International Journal of Disaster Risk Reduction 13 (2015) 20–36

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

Exploring the impacts of flood insurance reform on vulnerable communities

Earthea Nance

Urban Planning and Environmental Policy, Texas Southern University, 3100 Cleburne Street, Houston, TX 77021, USA

ARTICLE INFO

Article history:
Received 10 July 2014
Received in revised form
3 March 2015
Accepted 6 March 2015
Available online 11 March 2015

Keywords:
Flood insurance
Flood policy reform
Real estate market impacts
Vulnerable communities
Biggert–Waters Flood Insurance Reform Act of 2012

ABSTRACT

This paper identifies geographic areas whose real estate markets were potentially impacted by US flood insurance reform, and it explores concurrent vulnerabilities—by income and race—in the most impacted areas. Because of the geographic and demographic significance of the Gulf Coast in terms of flood risk, flood insurance, and vulnerability, the Houston-Galveston region was selected for analysis. Flood insurance reform under the Biggert–Waters Flood Insurance Reform Act of 2012 occurred unabated over a 21-month period from July 2012 to March 2014. This period represents a unique real-world intervention that can be analyzed using a quasi-experimental design. The period was characterized by numerous anecdotal reports of spiking flood insurance rates and market uncertainty. Market data were gathered for two years before and two years after Biggert–Waters in Harris and Galveston Counties. Paired *z*-tests were performed to examine before and after market differences. Findings showed 17 zip codes that experienced significant impacts ($p < 0.01$ in 14 zip codes, $p < 0.05$ in 3 zip codes). Among the significantly impacted zip codes, low-income households were overrepresented by 11% in Harris County and by 32% in Galveston County; and minorities were overrepresented by 43% in Galveston. These results support the hypothesis that flood insurance reform can have disproportionate impacts. The paper provides a straightforward approach for analyzing the real estate market impacts of flood insurance reform at a community scale. It also provides a basis for recommending that regulatory decisions involving flood insurance must be informed by an analysis of disproportionate impacts.

1. Introduction

Since Hurricane Katrina, the United States has been engaged in debates over how to reform its flood policy. Recent reforms to flood mapping and flood insurance suggest a paradigm shift in the US position on flood risk, perhaps influenced by the emerging realities of climate change, increasingly destructive floods, and the heightened costs of disaster recovery. Not long ago the position was that subsidized flood insurance should provide "affordable protection" that reduced taxpayer costs and minimized the economic hardship of floods [1]. A stated purpose of the National Flood Insurance Program (NFIP) was to encourage sound land use by minimizing exposure of property to flood losses [2]. But today the National Flood Insurance Program is widely criticized for having spurred development in high-hazard areas [3], and the flood maps on which the program depends, until just recently, had been allowed to lapse for as long as two decades before being updated [4]. Today's position employs full-risk insurance rates and risk-based mapping based on state-of-the-art science.

Passing both Houses of Congress with no debate and with no analysis of its socio-economic impact, the Biggert–Waters Flood Insurance Reform Act of 2012 [5], or BW12[1], promised to eliminate all flood insurance subsidies and to impose full actuarial insurance rates. Soon after, flood insurance rates for properties in Hawaii, Georgia, Louisiana, and elsewhere went from as low as $600 per year to as high as $20,000–$50,000 per year. Properties that had never flooded or where not considered at risk were now being mapped into high-risk flood zones and hit with the highest possible rates, all within a relatively short period of time. After almost two years of BW12, nationwide protest led to the passage of the Grimm–Waters Homeowner Affordability Act of 2014 [6], or GW14, which slowed down the pace of BW12. The period during which BW12 was fully active—from July 2012 to March 2014—therefore offers a window for observing the socio-economic impacts of policy reform thought necessary to realize the new US

[1] Abbreviations used in this paper: the Biggert–Waters Flood Insurance Reform Act of 2012 is abbreviated "BW12," the Grimm–Waters Homeowner Insurance Affordability Act of 2014 is abbreviated "GW14," and the National Flood Insurance Program is abbreviated "NFIP."

E-mail address: NanceEA@tsu.edu

http://dx.doi.org/10.1016/j.ijdrr.2015.03.001
2212-4209/

position on flood risk.

There is little or no published analysis of the impacts of BW12 on the most vulnerable communities and population groups. Moreover, there is not adequate research on the impacts of the shifting flood paradigm in general. If such a shift is necessary, and it most likely is, how will it affect people now living in harm's way, and what options will they have to adapt to the new paradigm? This paper addresses an understudied and important topic: identifying geographic areas where national flood insurance reform potentially affected real estate markets, and exploring the demographic vulnerabilities of the most impacted areas. The scale of analysis is the community (e.g., census block, census tract, zip code, flood zone, subdivision, neighborhood, or super-neighborhood boundaries) rather than the individual property owner. The research questions are: (1) *which real estate markets worsened during the BW12 period;* and (2) *were any population groups over-represented in the most impacted areas?* The paper uses the Houston-Galveston region as a case study; however, the approach developed in the paper can be replicated anywhere because it is based on easily accessible data.

1.1. Policy background

According to the National Oceanic and Atmospheric Administration (NOAA), states along the Gulf of Mexico have the highest sustained wetland loss rate in the country [7], and Southeast Louisiana in particular has the highest rate of relative sea level rise in the United States [8]. The Gulf Coast from Texas to Florida has the highest concentration of repetitive flood loss properties in the US, with hot spots in Houston-Galveston, New Orleans, Mobile, and Tampa [48]. The combination of land subsidence, rising sea level, wetlands erosion, and increasing storm activity is intensifying the flood hazard in this particular region. For about a decade FEMA has been responding to this changing flood risk profile by updating the nation's flood maps through its Map Modernization, Risk Map, and Digital Flood Insurance Rate Map programs. The updated maps reveal a more accurate understanding of today's flood risk and sometimes result in redrawn flood zone boundaries, changes in flood zone, and/or different base flood elevations in some communities. Flood map changes can trigger higher flood insurance costs for individual property owners and can affect the value of property and local real estate market conditions in general. The increasing risk of flooding is associated with the increased cost of flood disasters. Since the Sandy disaster, the National Flood Insurance Program (NFIP) has faced deepening debt of up to $24 billion as of July 2013 [9]. The NFIP program has also fallen short in other ways, as long recognized by Burby [10]. In Burby's analysis as quoted below, the NFIP suffers from:

- Incomplete flood hazard identification and use of flawed methods;
- Failure of mitigation to contain increasing exposure to property damage from floods and coastal storms;
- Failure of mitigation to markedly reduce exposure to loss of older buildings located in flood hazard areas; and,
- Low market penetration of flood insurance in spite of mandatory purchase requirements for new construction and the availability of subsidized insurance rates for older buildings located in flood-hazard areas.

