood (due to the frequent moves) (Walker & Burningham, 2011).

Personal Agency

The recognition of one's ability to affect change (what I call "personal agency" here) is essential to a person taking action in a given situation. If a person doesn't believe that acting will protect them from a flood, they won't act. Members of marginalized communities often do not have a sense of personal agency, and therefore will not protect themselves from hazards even if they know the risk and otherwise have the capacity to act (Masozera et al, 2007).

According to Brody, et al (2008), individuals "with higher perceived personal efficacy are more likely to define climate change as risky." That is, those who believe they have the ability and responsibility to mitigate climate change hazards tend to be more concerned about climate change. This "personal efficacy" was found to be one of the strongest predictors of risk perception in that study. He concludes from this as follows:

> *"If an individual's perception of risk depends on the belief that he or she can influence climate change outcomes, then public officials may benefit by more effectively engaging the public in the policy-making process… involving the public in addressing climate change policy issues may boost the perception of its associated risk and lead to more responsive and proactive local communities."*

CONCLUSIONS

Population characteristics that influence social vulnerability include socio-economic status, race and ethnicity, age, whether one rents or owns, the type of building in which one lives, education, health status, social dependence, and special needs (Masozera et al, 2007). Generally, research has found that socially marginalized communities are more likely to be exposed to hazards, such as flooding, and less likely to be able to withstand, adapt to, and recover from those hazards (they are less resilient).

Based on my review of the literature, I would expect similar trends to be evident within businesses located in marginalized communities. Through analysis of data collected from 100 small business owners across Rhode Island, I investigate this expectation.

METHODOLOGY

Rhode Island Small Business Vulnerability Assessment

Data Collection Process
In late 2018, one-hundred small business vulnerability assessments were conducted across Rhode Island by the consulting firms RPS Group and Milone and MacBroom, Inc. Participating businesses had the business owner, a manager, or another representative ("the business") take part in a semi-structured interview based on completion of an eight-page checklist. The checklist collected information including four factors of interest for this study:

A. The level of exposure to flooding or other hazards
B. The degree of vulnerability to flooding or other hazards
C. The degree to which hazard risk-reduction measures have been implemented
D. The level of concern and awareness of business owners about hazards.

Neighborhood demographic data was sourced from the Tufts Policy Map software (tufts.policymap.com) and associated with specific businesses based on the census tract code. This means that the demographic information associated with each business reflects the conditions of the neighborhood in which the business is located, not the business ownership or staff itself.

Of the one-hundred businesses initially interviewed, eighty-seven (87) produced results that were able to be coded and used for this study.

Data Analysis
Most of the four factors identified above were not directly measured or asked during the interview and data collection effort, and so are quantified by compiling relevant information for each factor to create "scores." These scores simplify a significant amount of information in an internally-consistent fashion, and are all normalized such that results can be compared internally; the scores were designed specifically for this study by the researcher and do not provide objective information about the state of a business useful outside of this study. Because of the nature of the data collected by this study, there are more types of "factor scores" than factors listed above. Factor scores are summarized below.

Degree of Risk Reduction
Each business is assigned a number between zero and one based on the amount and types of risk reduction measures they have implemented or which other resiliency capabilities they display. Measures considered to serve risk-reduction purposes were determined based on standard hazard mitigation practices, expert knowledge, and business input. Businesses that have implemented more, or more significant, risk-reduction measures are assigned higher Risk-Reduction Scores (closer to one) than those that have implemented few measures (closer to zero). Risk-reduction measures are defined here as actions taken to reduce a business's exposure to hazards or the severity of the impacts that would be incurred by the business if a hazard were to strike.

Table 1: Risk Reduction Measures Considered

Feature	Description
Backup Power	Batteries, generators, etc., that allow business to continue operating during power outage
Building Protection	Building retrofits designed to protect the building when it is impacted by hazards
Drainage	Work performed to improve site drainage and minimize the flow of water into the building
Electronic Backups	Essential business data is backed up electronically
Emergency Protocol	Plans or procedures to be implemented in the event of a disaster
Equipment	Retrofits or other work intended to protect key business equipment from hazards
Experience	Employees are able to prepare & respond to disasters because of experience or training
External Structures	Structures on the property designed to prevent hazards from impacting the building
Flood Insurance	Flood Insurance policy through the National Flood Insurance Program
Inventory	Steps taken to protect business inventory
Offsite Storage	Backup locations where the business can store items if primary site is compromised
Operational Flexibility	Ability to maintain operations during outage
Outside Resources	Support available from outside sources
Preparedness Materials	Physical materials to help withstand a disaster
Risk Assessment	Business has evaluated risks & vulnerabilities in an organized fashion
Servers and Data	Work intended to protect on-site servers and data from hazards.
Site Maintenance	Work performed over the life of a business to maintain usability of site
Sump Pumps	Pump installed in basement to remove water
Utilities	Retrofits or other work intended to protect building utilities from hazards

The Risk-Reduction Score is independent of the degree of vulnerability of a business; for example, a business that holds no inventory does not get "points" for inventory-risk reduction, while a business that has elevated its inventory on pallets in the basement *does* get an inventory-risk reduction "point," despite the fact that the latter has a higher level of vulnerability with regards to its inventory. Risk-Reduction Score measures only what actions have been taken, by the business or by third parties, to mitigate potential impacts from hazards.

Hazard Score

Hazard scores for businesses are broken into three categories:

- **Hazard Experience** reflects past impacts from hazards to each business.
- **Hazard Exposure** reflects the location of each business relative to mapped hazard zones or sources.
- **Effective Hazard** combines Hazard Experience and Hazard Exposure scores.

Hazard Experience

Each business is assigned a number between zero and one based on its reported experience with natural disasters including high wind events (from tropical storms, hurricanes, or other events), flooding events (from coastal storm surge, riverine flooding, or poor drainage), and snow. This Hazard Experience Score is calculated from the number of hazard events experienced, the degree of impact of the most severe hazard event, and the number of years the business has operated in its current location. A business that has experienced one hazard over the last 20 years has a lower Hazard Experience Score than one that has experienced one hazard over the last 1 year.

Hazard Exposure

Each business is assigned a number between zero and one based on its mapped exposure to flooding and erosion. The Hazard Exposure Score accounts for the following:

- **FEMA-mapped flood zone** in which the building is located, according to the local Flood Insurance Rate Map (FIRM)
- **Distance from water** of the building, based on the nearest mapped water body
- **Risk of erosion** to the building, based on knowledge of local conditions and reports from business representatives

Effective Hazard Score

Each business is assigned a number between zero and one to reflect its overall exposure to hazards based on both the business location and the historical incidence of hazards impacting the business. The Effective Hazard Score is calculated by dividing the sum of the Hazard Experience Score and Hazard Exposure Score by two.

Vulnerability Score

Each business is assigned a number between zero and one based on vulnerabilities reported by the business owner or manager or observed by the researcher. Factors identified as vulnerabilities were determined based on the expertise of flood management practitioners. A business with a low Vulnerability Score is relatively less likely than one with a high Vulnerability Score to experience negative consequences from being impacted by a hazard event. Factors considered to calculate Vulnerability Scores are presented in Table 2.

Vulnerability is defined here as the exposure of different aspects of the business to the possibility of being impacted by a hazard, regardless of hazard exposure or of implementation of certain risk reduction measures. For example, a business that depends on an inventory of perishable food and a high volume of customer flow through their property (both the inventory and the customer flow are vulnerable to hazards) has a higher hazard vulnerability than a one that conducts most of its business online (much of the business is conducted online or remotely, and so is not vulnerable to local hazard events).

Table 2: Vulnerability Level Coding Rubric

Feature	Description
Access	The ability of employees, customers, and suppliers or vendors to get to, and leave, the business
Assets	Off-site assets owned or managed by business, e.g. rental properties, storage facilities, project sites
Basement	Any partly or fully below-ground room accessible to business or in which utilities/equipment are kept
Customers	Business customers, and their ability and desire to access a business
Employees	Business employees, and their ability to access and operate a business
Equipment	Equipment important to business operations, such as manufacturing tools or construction vehicles
Interior	The physical, indoor space in which the business operates
Inventory	Items that the business stores and sells that are important to business operations
Outdoor Debris	Items located outdoors near business that may be lifted by flood or wind and become projectile hazard
Site	The physical, outdoor space located around the business building, or on which the business operates.
Utilities & Fuel	Building utilities (heat & electric) and fuel for those utilities or other equipment or business services.

Risk Score

Risk scores are calculated by multiplying hazard scores by vulnerability scores.

Perceived Risk Score

The product of the Vulnerability Score and the Hazard Experience Score is taken as the Perceived Risk Score, ranging from zero to one. Higher values indicate that a business has experienced hazard impacts in the past and is highly susceptible to those impacts. Lower scores indicate that a business owner or manager has not experienced many hazards at the business site, and the business has a low susceptibility to hazards.

Mapped Risk Score

Mapped Risk Score is calculated by taking the product of Hazard Exposure Scores and Vulnerability Scores. Businesses vulnerable to disasters and located within mapped flood hazard zones have the highest scores, while businesses with low vulnerability that are located outside of mapped zones and far from significant waterbodies have lower scores.

Effective Risk Score

The Effective Risk Score is equal to the product of the Effective Hazard Score and the Vulnerability Score. This score incorporates the historic impact of hazards on a business as well as the location of a business with respect to mapped hazard zones and water bodies.

Concern

Business representatives were asked directly whether or not they were concerned about the possible effects of future hazard events on their ability to continue operating their businesses. While this was presented as a binary "yes or no" question, many respondents added clarifying language to their responses. A "no" response was given a score of one (1), while a "yes" response (or a yes response conditioned with emphasizing terms such as "very" or "extremely") was given a score of three (3). A response conditioned with diminishing terms (such as "somewhat" or "a little") was given a score of two (2).

Summary of Measures of Vulnerability and Risk Reviewed

The measures of risk reduction, hazard level, vulnerability, risk, and concern used for this analysis are summarized in Table 3, below.