In an attempt to make flood insurance more financially sound, the federal government passed the Biggert–Waters Flood Insurance Reform Act in 2012. This act called for the eradication of subsidized insurance rates, the elimination of grandfathering, and other rule changes that affect individual property owners and local housing markets (see Table 1).

The combination of new flood maps and new insurance rules represents a paradigm shift in how the US manages flood hazards, with the new paradigm embracing up-to-date maps that reveal flood risk more accurately, and actuarial insurance rates that represent the actual costs of risk. There is less compromise in the new paradigm and more reliance on risk as a driver of decisions. After the passage of BW12, stagnant or falling prices and market uncertainty signaled the impacts of the paradigm shift. In Louisiana, the St. Charles Parish Tax Assessor implemented an across-the-board reduction in value for all properties in the parish [12]. The Houston Chronicle [13] described the impacts to the Houston-Galveston region in the following quote:

> Veteran Clear Lake-area realtor Priscilla Ennis said, "It's still a busy market, but people are reluctant to purchase in areas where the flood insurance has just gone off the charts." She said that was true in two ZIP codes in particular-one of them in Nassau Bay. One of her clients, Jack Boze, of Kemah, has had his house on the market for months and says several potential buyers have been scared away by high flood insurance quotes.

Evidence of nationwide impact is the formation of the 35-state Coalition for Sustainable Flood Insurance founded by Greater New Orleans, Inc. in May 2013 [14]. This group lobbied their representatives for relief and was victorious when Congress and the President signed the Grimm–Waters Homeowner Flood Insurance

Table 1
Summary of BW12 Reforms.
Source: FEMA [11].

Key reforms specified in the Biggert–Waters Flood Insurance Reform Act of 2012	
• Subsidized rate phase-out for all businesses and non-primary residences (second homes, vacation homes) in flood zones. Insurance premiums must reflect full actuarial risk within 4 years.	• Subsidized rate phase-out for all remaining subsidized policies, including primary residences, with map updates beginning in 2014.
• Subsidized rate phase-out for all repetitive loss and severe repetitive loss properties (within or outside the flood zone). Insurance premiums must reflect full actuarial risk within 4 years.	• Grandfathered/discounted rates phase-out for all grandfathered properties, with map updates over 5 years.
• New purchases, new policies, property sales, policy lapses, and repetitive losses must reflect full actuarial risk immediately.	• FEMA must continuously update flood maps nationwide. Out-of-date maps no longer allowed.

Note: "Flood zone" refers to the Special Hazard Flood Area as defined by FEMA. "Subsidized rates" refer to the past practice of allowing older "pre-FIRM" homes (built before the first flood maps) to purchase lower-cost insurance that did not reflect actual risk. "Grandfathered rates" (also known as "discounted rates") refer to the past practice of allowing existing properties built in compliance with previous standards to maintain their previous rates even as map changes reflected increasing flood risks. "Repetitive loss" and "severe repetitive loss" refer to properties that have flooded multiple times, as defined by FEMA.

Affordability Act of 2014 (GW14). While GW14 temporarily repealed two of the 50 sections of BW12, it also created new subsidies and retained some of the Biggert–Waters' reforms. Nevertheless, the overall effect of GW14 was to slow down BW12, not to stop it outright. The framework of reform, set by BW12, revealed some of the tactics employed to reach full rate insurance as well as the inevitable impacts to be experienced along the way.

1.2. Identifying affected communities

There is a conflict between moving to full risk-based pricing and affordability. The leading policy study on the subject, by Kousky and Kunreuther [15:2], analyzed the question "How might the NFIP provide insurance to residents who may require special treatment, such as low-income homeowners residing in flood-prone areas, because they cannot afford the higher risk-based premiums? Affordability in this case is the impact of increased flood insurance premiums on household income. Kousky and Kunreuther [15:15] suggest that 5 percent of gross income is an affordable amount; however, they also state that further research is needed to establish this percentage more accurately.

Many people lost their homes, businesses, and credit during the Great Recession, and those who did not may be facing that threat again with flood insurance reform. Those in the market for real estate may find flood insurance a major factor in the cost. Those who rent may find increased insurance costs passed on to them through rent increases by owners required to pay higher flood insurance rates. Full-risk rates are not affordable for many people, which is why the government started subsidizing rates in the first place. Flood insurance reform may impact some communities more than others.

How can one identify these highly impacted communities? Insurance rate increases are triggered by the purchase or sale of a property (i.e., federally-backed mortgages require the purchase of NFIP flood insurance), by map changes (e.g., new flood zone boundaries, new base flood elevations, or zone changes within an existing boundary), or by property category (e.g., new, lapsed, or subsidized policies; repetitive loss and pre-FIRM properties; second homes; and businesses). However, parcel-level information on lapsed policies, repetitive loss status, second homes, and subsidized policies is not typically available to the public. Property sale information may be available, but not at the parcel level in some states. New flood maps are available but usually not old flood maps for comparison (i.e., FEMA only makes one map available at a time; in limited areas FEMA Risk Maps are available that show both old and new maps, but not in the study area). Even so, flood boundaries themselves may or may not define the areas of impact because of the potential reach of future map changes. Some banks and mortgage lenders, who are requiring flood insurance as part of their lending criteria, already consider properties near water and properties within one to two miles of a special flood hazard area at-risk. The availability of data in any location will determine the methodology for identifying impacted communities.

In addition to the data gap, there is a knowledge gap. Public policies promulgated without analysis of impact and without access to the data leave the public uninformed about the individual and collective impacts. Individual impacts may include increased flood insurance premiums, mitigation expenses to offset increased insurance premiums, reduced home values due to higher premiums, increased rents to pay for higher premiums, and abandonment of properties. Collective impacts experienced at the community or neighborhood level may include a stalled real estate market, reduced property values, increased rent, increased number of rental properties, reduced commercial activity, increased blight, and increased out-migration. These policy impacts can reach properties located within and outside the flood zone. Individual impacts vary significantly depending on ownership conditions (e.g., federally backed mortgage, private mortgage, no mortgage), property age and elevation, existing subsidies, map accuracy, and others. It is known that properties below the base flood elevation (BFE), grandfathered properties, properties build before the first map (pre-FIRM), currently subsidized properties, and business properties will see large increases. Ownership conditions are not publicly available, but year built is typically available. Community impacts generally are easier to investigate because real estate market data are usually publicly available, whereas individual parcel and insurance premium data are not.

To address the lack of knowledge about flood policy impacts to individuals and communities, the National Academy of Science, as required under GW14, formed a special committee to examine the issue of affordability and to make policy recommendations to address it [16]. This paper contributes an additional analysis of affordability by identifying communities most vulnerable to the market impacts produced by the policy. Under the new policy paradigm, insurance rates for properties already in or near high-risk flood zones, older properties, repetitive loss properties, and businesses will increase, which could segment these areas into submarkets. If artificially subsidized flood insurance encouraged development in the past, then full risk rates could destabilize development in the future, resulting in depressed real estate submarkets. The notion of real estate submarkets was examined by Bourassa, et al. [17,18], who concluded that the use of real estate submarkets was important for optimized predictions of housing value. It is possible that real estate submarkets triggered by flood policy impacts will become significantly different from the general real estate market as flood hazards increase over time due to climate change, which could result in significantly disproportionate outcomes. Current and future map changes could continue to engulf more and more properties into the flood zone and, through mandatory purchase, require a higher proportion of structures to purchase flood insurance at full actuarial rates. Subsequent market impacts may eventually lead to land use change over time via increased out-migration of property owners and businesses, increased rental properties, increased blight, and increased geographic and economic segregation. This worst-case scenario could end up leaving the most vulnerable population groups in harm's way.

2. Theory

Research on the association of flood hazard and housing value has focused on estimating the relative value of properties in flood zones compared to properties outside of flood zones, and the impact of subsidized versus nonsubsidized flood insurance on housing markets. One key theory is the theory of consumer behavior under uncertainty as reflected in housing price fluctuations, which represent changes in consumer willingness to pay. MacDonald et al. [19] found that flood hazard had a measurable influence on property value differentials. Shilling et al. [20] tested the impact of subsidized and nonsubsidized flood insurance on property values and concluded that subsidized insurance represented a transfer of wealth to existing homeowners. Harrison et al. [21] studied housing values from 1980 to 1997 for nearly 30,000 property transactions in one Florida county and found that properties in flood zones tend to be assessed too high relative to non-flood areas. Bin and Polasky's [22] analysis of housing values before and after Hurricane Floyd found that the negative price differential for homes located in flood zones increased after the hurricane. Associated with consumer behavior theory are the notions of market failure that results from imperfect information and

the lack of markets for environmental goods, which may lead to increased exposure to flood risk [23]. Troy and Romm [24] analyzed home prices before and after the passage of a new flood risk disclosure law in California, which was intended to improve the information available to consumers. They found that after the disclosure law, home prices in floodplains decreased 4.2%, whereas there had not been a price differential prior to the law. The before and after price differential in Hispanic areas was even higher.

In addition to examining the relationship between unsubsidized flood insurance and property market values, this paper is also interested in the spatial and demographic distribution of the resulting property value differentials. The affordability of these impacts is currently unknown. The policy brief by Kousky and Kunreuther [15] directly addressed this issue by proposing to subsidize mitigation instead of insurance. Their idea was to continue on the path to full actuarial insurance rates because they give consumers clear messages about risk, while providing vouchers and mitigation loans to low-income residents who live in high-risk areas. The authors stop short of identifying the most vulnerable areas and they do not review the abysmal performance record of the mitigation program documented in the literature by Comfort et al. [25], Frazier et al. [26], and Godschalk et al. [27]. Flood policy reform represents an environmental and economic shift that threatens to place further burdens on the most vulnerable communities. Policymakers should tackle affordability issues with knowledge of the impacts of flood insurance policy on overall community resilience. The theory of disproportionate impact applies, which states that a risk-based allocation of resources will disadvantage vulnerable communities [28]. This paper applies the theories of consumer behavior under uncertainty, flood policy effects on property values, and disproportionate impacts. There are three expected findings. First, the passage of risk-based flood insurance under BW12 triggered individual property values to drop for properties targeted by the law. Second, BW12 increased real estate market uncertainty, partly by imperfect information, which reduced consumers' willingness to pay and resulted in market price stagnation beyond individual properties. Third, the disproportionately impacted areas had pre-existing or concurrent racial and socioeconomic vulnerabilities.

3. Materials and methods

3.1. The case study area

This study selected Harris and Galveston Counties as case studies because of their already established status as known areas of disaster vulnerability in the Gulf of Mexico. These counties represent a wide range of land use and land cover conditions (i.e., urban, suburban, industrial, rural) and types of flooding (i.e., coastal flooding, riverine flooding, flooding from inadequate urban drainage, and floods resulting from coastal erosion and subsidence). Fig. 1 shows the 13-county Houston-Galveston region with the main cities of Houston and Galveston highlighted.

Post-recession economic trends in the region were generally good. Real gross domestic product (inflation-adjusted GDP per capita) for the Houston Metropolitan Region varied from 3.0 to 6.8 percent per year from 2010 to 2013 [29]. Personal income (in thousands per capita) for 2013 was higher than state and national averages: $47.2 in Galveston County and $53.1 in Harris County, compared to $43.9k in Texas and $44.8k in the United States [30]. Overall growth in total real estate earnings (private, non-farm)