Table 3: Measures of Vulnerability and Risk Reviewed for this Analysis

Measure	Description	Factors Considered in Calculation	Statistics			
			Min	Mean	Max	σ
Risk Reduction Score	Measure of risk-reduction measures implemented, other capabilities	Structural & nonstructural mitigation, data backups, emergency generators, protection of utilities & inventory, emergency plans, etc.	0.00	0.19	0.48	0.12
Hazard Experience Score	Degree of historic natural hazard impact.	Number of historic events impacting business, degree of impact, years at current site.	0.00	0.19	1.0	0.21
Hazard Exposure Score	Exposure to hazards based on geography.	FEMA-mapped flood zones, distance from water, presence of erosion.	0.00	0.32	0.92	0.26
Effective Hazard Score	Exposure to hazards based on geography and history.	(Hazard Experience + Hazard Exposure)/2	0.00	0.26	0.92	0.17
Vulnerability Score	Expected impact to business were a hazard to occur.	Importance of building & site, presence of basement, reliance on and exposure of utilities, equipment, inventory, access routes, etc.	0.07	0.38	0.64	0.11
Perceived Risk Score	Expected risk based on past hazard events.	Vulnerability x Hazard Experience	0.00	0.08	0.46	0.09
Mapped Risk Score	Expected risk based on geography.	Vulnerability x Hazard Exposure	0.00	0.13	0.46	0.12
Effective Risk Score	Expected risk based on geography and history.	Vulnerability x Effective Hazard	0.00	0.10	0.31	0.08
Concern	Concern about possible effects of future hazards.	Concern levels reported by business representatives.	1.00	1.67	3.0	0.82

σ = Standard Deviation, calculated using Microsoft Excel STDEV.P (standard deviation based on entire population) function

Key takeaways for each measure are summarized below:

- **Risk Reduction Score:** Businesses have only implemented a minor to moderate amount of risk reduction measures, or have only implemented measures of minor to moderate significance.
- **Hazard Experience Score:** Most businesses reported some experience with natural hazards (mostly winter storm events), but very few reported significant damage or impact caused by those hazards. Hazard Experience Scores have a more narrow distribution and are skewed left more strongly than Hazard Exposure or Effective Hazard Scores.
- **Hazard Exposure Score:** Almost no businesses have zero exposure to natural hazards (based on the rubric used for this project; in reality, no asset has zero exposure to hazard), and overall the distribution of Hazard Exposure Scores is fairly large. Ultimately, most businesses have low or moderate exposure to hazards. Hazard Exposure Scores have a wider distribution and are less skewed to the left than Hazard Experience or Effective Hazard Scores.
- **Effective Hazard Score:** Effective Hazard Scores have a higher average and a larger standard deviation than either Hazard Experience or Hazard Exposure Scores.
- **Vulnerability Score:** The distribution of Vulnerability Scores is relatively un-skewed and centered around the average of 0.38.
- **Perceived Risk Score:** Perceived Risk combines Hazard Experience and Vulnerability Scores. Businesses in the study tend to have very low Perceived Risk Scores, and the Standard Deviation is very low.
- **Mapped Risk Score:** Mapped Risk combines Hazard Exposure and Vulnerability Scores. Businesses in the study tend to have low Mapped Risk Scores, but not as low as Perceived Risk.
- **Effective Risk Score:** Effective Risk combines Effective Hazard and Vulnerability Scores. Effective Risk Scores are higher than Perceived Risk but lower than Mapped Risk Scores, and the distribution is narrower than either.
- **Concern:** A little more than half of all businesses reported having no concern about natural disasters.

Demographic Data Extracted from the Policy Map Database

The Tufts Policy Map geographic database includes information on demographics, housing prices, health, and labor. A variety of demographic features are explored for use in this study, a selection of which are ultimately utilized in the analysis. Those features utilized are described in this section.

The Policy Map database information used in this paper is sourced from the 2013-2017 U.S. Census American Community Survey (ACS), which is a shorter form of the long-form Decennial Census survey and is administered on a more frequent basis. The ACS provides demographic estimates extrapolated from a sample of the population, and has a larger margin of error than the Decennial Census.

Measures of Wealth and Income

Two measures of individual wealth were explored.

Percent of Individuals Living in Poverty

This attribute is an estimate of the percent of the population living below the poverty level between 2013-2017. It was extracted from the Policy Map database at the Census Tract scale (based on 2010 Decennial Census boundaries) and matched with specific businesses based on their Census Block codes. The percent of individuals living in poverty values were taken to be consistent throughout each Census Tract; all Census Block Groups (CBG) within a given Census Tract were assigned the same value as the Tract.

Per Capita Income

The average individual income level, based on total Census Block Group population including those who are not working, was derived from the 2013-2017 ACS.

Measures of Race and Ethnicity

Percent Hispanic

This attribute is an estimate of the percent of the population of each 2010 CBG who identified as Hispanic between 2013-2017. It was extracted from the Policy Map database at the CBG scale and matched with specific businesses based on their Census Block codes.

Percent Non-white

This attribute is an estimate of the percent of the population of each 2010 CBG who identified as being of a race other than white between 2013-2017. It was extracted from the Policy Map database at the CBG scale and matched with specific businesses.

Percent Foreign Born

This attribute is an estimate of the percent of the population of each 2010 Census Tract between 2013-2017 that was born outside the United States. It was extracted from the Policy Map database at the Census Tract scale and matched with specific businesses based on their Census Block codes. CBG within a given Census Tract were assigned the same Percent Foreign Born value as the Census Tract.

Diversity Index

The diversity index represents the percent-probability that two individuals chosen at random within a given CBG group would be of different races or ethnicities. Values between 0% and 20% reflect more homogeneity while values above 50% suggest more heterogeneity. Diversity Index was extracted from the Policy Map database at the CBG scale and matched with specific businesses.

According to the Policy Map database data description:

> *Racial and ethnic diversity can be indicative of economic and behavioral patterns. For example, racially and ethnically homogenous areas are sometimes representative of concentrated poverty or concentrated wealth. They could also be indicative of discriminatory housing policies or other related barriers.*

Summary of Demographic Data Reviewed

The demographic and wealth measures used for this analysis are summarized in Table 4, below. The businesses assessed in this study are located in neighborhoods that are mostly white and relatively homogeneous, with a selection of specific areas that stand out as more diverse. Overall the study area is relatively low income with relatively high poverty levels, though in this case there is also some variation.

Table 4: Demographic Data Reviewed for this Analysis

Attribute	Description	Census Geography Scale	Statistics of Census Blocks in which study businesses are located			
			Min	Mean	Max	σ
Percent Living in Poverty	Percent of individuals living below the poverty level	Tract	2.5%	19%	43%	12%
Per Capita Income	Average annual income, including those who are not working	Block Group	$10,969	$39,136	$89,643	$17,688
Percent Hispanic	Percent of individuals who are of Hispanic culture	Block Group	0.0%	11%	67%	19%
Percent Non-white	Percent of individuals who identify as being a race other than white	Block Group	0.0%	14%	63%	19%
Percent Foreign Born	Percent of individuals born outside the United States	Tract	1.8%	13%	30%	9.1%
Diversity Index	Probability that two individuals chosen at random would be of different races	Block Group	0.0%	23%	71%	22%

σ = Standard Deviation, calculated using Microsoft Excel STDEV.P (standard deviation based on entire population) function.

It is important to note here that the study area is lacking in terms of representation of marginalized communities. This fact must be taken into consideration when assessing the results of the study.

Olneyville Health Equity Zone Community Resilience Assessment

Data Collection Process

In early 2019, ONE Neighborhood Builders (ONENB), a community development non-profit located in Providence, RI, surveyed ninety (90) residents of and workers in the Olneyville neighborhood in that city. The work was performed as part of a Rhode Island Department of Health (RIDOH) initiative called "Building Community Resiliency to Climate Change." This initiative made funding available to state-defined Health Equity Zones (HEZ) to aid with community climate-change resiliency planning and capacity building.

ONENB developed a survey that asked respondents about their awareness of and concerns about climate change and natural hazards, as well as their capabilities to reduce risks from those forces.

Data Analysis

Many of the survey questions for this dataset were presented as multiple-choice. Each possible multiple-choice answer was given a numerical value to enable quantitative comparison of each respondent. Open-ended questions were, for the most part, not used in this analysis. Questions of interest were those that related to the same aspects of interest in the Rhode Island Small Business Resiliency dataset, namely:

A. The level of exposure of each respondent to hazards
B. The degree to which each respondent in vulnerable to hazards
C. The degree to which each respondent has implemented risk reduction measures
D. The level of concern and awareness of each respondent

These factors were not directly measured in the survey, and so answers to multiple related questions were -combined to create "scores" for each. These scores provide internally-consistent measures of the factors of interest and are normalized such that they can be compared internally; the scores do not provide objective information that can be used outside of this study.

This dataset also includes self-reported demographic information about respondents. These are also included in the analysis. Factors included in the assessment are described below.

Measures of Vulnerability and Risk Extracted from the Assessments

Degree of Risk Reduction

Scored responses to five different questions were summed and then normalized to be on a scale of zero to one to calculate risk reduction scores. Flood insurance was weighted to have a larger impact on the overall risk reduction score than storing disaster supplies. Risk reduction score components are described in Table 5.

Table 5: Factors Included in Risk Reduction Score Calculation

Question (Questions have been altered for conciseness)	**Lowest Possible Score**	**Highest Possible Score**	**Multiplier**
Which best represents your preparedness?	0	4	1
Do you have disaster supplies at home?	0	1	1
Do you have disaster supplies in your car?	0	1	1
Do you have disaster supplies in your workplace?	0	1	1
Have you purchased flood insurance?	0	1	3

Hazard Experience Score

Survey respondents were asked whether they had ever experienced flooding and how that flooding had impacted them. Answers to the first question were binary (yes or no), and answers to the second were open-ended. Open-ended questions were analyzed and scored as follows:

- **0:** no impact or no answer
- **1:** description of minor impact
- **2:** description of interference with transportation or travel
- **3:** any description of notable damage

The flood-impact score was divided by the number of years for which the respondent has lived in Olneyville so that those who has experienced flood impacts more recently had higher hazard experience scores.

The majority of respondents (84) did not report any experience with hazards. Of those who did report hazard experience, three received "low" scores of less than one, and three received scores higher than one.