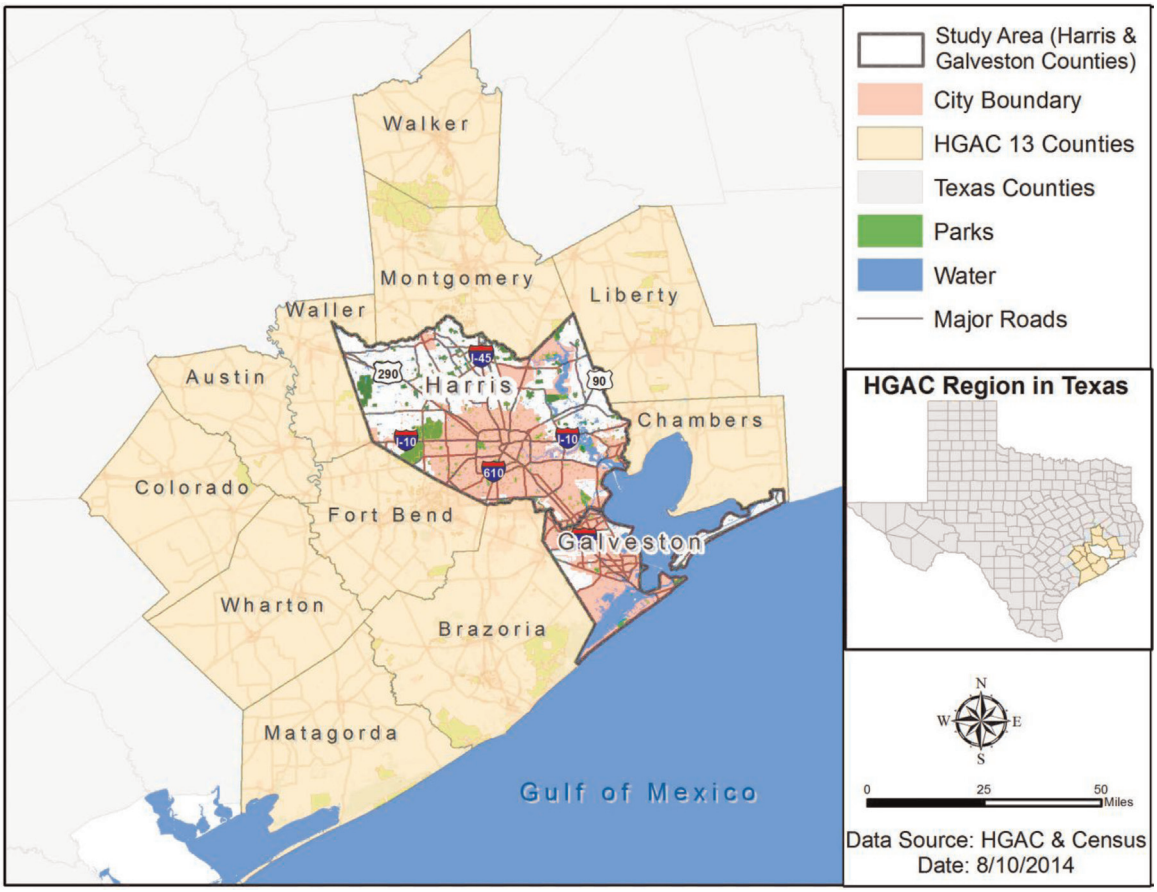

Fig. 1. The Houston-Galveston Region.

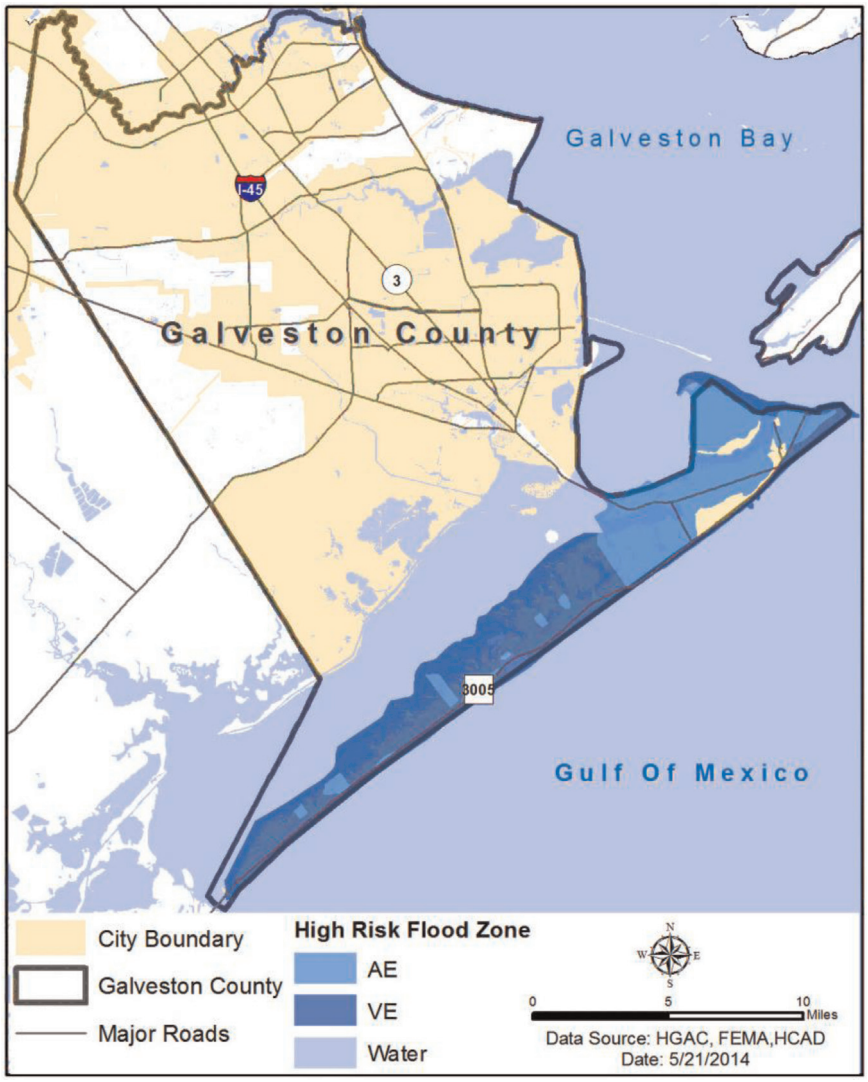

Fig. 2. High risk flood zones in Galveston County.

from 2010 to 2013 was positive for Galveston County (22.5%) and Harris County (38.7%) [31]. However, real estate earnings growth dropped in Harris County after 2012 (from 27.9% down to 6.8%) and increased in Galveston County (from 0.9% up to 8.3%) [31].

A visual analysis of Galveston County (see Fig. 2) reveals that most of the Galveston barrier island is at risk of VE-zone flooding (coastal surge) because of its location in the Gulf of Mexico. A sea wall along the northeastern portion of the island protects the densely developed area from surge and reduces its flood zone status to AE. Rivers and streams crisscross the mainland of Galveston County, creating many areas of riverine AE-zone flooding (1% annual chance flood risk). Additional VE-zone risk exists along the mainland coast, however these areas are somewhat protected by the barrier island.

Fig. 3 shows pre-FIRM structures constructed prior to 1970 in Galveston County, before the existence of flood insurance rate maps. At the beginning of the NFIP program, FEMA automatically grandfathered-in these older properties and allowed them to pay subsidized insurance rates in accordance with program rules. Over the years, FEMA also allowed properties that complied with current flood maps to grandfather-in (i.e., discount) their rates, even as the agency updated its flood maps to show changes in flood risk. The Biggert–Waters Act targeted the subsidies and discounts associated with these structures. Data on properties with map discounts were not available to the public due to privacy considerations; therefore, this study focused on subsidized pre-FIRM properties. As of 2011, there were approximately 45,219 pre-FIRM structures in Galveston County [32].

Fig. 4 combines the flood zone and pre-FIRM map layers to reveal those pre-FIRM structures located in high-risk flood zones. Despite their location in the most high-risk areas, many property owners did not mitigate their pre-FIRM structures against flooding. If insured at subsidized rates, these structures represent a significant cost to the NFIP program. On the other hand, the sea wall mitigates the dense cluster of pre-FIRM structures on the barrier island. The structures are still at risk, but the risk is mitigated because of the wall.

Fig. 4 overlays land values on top of flood zones and pre-FIRM structures, revealing that most of the lowest valued land in Galveston County coincides with pre-FIRM structures in high-risk flood zones. Based on the visual analysis in Fig. 4, the structures targeted by Section 205 of BW12 are most likely located in areas below median land value, at least in Galveston County. This finding suggests the possibility of disproportionate impact to low-income

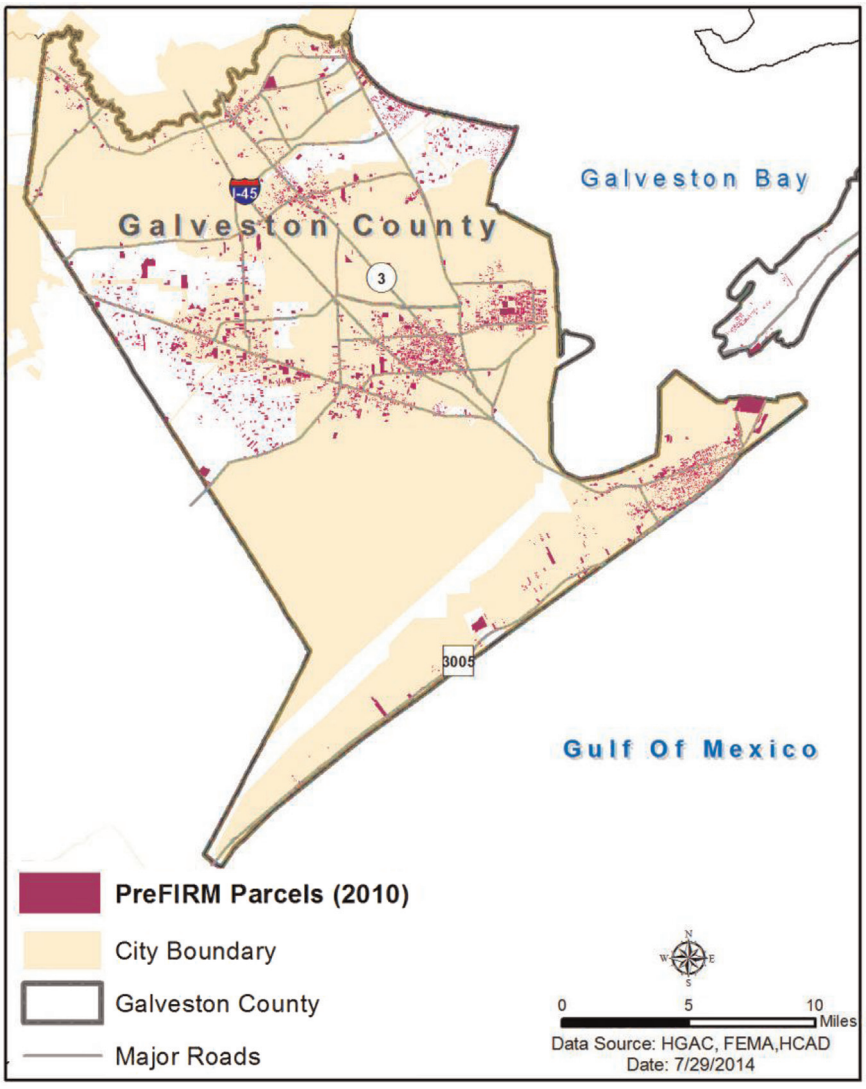

Fig. 3. Pre-FIRM structures in Galveston County.

residents in this primarily coastal area. The next section presents the same visual analysis for Harris County, a primarily riverine area.

Figs. 5–7 show the same features for Harris County. Like Galveston, Harris County had considerable overlap between Pre-FIRM parcels, high-risk flood zones, and low land values. However, Harris County flood risk is more dispersed compared to Galveston's barrier island, and this reflects the characteristics of a riverine floodplain rather than a coastal floodplain. As of 2011, there were approximately 437,599 pre-FIRM structures in Harris County [32]. Fig. 7 shows that many of the pre-FIRM parcels in Harris County flood zones are located in areas below median property value. This visual analysis suggests a possible relationship between parcels impacted by BW12 and demographic conditions, and it suggests the hypothesis that low-income residents may be disproportionately impacted.

To summarize the findings of the preceding visual analysis, in 2010 there was considerable overlap between Pre-FIRM parcels, high-risk flood zones, and low land values in both Harris and Galveston Counties, which indicates a possible correlation between parcels targeted by BW12 and demographic conditions.

The next section develops a framework for identifying areas potentially most impacted by the new flood policy approach based on how real estate markets reacted to BW12 during the nearly 2-year period of unmitigated implementation.

3.2. Hypotheses, variables, and methods

Potential measures of local real estate market impacts include changes in sales price, number of sales, appraisal value, assessed tax value, and list price reductions. Of these, list price reductions (LPRs) are more comparable from property to property within a local area, while still reflecting real-time changes in market price. List price reductions are dynamic indicators of how buyer demand interacts with price; and as co-incident indicators they change with market conditions [33–35]. Lagging indicators such as land value, appraisal value, tax value, number of sales, and sales price typically change too slowly to capture the very short-term impacts of interest [33–35]. For the short-term analysis performed in this study, LPR was the most practical indicator.

The analysis set out to identify statistically verified areas where BW12 insurance rule changes had negative impacts on the list price of properties. The study intended to develop a framework of analysis that was portable and comparable with other regions of the US using commonly available data at the community scale. Analyzing market data at the parcel scale would offer a fine-