Vulnerability Score

There are a limited number of questions that pertain to vulnerability, all of which are binary "yes-or-no" questions. The sum of these three questions is divided by three to calculate a Vulnerability Score between zero and one. Individuals who score a one have more vulnerabilities than those who score a zero.

The questions included in this calculation are:

- "In the event of a disaster that required you to leave the area, would you need to rely on public transportation or the government for transportation?" (Individuals who would need to rely on outside help for transportation are considered to be more vulnerable than those that own their own vehicles.)
- Do you, or someone you live with, have a disability or a health condition that might affect your households' ability to prepare for an emergency situation?

- Do you, or someone you live with, have a disability or a health condition that might affect your households' ability to respond to an emergency situation?

The distribution of vulnerability scores skews to the left, such that fewer individuals have significant vulnerabilities than those who do not.

Level of Concern

This measure captures the relative level of concern that each respondent has about a flood directly impacting them. It is calculated based on the answers respondents gave to five questions, presented in Table 6.

Table 6: Factors Included in Concern Level Calculation

Question (Questions have been altered for conciseness)	**Lowest Possible Score**	**Highest Possible Score**
How likely is it that a natural disaster will occur in your community?	0	5
X		
How severe do you think the impact would be to you?	0	5
+		
How much do you know about climate change in your area?	0	3
X		
Do you think that climate is changing in your area?	0	2
+		
Do you worry about having to permanently relocate due to flooding?	0	2

The distribution of concern level across the surveyed population follows a pattern relatively close to a traditional bell curve, only slightly skewed to the left.

Demographic Data Extracted from the Assessments

Race

Respondents were asked to select which category they identified with as their race. Selections made by respondents were "white," "black or African American," "Other," or "Unknown."

Only four respondents selected "black or African American," which was not considered to be a large enough sample to make any useful conclusions. For analysis, "black or African American" and "Other" were merged, and the two racial groups compared to one another were "white" and "Non-white." "Unknown" responses and blank responses were removed for this analysis.

Hispanic

Respondents reported whether they identified as "Hispanic or Latino" or not.

ANALYSIS

The RISB Vulnerability Assessment dataset is analyzed to identify correlations between demographic features, level of concern, and hazard preparedness. The goal of this analysis is to identify relative strengths of correlation between the features listed, not to determine causation or explanation.

Two Microsoft Excel basic statistical analysis tools are used, and are considered sufficient for this purpose.

Coefficient of Determination

The Microsoft Excel "LINEST" function uses the "least squares" regression method to calculate a straight line that best fits a dataset. This function also reports a coefficient of determination R^2, which compares the actual y-values of the dataset to those of the best-fit straight line. R^2 values range from zero to one, with a value close to one indicating that the regression equation calculated by LINEST is a strong explainer of the relationship among the variables (strong correlation).

Correlation Coefficient

The Microsoft Excel "CORREL" function is used to calculate the correlation coefficient *C* for different arrays. The equation for the correlation coefficient is:

$$Correl(x, y) = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2\sum(y-\bar{y})^2}}$$

where $\bar{x}$ and $\bar{y}$ are the average values of array one and array two, respectively. The closer the value of C to either 1.0 or negative 1.0, the stronger the positive or negative correlation between arrays.

Demographics and Hazard Attitudes

The RISB Vulnerability Assessment show only negligible relationship between the demographic characteristics of the CBG within which a business is located and the level of concern about natural hazard expressed by that business. Table 7 shows this for both the coefficient of determination and the correlation coefficient when relating concern level to ethnicity, wealth, diversity, and country-of-birth. To give context, level of concern was also compared to a random number array; in some cases there is a stronger relationship reflected between concern and that array than between concern and local demographics.

Table 7: Dependence of Concern Level on Neighborhood Demographic Features

Demographic Feature	R^2	*C*
Percent Hispanic	0.0001	0.010
Percent in Poverty	0.0070	-0.084
Average Income	0.0002	-0.015
Diversity Index	0.0007	-0.027
Percent Foreign-Born	0.0041	-0.064
Percent Non-white	0.0014	-0.037
Random Number Array*	0.0037	-0.061

Analysis of the Olneyville HEZ Community Resilience Survey produced the same conclusion; no relationship appears to exist between the racial or ethnic identities of survey-takers and the level of concern they expressed about natural disasters (Table 8).

Table 8: Dependence of Concern Level on Individual Demographic Features

Demographic Feature	R^2	*C*
Identifies as Hispanic	0.0007	-0.0262
Identifies as Non-white	0.0022	0.0456

Figure 1 explores the relationship between concern levels reported by individuals and their racial or ethnic identities. The average reported level of concern for non-Hispanic individuals was slightly higher than for Hispanic Individuals, and the first quartile of responses does not extend as far downward on the concern-level axis. Average reported concern is slightly lower for white individuals than for individuals of other races, though the lower end of the first quartile extends farther downward for non-white individuals.

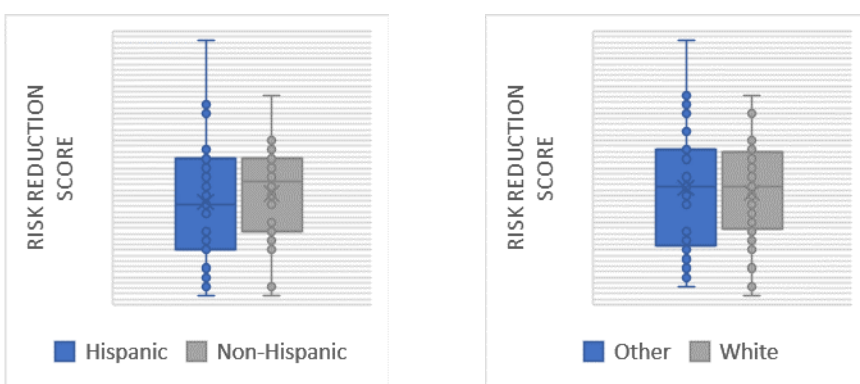


Figure 1: Level of Concern Scores Across Ethnicity and Race

In all, no obvious correlations can be drawn between concern levels and demographics.

Demographics and Risk Reduction Efforts

Analysis of the RISB Vulnerability Assessment found minor correlation between the degree to which risk-reduction actions have been enacted by a business and two demographic features of the census block-group in which that business is located. As presented in Table 9, both Diversity Index and Percent Foreign-Born show minor but not insignificant values for both coefficients when compared to risk reduction scores.

Table 9: Dependence of Risk Reduction Level on Neighborhood Demographic Features

Demographic Feature	R^2	*C*
Percent Hispanic	0.0216	0.147
Percent in Poverty	0.0081	0.090
Average Income	0.0004	0.020
Diversity Index	0.1011	0.318
Percent Foreign-Born	0.0914	0.302
Percent Non-white	0.0554	0.235
Random Number Array*	0.0034	0.058

Diversity Index and Percent Foreign Born both have R^2 values around 0.1; in other words, each of those factors can be said to explain 10% of the distribution of Risk Reduction Scores. These R^2 values are nearly two orders of magnitude larger than that of the Random Number Array.

These two features are visualized and explored in more detail in the following sections.

Risk Reduction and Diversity

Figure 2 shows the linear regression line calculated by the LINEST function, reflecting a gentle upward trend in business risk reduction implementation as neighborhood diversity increases. There is a high degree of scatter, as expected from the significant but still relatively low R^2 value.

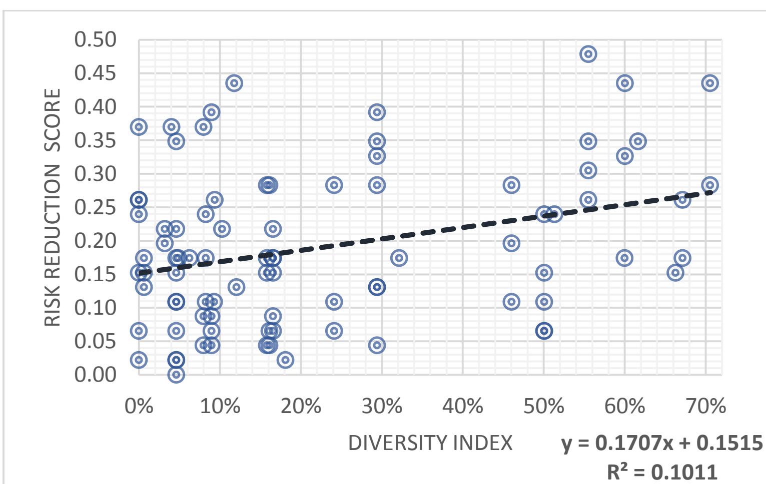


Figure 2: X-Y Graph Depicting the Relationship between Risk Reduction Score and Diversity Index

This upward trend can be seen more clearly when Diversity Index is separated into bins. Figure 3 presents a box-plot that focuses in on differences between CBG with Diversity Indexes below 20% (exclusive), from 20% to 40%, from 40% to 60%, and from 60% to 80% (the highest Diversity Index in the study area was 71%). While risk reduction scores don't show a strong trend in areas with Diversity Index values between 20% and 60%, the differences between the lowest and the highest diversity index areas is clear.

The strongest signal is seen in the lowest risk reduction scores: no business located in the most diverse areas scored below a 0.15, while 0.16 was the average in the least diverse areas. On the other hand, maximum Risk Reduction Scores, or even the upper ends of the Standard Deviation boxes, show a much less clear trend. For example, a small number of businesses in less diverse areas have very high risk reduction scores.

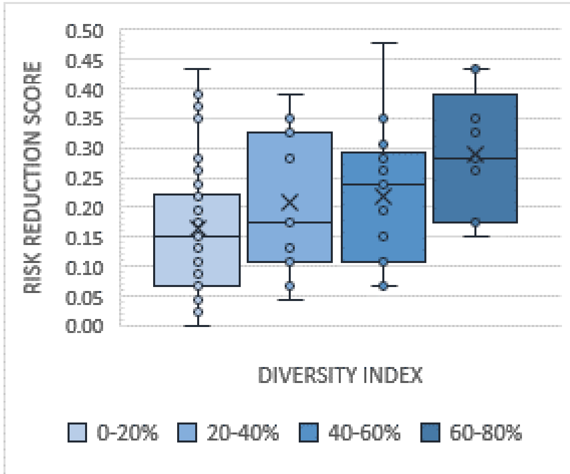


Figure 3: Box-Plot Depicting the Relationship between Risk Reduction Score and Diversity Index

While the patterns described above suggest that neighborhood Diversity Index has a strong *negative* correlation with local businesses *neglecting* to implement risk reduction measures, it has a weaker correlation with local businesses maximizing their risk reduction initiatives.

Risk Reduction and Percent Foreign-Born

Figure 4 shows a moderate upward trend in risk reduction implementation as the percentage of the local population that was born outside the United States increases. This upward trend is slightly stronger than that of diversity index; however, the R^2 value here is slightly lower.

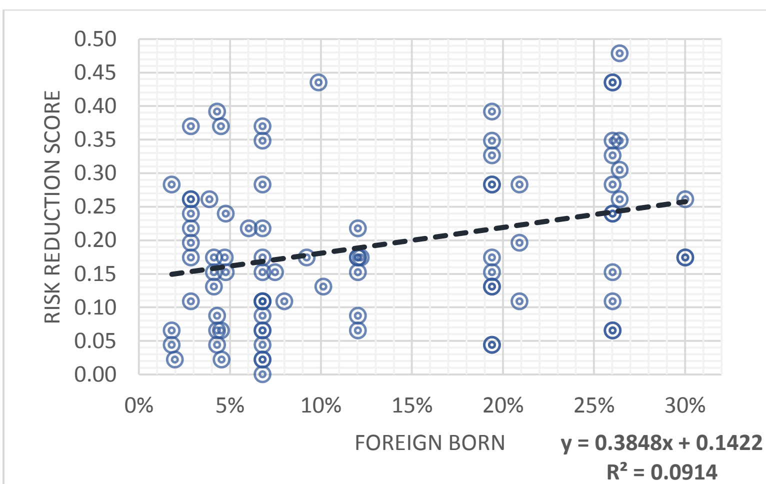


Figure 4: X-Y Graph Depicting the Relationship between Risk Reduction Score and Diversity Index

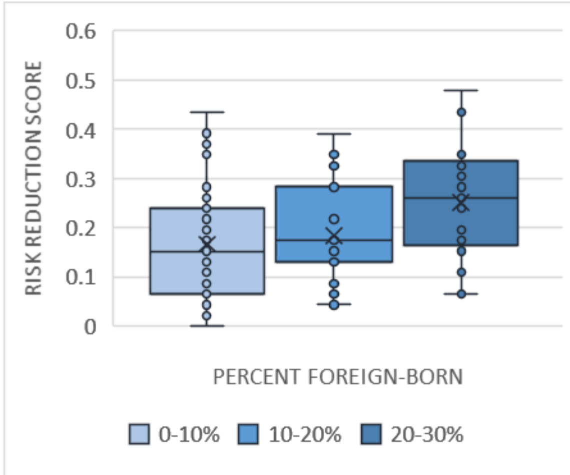


Figure 5: Box-Plot Depicting the Relationship between Risk Reduction Score and Foreign-Born Population Percentage

The relationship between Risk Reduction Score and the percentage of the local census block-group that is foreign born can be seen more clearly when percent-foreign-born is separated into bins. Figure 5 divides the foreign-born percentage into three bins: less than 10% (exclusive), from 10% to 20%, and from 20% through 30% (inclusive; the highest diversity index in the study area was 30%). A notable upward trend in both average risk-reduction scores and lowest risk reduction is present.

As with the relationship between Risk Reduction Score and Diversity Index, the trend relating Risk Reduction Score and Percent Foreign Born is clearest with the lowest Risk Reduction Scores within a Percent Foreign Born bin, while the highest scores do not follow a clear trend. In this case, however, it is only the highest values that don't follow the trend – the upper ends of the standard deviation boxes do follow the upward trend.

Risk Reduction and Other Demographic Features

The correlation coefficients between "Percent Non-white" and Risk Reduction Score and between "Percent Hispanic" and Risk Reduction Score are both about an order of magnitude larger than the "Random Number Array" (see Table 9), indicating those correlations have some significance. Both of these measures relate to the diversity of an area, so this correlation (positive in both cases) is to be expected based on the Diversity Index correlation.

Figure 6 presents the relationship between "Percent Non-white" and business risk reduction. A gentle upward trend with significant scatter can be seen. The upward trend is strongest for neighborhoods with between around 5% and 60% non-white residents. The neighborhoods with non-white resident percentages below 5% show a high degree of scatter with regards to Risk Reduction Scores, while the neighborhoods with the highest percentages of non-white residents (63%) show lower Risk Reduction Scores than would be expected based on the overall trend. The trend is clearest when looking at the low end of the Risk Reduction Score distribution across the dataset; the trend is not apparent at the high end of the distribution.

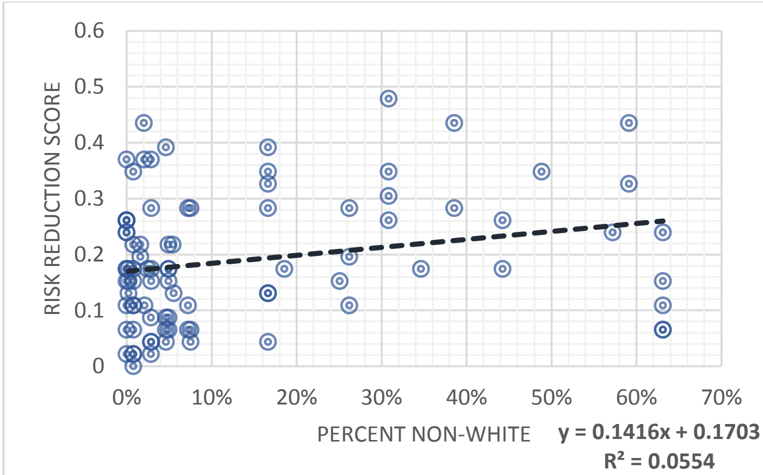


Figure 6: X-Y Graph Depicting the Relationship between Risk Reduction Score and Non-white Population

The majority of sites assessed are located in areas where less than 10% of the local population is of a race other than white, which may help explain the large degree of scatter (there is a larger pool of sites to plot, and so it is to be expected that there would be a larger variety of Risk Reduction Scores). This uneven distribution of non-white percentage figures makes deeper analysis of areas with higher non-white populations more difficult.

Plotting "Percent Hispanic" against Risk Reduction score shows a positive correlation with a gentle trend and a significant but very low R^2. Most businesses assessed are in census block-groups with Hispanic populations below 10% of the total population. Deeper analysis of areas with higher Hispanic populations is difficult because of the small number of such areas available in the dataset. See Figure 7.

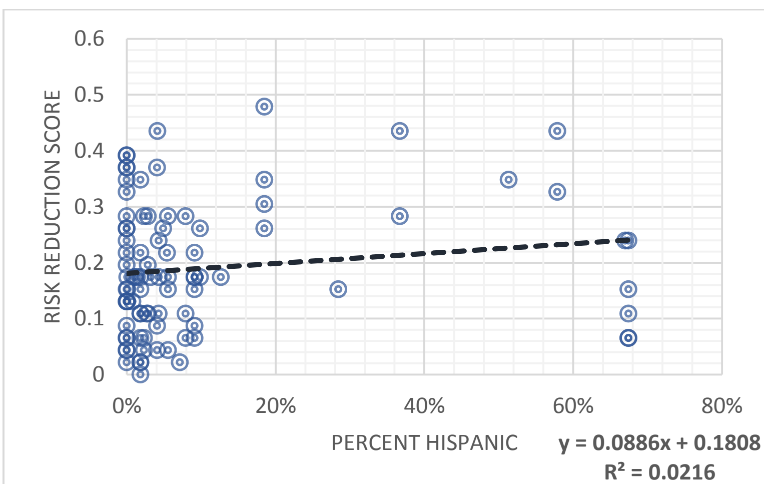


Figure 7: X-Y Graph Depicting the Relationship between Risk Reduction Score and Hispanic Population

These results show a similar pattern to those comparing the non-white population percentage to Risk Reduction Scores. The majority of businesses assessed are located in less-Hispanic areas and there is a high degree of scatter for those businesses. There is an upward trend (weaker here) and then a drop at the very high Hispanic population areas.

Further Exploration of Specific Risk Reduction Actions and Demographics

The Risk Reduction score used in the analyses above is calculated by looking at whether or not businesses have implemented any of a suite of individual risk reduction actions. To explore the relationship between Risk Reduction Score and neighborhood demographics more deeply, correlations between demographic features and each individual risk reduction measure are investigated.

Two risk reduction actions have relatively strong correlations to local demographics: protection of important documents, data, and computer servers, and performance of a formal business risk or vulnerability assessment. Those relationships are discussed below.

Protection of Servers and Documents, and Local Demographics

Implementation of server and data protection measures by businesses is positively correlated with the local demographic features of percent living below the poverty line, percent born outside the United States, percent non-white, and Diversity Index. The R^2 coefficient for all of these relationships is around 0.15; relatively high compared to other correlations evaluated in this study.

These results suggest that businesses located in neighborhoods with larger proportions of traditionally marginalized residents tend to implement more server and data protection measures.

Table 10: Correlations between Server and Document Protection and Certain Neighborhood Demographic Features

Demographic Feature	R^2
Percent in Poverty	0.1487
Diversity Index	0.1418
Percent Foreign-Born	0.1467
Percent Non-white	0.1526

Performance of Risk Assessments and Local Demographics

The percent of the local population identifying as Hispanic, living below the poverty line, and identifying as being of a race other than white, as well as the local Diversity Index, is each positively correlated with performance of business risk or vulnerability assessments. The R^2 coefficient for all of these relationships is around 0.2, with the exception of the relationship between assessment performance and Diversity Index (R^2 = 0.10). These values are relatively high compared to other correlations evaluated in this study.

As with the correlations between server and data protection and neighborhood demographics, these results suggest that businesses located in neighborhoods with larger populations of traditionally marginalized individuals are more likely to perform risk assessments.