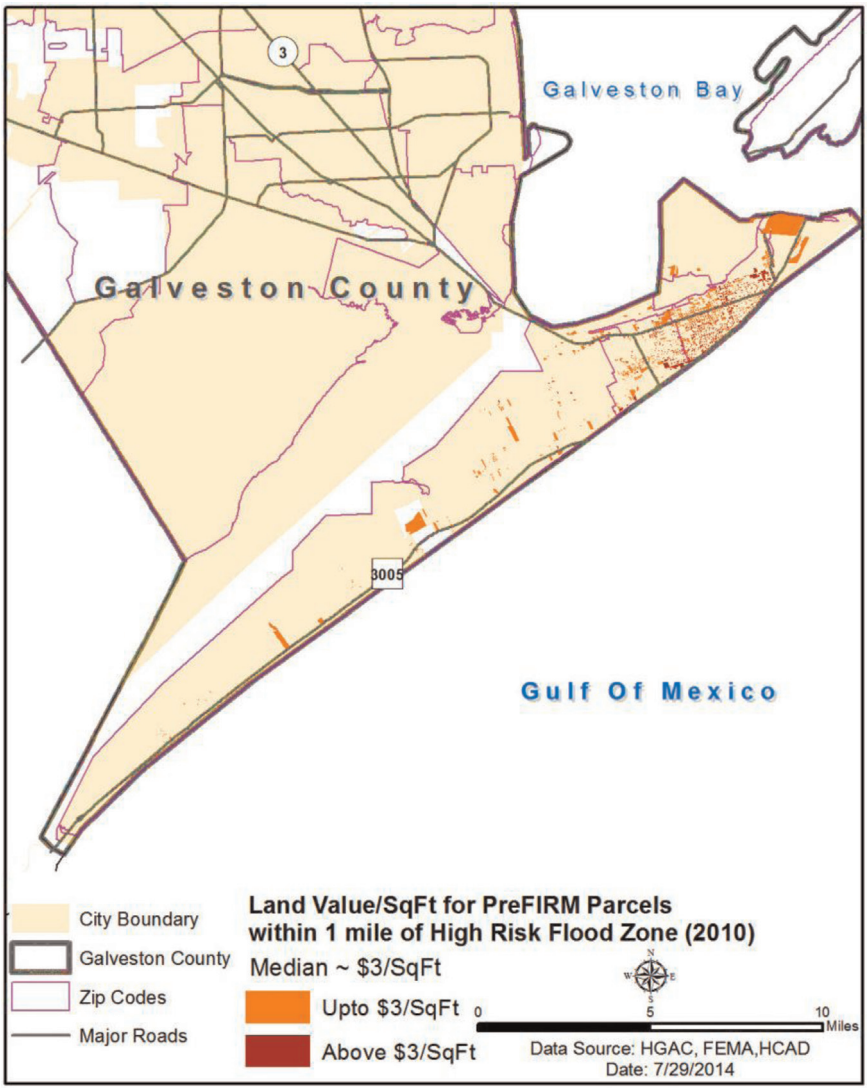

Fig. 4. Land value of Pre-FIRM structures within 1 mile of high risk flood zones in Galveston County.

grained analysis but would be impractical in large urban areas with millions of parcels (Harris County has over 1.7 million parcels). Depending on the size of the area and the availability of data, census block, census tract, zip code, flood zone, subdivision, neighborhood, or super-neighborhood boundaries could be used as proxies for community (instead of using parcels). This study selected zip code because real estate market data and demographic data were readily available online at the zip code level for the Houston-Galveston region, covering 16 of the 17 zip codes in Galveston County and covering 128 of the 132 zip codes in Harris County. The five inactive zip codes were ignored and two zip codes with incomplete market data were removed, resulting in a usable population of 142 zip codes with data.

Table 2 summarizes the hypotheses, variables, and methods used in the study. The first hypothesis of the study was that BW12 impacts were associated with real estate market changes. The impact variable for this hypothesis was percent of list price reductions (LPRs) by zip code. List price reductions are the percent of real estate listings (i.e., properties for sale) with at least one reduced sales price, tracked monthly by zip code. In general, a high LPR indicates a relatively weak (or unstable) real estate market, and a low LPR indicates a strong (or stable) market. For example, during the 2007–2009 recession, LPRs typically surpassed 50% in markets throughout the United States; indicating at least one price reduction each for more than half of all properties was needed in order to attract a sale. Real estate research firms and market economists track the LPR indicator. LPR is a direct measure of real estate market quality and it varies in real time with market fluctuations (no lag). The LPR is comparable across markets, regions, and neighborhoods with different price points, making it a better indicator than sales price for the purposes of this study.

In this study, LPR serves as an interval level variable that measures the degree of market impact associated with BW12 implementation. The planned elimination of subsidies, the simultaneous updating of flood maps, and the resulting non-trivial increases in insurance premiums are expected to have reduced the demand for properties impacted or perceived to be impacted by the law, making them relatively harder to sell and therefore increasing the percent of properties with price reductions (LPRs). A set of monthly LPR data ($N=6786$) was obtained for a four year period from May 2010 to April 2014, representing approximately two years before and two years after passage of the Biggert–Waters Act. The study used publicly available zip code data, including means and standard deviations, for all available zip codes in Harris and Galveston Counties throughout the 48-month period of analysis. Consequently, the study was able to use the population mean

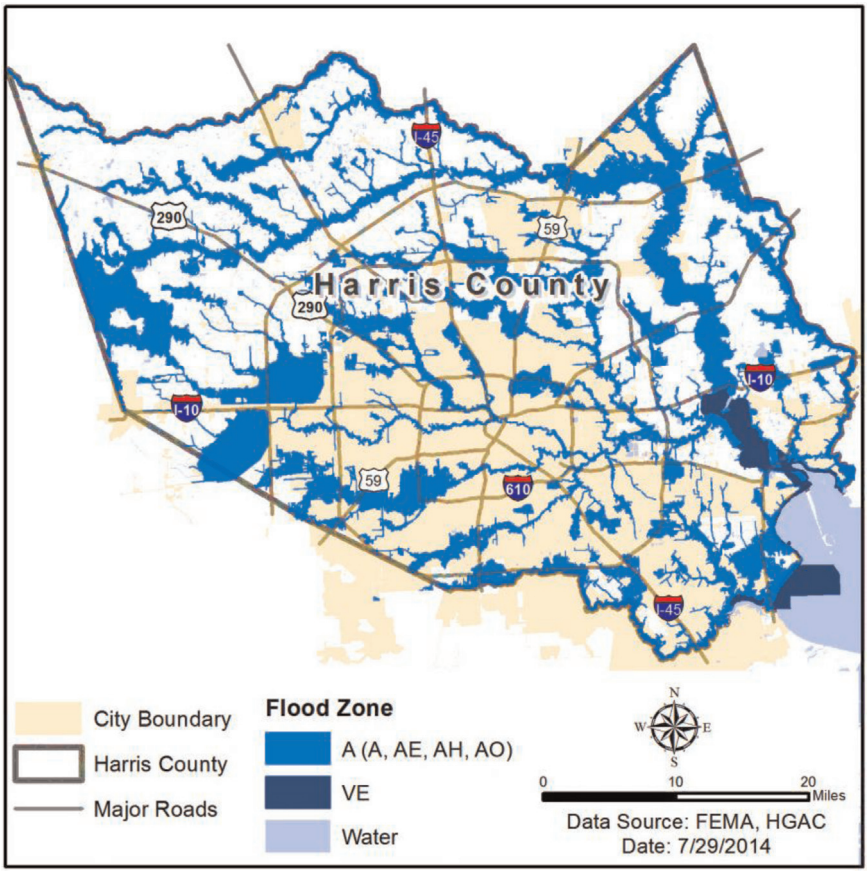

Fig. 5. High risk flood zones in Harris County.

as the expected mean to test the null hypothesis that there is no difference between the sample mean and the expected mean. With the confidence level set to $\geq 95\%$, the study tested the null hypothesis for differences between the mean list price reduction (LPR) for each sample zip code and the mean of the population of zip codes. In cases where the difference was significant (at $p < 0.05$), then the null hypothesis was rejected and a pretest/posttest analysis was performed using BW12 as the intervention.