Table 11: Correlations between Performance of Risk Assessments and Certain Neighborhood Demographic Features

Demographic Feature	R^2
Percent Hispanic	0.2065
Percent in Poverty	0.2038
Diversity Index	0.1012
Percent Non-white	0.2009

Risk Reduction and Personal Race/Ethnic Identity

Analysis of the Olneyville HEZ Community Resilience Survey showed only minor correlation between both individually-reported race and ethnicity and level of risk reduction. Very small R^2 values are reported for both features in Table 12; however, both are more than an order of magnitude larger than the R^2 values reported for concern level in Table 8 or for a random number array in Table 9. It is also important to note that the binary nature of this dataset (a respondent either identifies as Hispanic, for example, or does not) makes R^2 analysis minimally effective.

Table 12: Dependence of Risk Reduction Level on Individual Demographic Features

Demographic Feature	R^2	*C*
Identifies as Hispanic	0.0499	-0.2234
Identifies as Non-white	0.0395	-0.1987

The box-plots presented in Figure 8 are somewhat more useful for this dataset. In that figure it is clear to see that individuals identifying as non-Hispanic (rather than Hispanic) or white (rather than non-white) tend to have higher risk-reduction scores than those who identify as the opposite. This is different than the findings of the RISB Resiliency Assessment, in which businesses located in areas with higher non-Hispanic or white populations tend to have lower risk-reduction scores.

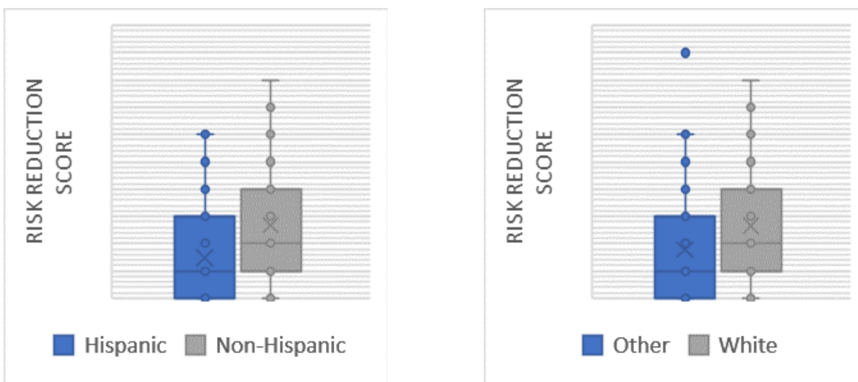


Figure 8: Risk-Reduction Scores Across Ethnicity and Race

Demographics and Risk Reduction Summary

The analysis above presents four key findings:

- Business Risk Reduction Scores tend to be higher in neighborhoods that are more diverse, in which a higher percentage of the population is made up of traditionally marginalized communities, and with higher poverty rates and lower overall income levels.
- The correlation between risk reduction and neighborhood demographics is seen most strongly with regards to protection of documents, data, and servers and performance of risk and vulnerability assessments.
- Individuals who identify as Hispanic or as a race other than white tend to have *lower* Risk Reduction Scores.
- The correlations between Risk Reduction Scores and demographics are flipped when considering local businesses versus individuals.

Demographics and Vulnerability

The RISB Vulnerability Assessment showed no significant relationship between neighborhood demographic characteristics and the level of natural hazard vulnerability of businesses. Table 13 shows very small or negligible coefficients of determination and correlation coefficients when relating vulnerability level to ethnicity, wealth, diversity, and country-of-birth. As a control, level of vulnerability was also compared to a random number array; in some cases there is a stronger relationship reflected between vulnerability and that array than between vulnerability and local demographics.

Table 13: Dependence of Vulnerability Level on Neighborhood Demographic Features

Demographic Feature	R^2	*C*
Percent Hispanic	0.016	-0.127
Percent in Poverty	0.033	-0.181
Average Income	0.022	0.148
Diversity Index	0.003	-0.056
Percent Foreign-Born	0.003	-0.057
Percent Non-white	0.004	-0.059
Random Number Array*	0.007	-0.085

The highest R^2 and *C* values are for the relationship between the percent of the local population living in poverty and business vulnerability, and the average income of the local population and business vulnerability. Both of these features measure the wealth of the local population, though in different ways, and are explored below.

Vulnerability and Wealth

Figure 9 below depicts a gentle downward trend in Vulnerability Score as the percentage of the local population that is living below the poverty level increases. This is a weak relationship, as indicated by the very low R^2 value (0.03).

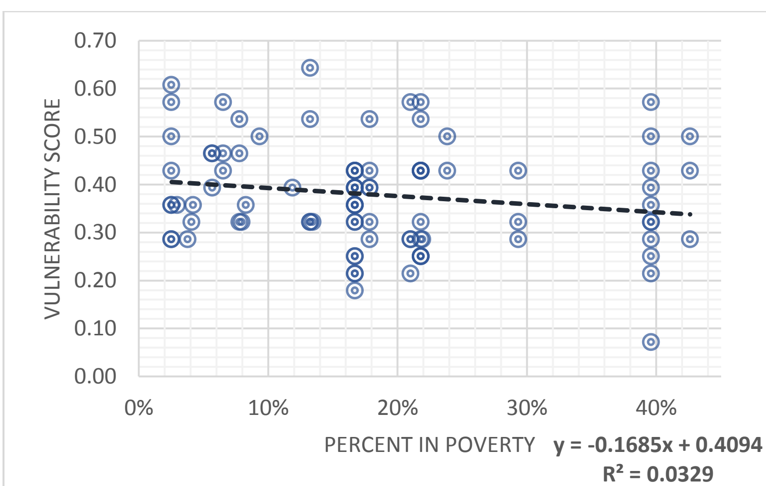


Figure 9: X-Y Graph Depicting the Relationship between Vulnerability and Local Poverty

As seen in Figure 10, there is a slightly *positive* relationship between CBG average income and the Vulnerability Scores of local businesses (note that the very small slope value of the line is due in part to the scale difference between Vulnerability Score [zero to one] and average income [$0 to $100,000, approximately]). This relationship also has a very low R^2.

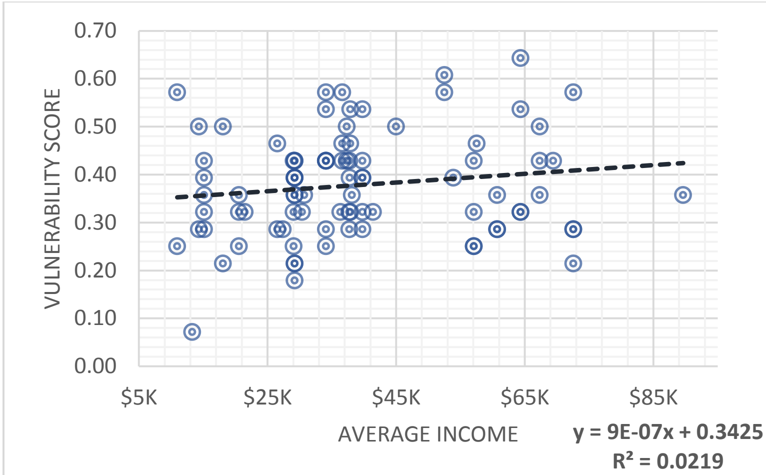


Figure 10: X-Y Graph Depicting the Relationship between Vulnerability and Average Income

The box-plot in Figure 11 shows a relatively strong upward trend in vulnerability as average income increases from less than $15,000 to $60,000; above that level the trend fails.

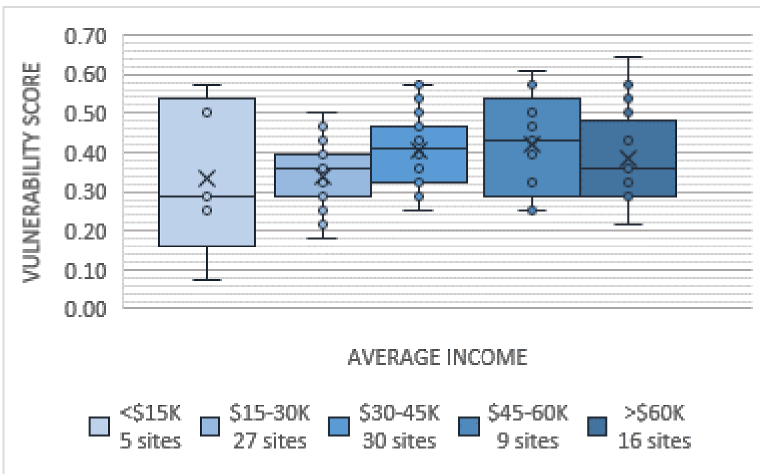


Figure 11: Box-Plot Depicting the Relationship between Vulnerability and Average Income

The combination of a weak downward trend in Vulnerability Score as local poverty level increases, with a weak upward trend as local average income increases, seems to suggest that increasing wealth correlates with increasing business vulnerability, to some extent.

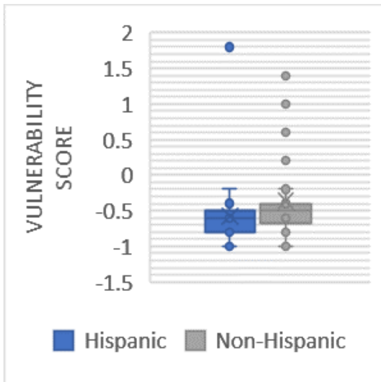
Vulnerability and Personal Race/Ethnic Identity

The Olneyville HEZ Community Resilience Survey results also show only a weak correlation when comparing Vulnerability Score with race and ethnicity. The negative *C* values for the relationships between vulnerability and both race and ethnicity indicates that non-Hispanic individuals and white individuals tend to report higher levels of vulnerability. See Table 14.

Table 14: Dependence of Vulnerability Level on Individual Demographic Features

Demographic Feature	R^2	*C*
Identifies as Hispanic	0.0292	-0.1710
Identifies as Non-white	0.0262	-0.1619

Figure 12 visualizes these relationships. The average vulnerability scores for non-Hispanic and for white individuals tend to be higher than for Hispanic and non-white individuals. In other words, individuals belonging to marginalized groups report lower levels of vulnerability than their fellows.