The criterion for the pretest/posttest analysis was that any significant changes in mean LPR would have to be "causally relevant" in a qualitative sense as defined by Berg-Schlosser et al. (2008:8) [36] and Yin (2013:189) [37], which refers to a combination of conditions that leads to a relevant outcome, and to causal sequences that must occur linearly in time. In this case, change in LPR is an outcome relevant to flood policy reform, and the sequence of LPR change is relevant only under one time condition. Under a pretest/posttest design with BW12 as the intervention, causally relevant change between the before and after time periods is only observed when real estate market conditions suddenly worsen during the entire BW12 period.

Monthly LPR data for approximately two years prior to BW12 established the pretest trend for each zip code. Likewise, monthly LPR data for approximately two years after BW12 established the posttest trend. There were four possible conditions relative to changes in the mean LPR: (1) high before and high after; (2) high before and low after; (3) low before and high after; and (4) low before and low after. Only condition #3 is causally relevant and indicates measurable impacts to local real estate markets that took place during the BW12 period. Conditions #1 and #4 denote no change in market state before and after the intervention, and condition #2 indicates improvements during the BW12 period. Only condition #3 reflects movement from stable market conditions before the intervention to worsening market conditions after the intervention, as measured by significant changes in the LPR. Therefore, zip codes that were both causally relevant and statistically significant were necessary to reject the null hypothesis. Real estate markets in these zip codes would have the highest chance of exhibiting measureable impacts during the BW12 period.

Statistical significance was determined using paired z-tests. Sample variances were highly unequal, ranging from 27 to 229, and skewness was substantial, ranging from -2.44 to $+0.99$. Unlike the t-test, the z-test does not require equal variances. However, to use a z-test (one-tailed) at the range of sample sizes within each zip code ($n = 28$–48), the standard error of the population mean must be known. This study utilized the entire population of zip codes in the Houston-Galveston region (rather than a random sample), so population level information was indeed known. The population standard error for the study was $\sigma_{\bar{x}} = 0.111$ and the population variance was 84.31 ($N = 6786$). Most, but not all, of the sample sizes in the study were sufficiently large ($n > 30$) so that lack of a normally distributed population did not invalidate the test. Normal probability plots (using z scores) revealed non-normal distributions for 72 of the 142 zip codes ($p = 0.05$). Further probability plots of the sample means found that the sample means were in fact normally distributed ($r = 0.9943$, $p = 0.01$), thus confirming sufficient normality to meet the test conditions. Under these conditions the z-test was the most appropriate statistical test.

The second hypothesis of the study is that the distribution of impacts was disproportionately associated with income. Flood insurance reform potentially impacts all population groups, including wealthy property owners, business owners, middle-class

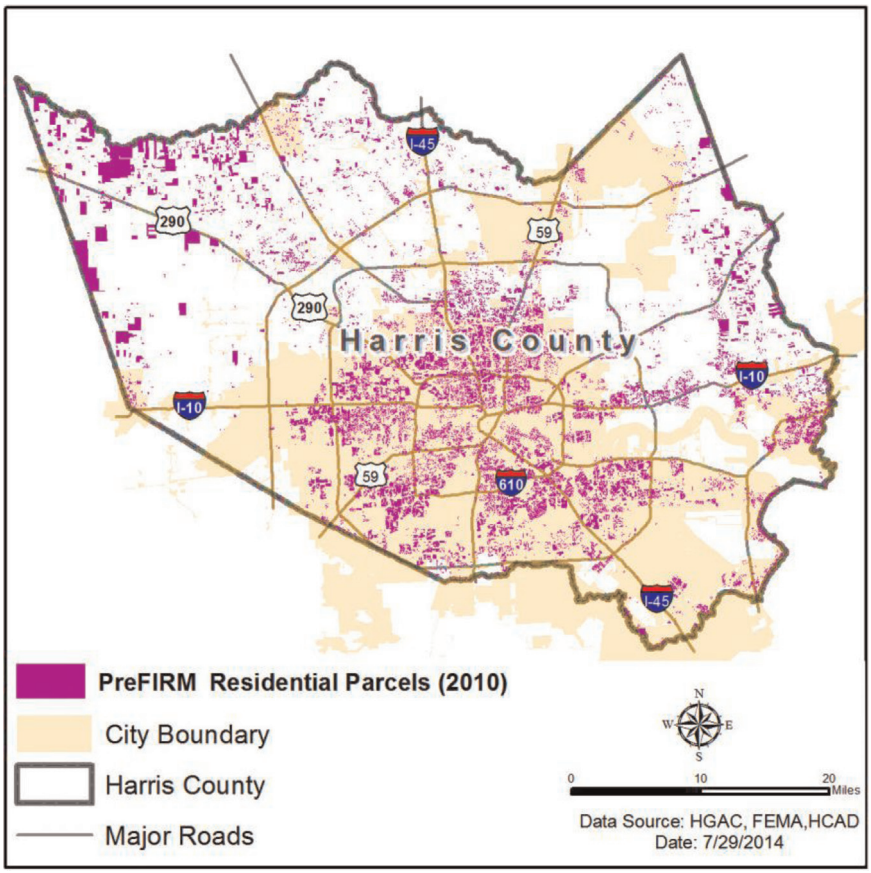

Fig. 6. Pre-FIRM structures in Harris County.

homeowners, renters, and low-income residents. Certain properties were targeted by BW12 (e.g., properties in flood zones, pre-FIRM and repetitive loss properties, vacation homes, businesses), but it is not clear that any particular income group is affected specifically. However, because flood insurance is the responsibility of property owners, all of the primary impacts of BW12 fall on property owners as a group, with renters absorbing secondary impacts as owners transfer higher insurance costs into higher rents. This study asks if the impacts of BW12 take on a geographic significance, and in places where they do is there an over- or underrepresentation of certain income groups. This study adopted a methodology employed by the Environmental Protection Agency [38] to investigate disproportionate impacts of environmental regulations on low-income and minority population groups. After identifying significant zip codes using the previously described methodology (i.e., zip codes with statistically significant market impacts), the study compiled demographic data from the US Census [39] for each significant zip code. The potential for disproportionate impact by income was determined as the ratio of percent in poverty in the significant zip codes to the percent in poverty in the county, and in the state. Ratios above 1.0 indicate a positive potential for disproportionate impact by poverty status.