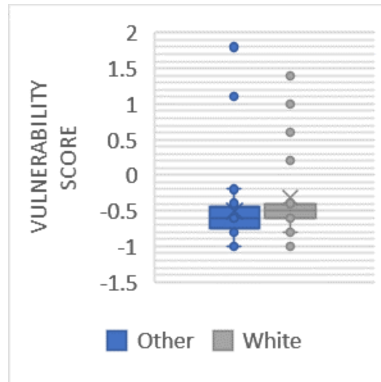


Figure 12: Vulnerability Scores Across Ethnicity and Race

Demographics and Vulnerability Summary

The analysis above presents the following key findings:

- Business vulnerability is positively correlated with neighborhood wealth, though only weakly so.
- Individual vulnerability is positively correlated with identification as white and non-Hispanic.

RELATIONSHIPS BETWEEN HAZARD ATTITUDE, RISK, VULNERABILITY, AND PREPAREDNESS

RISB Vulnerability Assessment results show a gentle upward trend in risk reduction implementation as concern level increases, with a small but not insignificant R^2 value (R^2 = 0.08). It is important to note that a value of two (2) or three (3) for concern level indicates the respondent reported *some* concern, while a value of one (1) indicates *no* concern. Considering that binary and Figure 13, the influence of concern level on risk reduction is somewhat more clear. A business that reported *any* concern (low or high) about natural disasters is more likely to have implemented risk reduction measures than one that reported no concern.

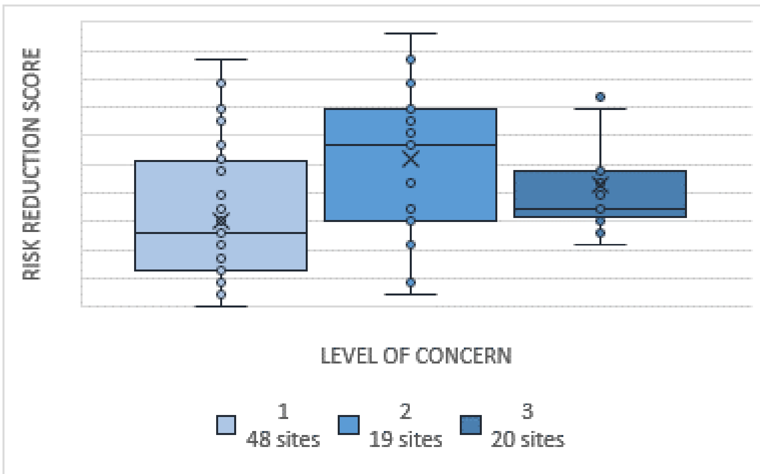


Figure 13: Box-Plot Depicting the Relationship between Concern Level and Risk Reduction

Further Exploration of Specific Risk Reduction Efforts and Concern

The influence of concern level on Risk Reduction Score can be explored in more detail by breaking out the different types of risk reduction measure presented in the dataset. Two specific risk reduction measures were found to have notable correlations with concern level, as summarized in Table 15.

Table 15: Correlations between Concern and Certain Risk Reduction Efforts

Risk Reduction Measure	R^2	*Slope*
Protection of Servers and Data	0.4284	0.78
Performance of Risk Assessment	0.4691	0.67

Concern level has a relatively strong relationship both to protection of servers and data, and to performance of risk assessments; businesses that are highly concerned about natural disasters are significantly more likely to conduct a risk assessment and to implement measures to protect their servers, documents, and data, than those that are not.

Risk Reduction and Concern Summary

The analysis above produces the following key points:

- Businesses that are more concerned about hazards are more likely to have implemented risk reduction measures.
- Businesses that are concerned about hazards are most likely to have protected data and servers and to have performed risk assessments.

Risk and Risk Reduction

Hazard exposure, or the degree to which a site is expected to be at risk from hazards based on its location and the locations of mapped hazard zones, has a connection to the degree to which the business implements risk reduction measures. Figure 14 depicts the relationship between Hazard Exposure and Risk Reduction Scores. This plot shows that risk reduction implementation increases as mapped risk increases, with a small but significant R^2 value. Hazard experience (the degree to which a business has historically been impacted by a disaster) did not have a notable correlation to risk reduction implementation.

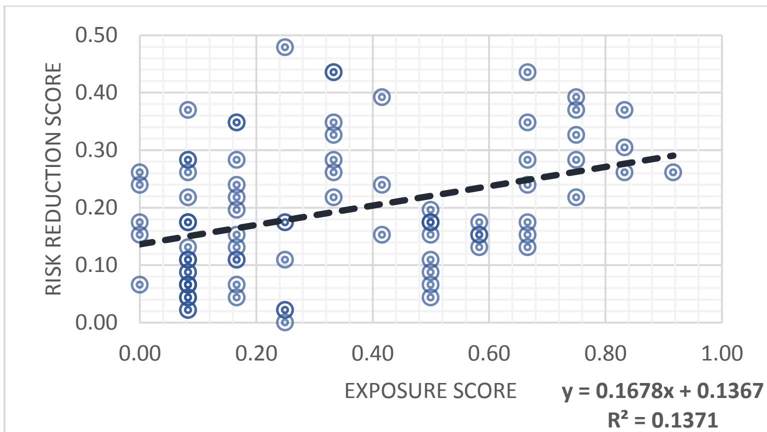


Figure 14: X-Y Graph Depicting the Relationship between Risk Reduction and Hazard Exposure

Hazard exposure was found to have minor to moderately correlation with all of the demographic measured assessed. This is summarized in the Table below. The strongest correlation is between Hazard Exposure Score and CBG average income (R^2 = 0.15), followed by Percent Hispanic (R^2 = 0.06) and Percent non-white (R^2 = 0.05).

Table 16: Relationship Between Hazard Exposure and Neighborhood Demographic Features

Demographic Feature	R^2	*C*
Percent Hispanic	0.059	-0.242
Percent in Poverty	0.043	-0.207
Average Income	0.153	0.391
Diversity Index	0.037	-0.193
Percent Foreign-Born	0.015	-0.123
Percent Non-white	0.051	-0.226
Random Number Array*	0.005	0.054

Risk Reduction and Concern Summary

These results suggest that more diverse and lower-income neighborhoods in the areas assessed tend to have lower levels of risk than higher-income, more white neighborhoods. This likely is due to the positive amenity of proximity to coastlines and waterbodies. Businesses located in areas with higher risk levels are more likely to have implemented risk reduction measures.

ANALYSIS SUMMARY

Based on the analysis presented above, there are a number of notable correlations between business features, demographics, and natural hazard concern, vulnerability, and risk reduction. These are visually summarized in Figure 15. To reiterate the section summaries presented earlier, the key findings from the analysis are as follows:

1. There is no correlation between concern levels and demographics
2. Risk reduction in higher in neighborhoods with higher marginalized populations
3. Risk reduction is lower for individuals who identify with marginalized groups
4. Risk reduction trends for businesses do not match those for individuals
5. Business vulnerability is higher in wealthier neighborhoods
6. Individual vulnerability is higher among white and non-Hispanic individuals
7. Businesses with higher concern have higher risk reduction
8. Higher-income and whiter neighborhoods tend to have higher risk levels
9. Businesses in higher risk areas have higher risk reduction

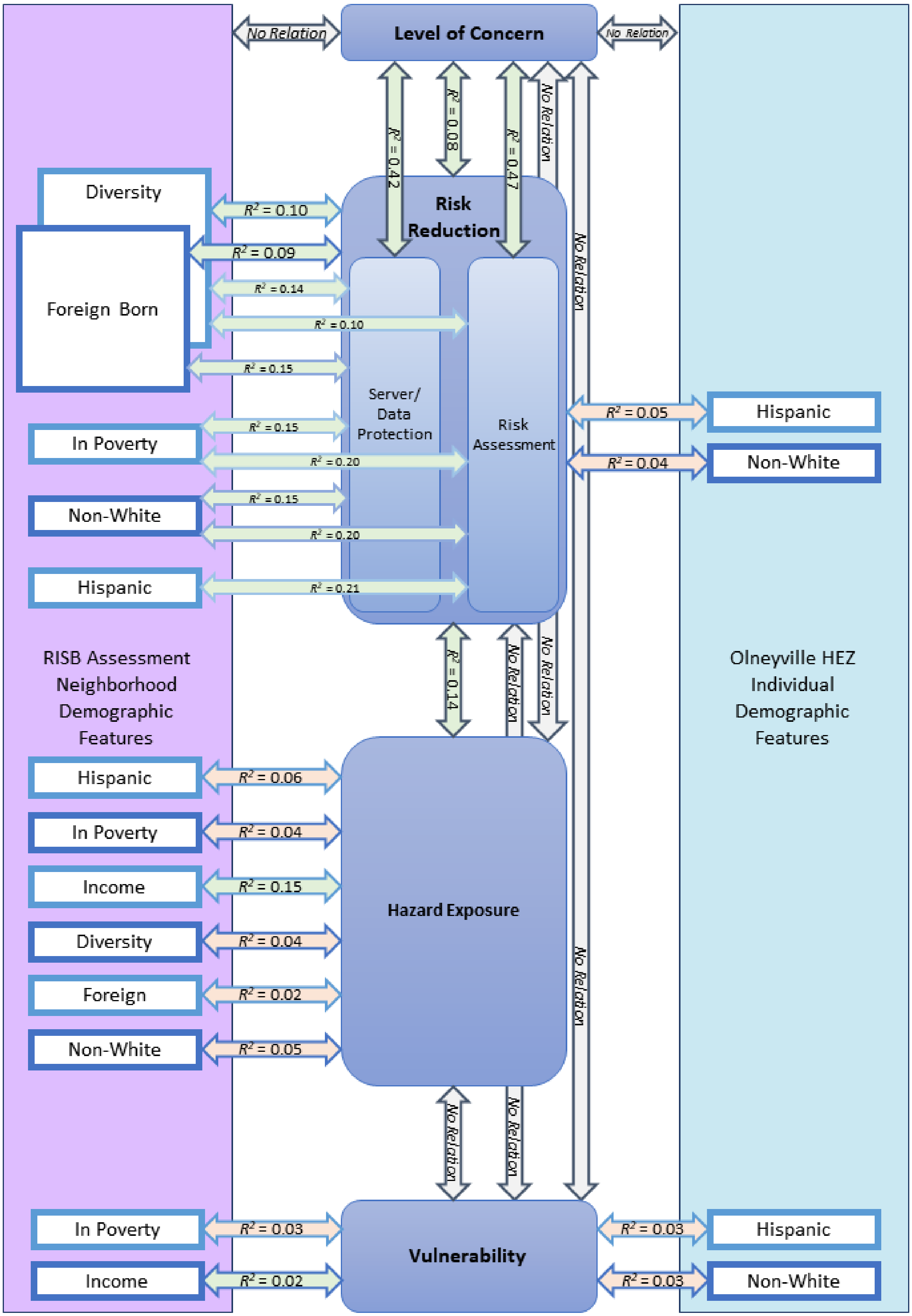


Figure 15: Conceptual Model Summarizing Analysis Results

DISCUSSION

Comparison of the Two Datasets

Investigation of both the RISB Vulnerability Assessment dataset and the Olneyville HEZ Resiliency Assessment allows us to tell two stories. The RISB dataset tells us about the relationship between local small businesses and their neighborhoods with regards to hazard vulnerability and resiliency. The Olneyville dataset reveals the personal attitudes and experiences of the individuals who live in those neighborhoods. Interpretation and comparison of the two datasets can allow us to consider how a natural hazard event may affect both individual residents and the small businesses that are so important to those residents.

In this section, I discuss the implications of the analysis results described previously.

Concern Results

Correlation between concern level and demographic features was found to be minimal in both datasets analyzed for this study. There are a number of possible explanations for this divergence from the findings of past studies. The level of concern about hazards had a strong positive correlation with implementation of risk reduction measures. The significance of these findings must be tempered by the fact that the term "concern" is not clearly defined and may have meant different things to different study participants. These points are discussed in more detail below.

Concern and Demographic Features

No significant correlation was found between levels of concern and demographic characteristics, neither when comparing businesses and neighborhoods nor when looking at individual residents. This finding does not reflect those presented in the literature review at the beginning of this paper. Recall that a number of studies reviewed by Brody, et. al. (2008) have identified correlations between "risk perception" and demographic characteristics, and that Savage (1993) specifically found that women, blacks, and lower-income individuals had higher levels of "dread" about hazards than men, whites, and higher-income individuals.

It is possible that this current study is accurately capturing a different reality than those of the studies referenced above. Individuals in Rhode Island may live in a different cultural framework that those assessed by other studies (Brody, et. al. 2008 found that culture affects concern levels). If this is the case, then the conclusion of many previous studies that demographics are correlated to concern level does not apply across all populations.

The lack of correlation in this study between demographics and hazard concern may also be explained by the relationship that *does* exist between demographics and hazard exposure. This study finds that neighborhoods with higher populations of Hispanic, poor, foreign, and non-white individuals tend to have *lower* exposure to flood hazards that whiter, wealthier neighborhoods; in other words, marginalized communities tend to be farther from the hazard source (i.e. floodplains or waterbodies). Brody, et. al. 2008 reported that past studies have found a positive correlation between "risk perception" and proximity to the risk source. It is possible that in this study the negative correlation between marginalized populations and hazard exposure is balanced by the positive correlation between marginalized populations and hazard concern. Marginalized communities tend to have higher concern levels but in this study are farther away from hazard sources, diminishing concern levels and making the trend not visible; whiter and wealthier communities tend to have lower concern levels, but in this study are closer to hazard sources, increasing their concern levels and making the typical trend not visible. Hazard exposure was found to have a minor, positive correlation with concern level in this study.

A final explanation for the lack of a correlation between demographic characteristic and level of concern may be the lack of clarity around the term “concern” itself; this is explored further shortly.

Concern and Risk Reduction

Relatively strong positive correlation was found in the RISB Assessment between concern levels and implementation of risk reduction measures. This matches the conclusions of previous studies (as summarized in the literature review), as well as common sense; a business owner with a higher level of concern about hazards is more likely to act to mitigate damage from those hazards.

The strongest correlations were found between level of concern and two specific risk reduction measures: protection of servers and data, and completion of risk assessments. This may indicate that those two measures are a higher priority or more accessible to business owners than others, and that therefore business owners concerned about hazards implement them first. This relationship may not be causational, instead indicating a correlation between, for example, an awareness of data backup technologies and a concern about hazard risks.

Many of the businesses that received points for performing formal risk assessments had done so to receive elevation certificates. Elevation certificates are primarily used by flood insurance policy holders, who in turn tend to be located in flood hazard zones. As noted previously, location in a hazard zone has been found (in other studies) to correlate with concern levels. The correlation in this study between concern level and completion of a risk assessment may in fact be reflecting a correlation between concern level and location in a hazard zone (note that, in this dataset, correlation between location in a hazard zone and concern level is very low).

Regardless of the underlying reason, the level of concern a business has about hazards has a clear positive correlation with implementation of risk reduction measures at that business.

Additional Considerations

The term “concern” can have many meanings, and therefore reported “level of concern” is hard to interpret. An individual responding that they have “low concern” about natural hazards may mean that:

- They do not believe a hazard event is likely to occur, and so are not concerned
- They believe a hazard event is likely to occur, but they have enacted risk reduction efforts sufficient to protect them, and so are not concerned
- They believe that a hazard event will occur and will impact them, but they’ll somehow come out ok
- They believe that a hazard event will occur and will impact them, and they won’t come out ok, however they are resigned to that fact and don’t think they can do anything to change it, therefore they find no purpose to being concerned.

Due to this diversity of possible interpretations of questions about “concern,” it is difficult to make any strong conclusions with regards to patterns around levels of concern among respondents. The findings discussed above, therefore, should be considered with this lack of clarity in mind.

RISK REDUCTION RESULTS

Correlation between business risk reduction and marginalized neighborhood demographics was found to be positive, despite the fact that the literature review performed for this study concluded that marginalized communities tend to have lower levels of risk reduction. There may be positive influences that arise from more diverse neighborhoods that encourage implementation of risk reduction projects, or negative influences that lead to efforts to reduce risks not related to natural hazards; alternatively there may be other correlations that lead to this pattern that are not able to be extracted from this dataset.

Negative correlation was found between individual's identifying as black or Hispanic and actions taken by those individuals to reduce risks. This does not reflect a conflict with the results described above, as one reflects the relationships between businesses and their neighborhoods, and the other reflects individual identities and behaviors.

These findings are described in detail, below.

Business Risk Reduction and Neighborhood Demographics

Analysis of the RISB Assessment data indicates a positive correlation between the presence of marginalized groups in neighborhoods and implementation of risk reduction measures in local businesses. This does not match the *negative* correlation between minority communities and risk reduction implementation described in the literature review. The results are particularly interesting when considering other findings showing that the presence of those groups correlates negatively with hazard exposure, and does not correlate significantly with hazard concern. It appears that businesses located in neighborhoods with higher populations of marginalized individuals have higher Risk Reduction Scores despite the fact that they are less likely to be exposed to natural hazards, and not likely to be any more concerned about natural hazards than businesses located anywhere else.

It is possible that the reason for the increased implementation of risk reduction measures in these neighborhoods is cultural. The more diverse communities in these neighborhoods may include people with more experience dealing with natural disasters, leading to a culture that encourages mitigation. It is also possible that such neighborhoods are more likely to experience disruptions and stresses other than natural hazards. In that case, businesses may be implementing risk reduction measures that protect them from natural hazards while being designed to protect against those other stresses (such as loss of services, utility failures, or crime); such businesses may have high risk reduction scores despite not being specifically concerned about natural hazards.,

An alternative reason for the trend may relate to the types of businesses located in neighborhoods with larger marginalized communities. Risk reduction measures may be easier to implement for some business types than others (it is relatively easy to elevate the inventory of a retail store on pallets, while elevating an entire hotel, or protecting sensitive manufacturing equipment, may be less accessible). If the types of businesses in these neighborhoods are different than those in higher-income, more white neighborhoods, it may correspond with differences in typical Risk Reduction Scores.

Individual Risk Reduction and Demographics

Analysis of Olneyville HEZ data shows minor *negative* correlation between identification as Hispanic or non-white and implementation of risk reduction measures. In other words, Hispanic people or non-white people are *less* likely to implement risk reduction measures than non-Hispanic people or white people, respectively. This matches the conclusions of Masozera et. al. (2007), Yan Zhang (2010), and Walker & Burningham (2011), described in the literature review.

Individual versus Businesses Risk Reduction Behaviors

The difference between the RISB and Olneyville HEZ results, described above, does not imply disagreement. The RISB data reflects patterns in the behaviors of individual businesses based on neighborhood characteristics, while the HEZ data reflects patterns in the behaviors of individuals based on their own identities. What analysis of the two datasets with regards to risk reduction and demographics seems to tell us, therefore, is that while members of marginalized groups are less likely to implement risk reduction measures, the businesses located in marginalized neighborhoods are *more* likely to do so.

This is potentially a significant finding. Local small businesses are an important part of community resiliency and hazard recovery; if the resiliency of local small businesses is increased, the resiliency of the entire neighborhood or community can be increased. The fact that the level of risk reduction at small businesses not only does not follow the trend of reduced risk-reduction among marginalized communities, but in fact follows an inverted trend, suggests that the resilience of a community can be increased through the resilience of its small business ecosystem regardless of the resilience of local residents.

Additional Considerations:

The Risk Reduction Scores for each business attempt to account for both recent retrofits and initial construction designs, both actions performed by the business owner and those performed by the property owner (if not the same person), and both actions specifically intended to reduce hazard risks as well as those that reduce risk but were intended for other purposes. For example, whether a business owner elevated a building or moved into an already elevated building, they were given "credit" for building elevation. Risk reduction assessments were mostly completed based on reported actions by the business owners, so there may be inconsistencies is scoring based on inconsistencies in what different business owners reported or knew.

VULNERABILITY

Only minor correlations were identified between level of vulnerability and demographic characteristics. Within the RISB dataset, businesses located in wealthier areas tended to be more vulnerable to coastal hazards then those located in poorer areas. The HEZ dataset showed that individuals who identified as Hispanic or as a race other than white had lower levels of vulnerability.

Correlation between wealth and vulnerability in the RISB dataset may have more to do with the types of businesses located in areas of different wealth than with the way business owners address vulnerabilities. The vulnerability score rubric gives higher vulnerability scores to businesses focused on customer service and experiences (such as restaurants and hospitality businesses). For these businesses, vulnerabilities may exist not only in the physical business site and features, but also the customer experience the business aims to provide. These types of businesses (for example, restaurants, spas, hotels, and gyms) may be more likely to exist in higher economic-class neighborhoods.

It is not clear why the HEZ dataset shows lower vulnerability levels among Hispanic and non-white individuals.

Considerations

Vulnerability here does *not* address the impact of hazard losses on the economic well-being of individuals or neighborhoods, only the likelihood that a hazard will have some impact on the business. While higher economic-class areas may have businesses that, by their natures, are more likely to be negatively impacted if a hazard occurs in their vicinity, they will likely be less-effected on the long term by those negative impacts than a lower-economic class area.

CONCLUSION

The previous discussion presents a number of interesting observations about the relationships between individual demographics, neighborhood demographics, and the relationships of individuals and businesses to natural hazards. Overall, though, I found that two key, overarching conclusions arise from this study. They are presented below.

Correlation is Weak

The data analyzed through this study do not show strong correlations between demographics and measures of resiliency. Correlations exist and some are relatively significant, but demographics to not appear to be a primary variable affecting resiliency levels. On the other hand, the correlation between hazard exposure and risk reduction was relatively low, which brings into question the definition of "strong" and "significant". It may be that reviewing and revising the rubrics for scoring the different resiliency measures could produce different correlation coefficients that reflect more significant relationships, or that it might be reasonable to consider R^2 values around 0.1 and 0.2 to be "strong" in this case. Regardless, it is clear that factors other than personal or neighborhood demographics have a significant impact on resiliency.

Small Businesses Versus Individuals

The degree to which businesses implement risk-reduction measures was found to follow a pattern opposite that which might be expected. While past studies show that risk reduction measures tend to be less available and accessible to marginalized communities, analysis of the RISB study found that small businesses located in neighborhoods with larger populations of individuals from marginalized communities (people of color, Hispanics, foreign-born immigrants, and people living in poverty) actually had higher levels of risk reduction implementation. This pattern emerged *despite* the fact that, in this study, the presence of marginalized communities in a neighborhood was found to be negatively correlated with risk exposure, and risk exposure was found to be *positively* correlated with implementation of risk reduction measures. In other words, despite the fact that individuals from marginalized communities tend to live outside of flood hazard zones, where risk reduction measures are expected to be less necessary, businesses located within those communities tend to implement more risk reduction measures.

Regardless of the possible explanations for this (see the Discussion section), this finding is a hopeful one. Small businesses can be important engines of community recovery following a disaster; they restart the local economy, provide key services to local residents, and reestablish a sense of community and normalcy. This study shows that the risk-reduction implementation trends of small businesses, and therefore, theoretically, the hazard resiliency of small businesses, does not necessarily align with the expectation that marginalized communities have lower physical resiliency. Therefore, work to improve the resiliency of marginalized communities may benefit from directing the focus to the local small businesses.

Areas for Further Study

Future research into the relationship between small business resiliency and the resiliency of the individuals living in the neighborhoods within which those businesses are located is recommended. A larger dataset would be able to reveal more details about this relationship, and developing an assessment aimed specifically at answering this question would provide more relevant information that would be easier to interpret more consistently than the data gathered for this study. Future studies should be intentional about the demographic characteristics of the areas studies in order to ensure a variety of neighborhood types are sufficiently represented.

Additionally, there is a need for future studies to identify the causations that may be underlying the correlations observed in this study. Sociological studies that explore the reasoning behind decisions made by business owners would help shed light on this.

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APPENDIX A:

DETAILED RUBRICS FOR CALCULATING RISK REDUCTION AND VULNERABILITY SCORES

Risk Reduction Level Coding Rubric

Feature	Description	Score	Rubric
External Structures	Structures on the business property designed to prevent hazards from impacting the building.	**0**	None
		1	Bank stabilization (bulkheads, riprap)
		2	Flood or wave protection (seawalls, levees)
Building Protection	Building retrofits designed to protect the building when it is impacted by hazards	**0**	None
		1	Minor or moderate retrofits (hurricane-proof windows or shutters, waterproof sealing, minor wet- or dry-floodproofing)
		2	Major retrofits (roof renovation, building elevation, major floodproofing
Sump Pumps	Pump installed in basement to remove water	**0**	No sump pump
		1	This score not applied
		2	Sump pump present
Preparedness Materials	Physical materials to help withstand a disaster	**0**	None
		1	Minor items (food & water, wooden boards for windows, sandbags)
		2	Major equipment (snowplows, other)
Utilities	Retrofits or other work intended to protect building utilities from hazards.	**0**	None
		1	Utilities elevated on platforms or mounted on walls in the basement or on the at-risk first floor; outdoor utilities are secured
		2	Utilities moved to upper floor; switched to a more resilient fuel source
Servers and Data	Work intended to protect on-site servers and data from hazards.	**0**	None
		1	Servers or data elevated in the basement or on the at-risk first floor
		2	Servers or data moved to upper floor
Electronic Backups	Essential business data is backed up electronically.	**0**	No electronic backup
		1	Data backed up electronically
		2	Data backed up on the cloud or offsite
Equipment	Retrofits or other work intended to protect key business equipment from hazards.	**0**	None
		1	Elevated or protected on at-risk floor
		2	Relocated to upper floor
Inventory	Steps taken to protect business inventory	**0**	None
		1	Elevated or protected on at-risk floor
		2	Relocated to upper floor
Backup Power	Batteries, generators, other equipment, or other steps taken to allow a business to continue operating during a power outage	**0**	None
		1	Minor backup power (batteries, small generator, generator for business purpose that may be usable), high passive survivability.
		2	Major generator allowing operation at or near full capacity
Drainage	Work performed to improve site drainage and minimize the flow of water into the building	**0**	None
		1	Minor drainage work, or not hazard-specific drainage work completed
		2	Major drainage work completed
Site Maintenance	Work performed over the life of a business to maintain usability of site.	**0**	No specific maintenance reported
		1	Minor maintenance (clearing gutters, drains, or outdoor debris)
		2	Significant maintenance & repairs, specifically of risk reduction features

Feature	Description	Score	Rubric
Emergency Protocol	Plans or procedures to be implemented in the event of a disaster	**0**	None (emergency contact for employees falls within this category)
		1	Informal (not written) plans reported
		2	Formal (written) plans reported
Operational Flexibility	Ability to maintain operations during outage	**0**	None reported
		1	Some flexibility (secondary sites; diverse services offered)
			Complete (remote work, offsite service provision)
Outside Resources	Support available from outside sources	**0**	None reported
		1	Business reports that friends and family can help out
		3	Supported by professional organizations, formal agreements
Offsite Storage	Backup locations where the business can store items if primary site is compromised	**0**	None
		1	Business owner can use home or spaces belonging to others
		2	Business owns offsite storage location
Experience	Business employees are able to prepare and respond to disasters because of previous experience or training	**0**	None
		1	Employees have experience to deal with disasters
		2	Employees have training to deal with disasters
Flood Insurance	Flood Insurance policy through the National Flood Insurance Program	**0**	None held
		1	Flood Insurance policy held
		2	Flood Insurance policy, with content insurance, held
Risk Assessment	Business has evaluated risks & vulnerabilities in an organized fashion	**0**	None performed
		1	Informal, self-performed, or partial assessment (includes Elevation Certificate).
		2	Formal assessment performed by professional; includes a thorough assessment of risk, hazards, and vulnerabilities

Vulnerability Level Coding Rubric

Feature	Description	Score	Rubric
Interior	The physical, indoor space in which the business operates.	0	Business is located entirely on upper floors
		1	Business is located on first floor but can withstand some flooding
		2	Significant assets are located on first floor and cannot withstand flooding
Site	The physical, outdoor space located around the business building, or on which the business operates.	0	No business operations take place outside the building on the business site
		1	Outdoor space contains furniture, storage, or other uses
		2	Outdoor space is essential to the business
Basement	Any partially or fully below-ground room accessible to the business or in which utilities or equipment are located.	0	No basement on site
		1	Crawlspace is present
		2	Basement is present
		3	Finished basement is present
Access	The ability of employees, customers, and suppliers or vendors to get to, and leave, the business.	0	Access is never needed or site has numerous access routes
		1	Access is needed and limited; access routes are in risk zone
		2	Access is essential and limited; access is needed and routes are in risk zone
		3	Access is a major concern
Utilities & Fuel	Building utilities such as heat and electricity, as well as fuel for those utilities or other equipment or business services.	0	No utilities present
		1	Utilities are on upper floors or are otherwise resilient, and not a concern
		2	Utilities are essential to business operations and are somewhat protected
		3	Utilities are essential and at high risk, in basement, outside, etc.
Equipment	Equipment important to business operations, such as manufacturing tools or construction vehicles.	0	No equipment is present
		1	Equipment is on upper floors or are otherwise resilient, and not a concern
		2	Equipment is at high risk, in basement, outside, etc.
		3	Equipment is essential and at high risk, in basement, outside, etc.
Inventory	Items that the business stores and sells that are important to business operations.	0	No inventory is present
		1	Inventory is on upper floors or are otherwise resilient, and not a concern
		2	Inventory is at high risk, in basement, outside, etc.
		3	Inventory is essential and at high risk, in basement, outside, etc.
Assets	Off-site assets owned or managed by the business, such as rental properties, storage facilities, and project sites.	0	None
		1	Minor assets (storage, project sites)
		2	Significant assets (major storage, rental properties)
		3	Assets are a central part of business (eg: rental company, property manager)
Employees	Business employees, and their ability to access and operate a business.	0	Employees do not work during hazardous conditions
		1	Employees may have to travel in hazardous conditions
		2	Employees may have to put themselves at risk to work during a hazard event
Customers	Business customers, and their ability and desire to access a business.	0	Customers will not be affected by hazard, or if they are it will not affect business
		1	Hazard could affect customer flow, and that is a minor problem
		2	Hazard could affect customer flow, and that is a major problem
Outdoor Debris	The presence of items located outdoors near the business that may be lifted by floodwaters or wind and become projectile hazards.	0	There is not a significant risk from outdoor debris at the business site
		1	There are some outdoor items that could be debris near the business site
		2	Outdoor debris is a major concern (selected for all marinas)