The third hypothesis of the study is that the distribution of impacts was disproportionately associated with race. Like income, it is not clear that BW12 affected any particular racial or ethnic group specifically. Certainly, property owners as a group are racially overrepresented, but this study is asking if geographic areas with measurable real estate impacts during BW12 also have an over- or underrepresentation of certain races. Hypothesis #3 used the same EPA methodology as previously described [38]. The potential for disproportionate impact by race was determined as the ratio of percent minority in the significant zip codes to the percent minority in the county, and in the state. Ratios above 1.0 indicate a positive potential for disproportionate impact by minority status.

3.3. Limitations of the research methods

The methodology of the research was limited due to a lack of access to NFIP parcel data and property sales data. However, balancing this limitation was the fact that other locations may experience the same lack of data and that a universally applicable approach was more advantageous. The study intent was to develop a framework for identifying geographic areas with a high probability of intense impact associated with BW12. Some areas may have been so affected that selling property was unviable, a situation that would be difficult to measure using list price reduction data. However, complementing this limitation is the simultaneous possibility that wealthier property owners could intentionally postpone sales and strategically wait out the period, something that low-income property owners are less able to do. Furthermore, list price reduction data does not imply a property sale. The LPR includes unsold properties with price reductions, so in cases with few sales LPR would be high, correctly indicting market instability. The use of LPR as the outcome variable was therefore advantageous. Finally, focusing the analysis on clusters of pre-FIRM properties instead of the entire zip code would likely sharpen the demographic analysis.

An advantage of the research framework is that it is transportable to other locations because the data are open source and the analysis is relatively straightforward. Also important is that the framework focused on vulnerable areas and vulnerable population groups instead of individual property owners, which facilitates

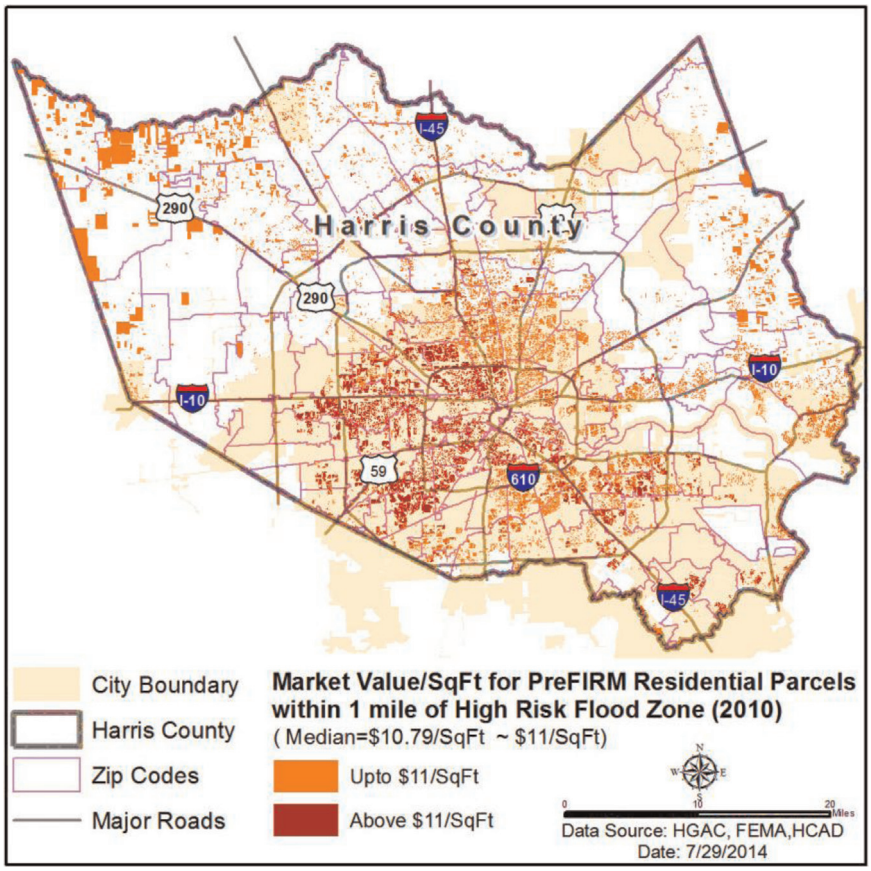

Fig. 7. Market value of pre-FIRM residential structures within 1 mile of high risk flood zones in Harris County.

public policy discussions on long-term land use planning, hazard planning, flood risk management, and climate action planning in addition to insurance rates. While specific findings for the study area may not generalize to the entire United States, the topic has national implications. Many counties and metropolitan areas across the US are expected to have zip codes with co-located flood vulnerability and social vulnerability whose real estate markets would be disproportionately impacted by flood insurance reform. The methodology developed herein could be applied across the United States as a screening tool to estimate the potential extent of the problem. It is possible that other, unstudied factors affected real estate markets both within and outside of the statistically significant impact areas during the BW12 period. Because of the limitations in methodology, this study cannot prove the source of the real estate impacts observed. However, the methodology is robust enough to identify whether or not flood insurance reform may have disproportionate impacts on local real estate markets; thereby establishing the salience of the research question and the need for additional analysis. Further research would be needed to quantify the contribution of flood insurance reform to real estate markets.

4. Results

Table 3 presents descriptive statistics for LPR market data in Galveston and Harris Counties. In general, list price reductions went down after BW12 in both Galveston and Harris Counties, with Harris County experiencing a greater reduction. Most zip codes (113 out of 142 total zip codes with data) experienced a constant or improving real estate market where fewer and fewer properties needed price reductions in order to sell. Some zip codes, however, did experience worsening market conditions.

Paired, one-sided *z*-tests of independence were performed on LPR data for each zip code (over a 48-month period) to test the null hypothesis that there was no difference between a zip code mean LPR and the expected mean LPR of all zip codes. Results exceeding 95% probability (for a right-tailed test at $p < 0.05$) were unusually

Table 2
Hypotheses, variables, and methods used in this study.

Hypotheses	Variables	Methods of Analysis
1. BW12 was associated with real estate market impacts.	Impact variable = Percent of properties with list price reductions	Paired *z*-tests, and pretest/posttest analysis
2. The distribution of impacts was associated with income.	Correlated variable = Percent in poverty	Ratio of percent in poverty
3. The distribution of impacts was associated with race or ethnicity.	Correlated variable = Percent minority	Ratio of percent minority

Table 3
Descriptive Statistics for List Price Reductions[a] in Harris and Galveston County, Before and After Enactment of the Biggert-Waters Act[b].
Source: Calculated using monthly list price reduction data from Zillow.com, tracked by zip code [40].

	Galveston County		Harris County	
	Before BW12 (5/2010–6/2012)	**After BW12 (7/2012–4/2014)**	**Before BW12 (5/2010–6/2012)**	**After BW12 (7/2012–4/2014)**
Number of zip codes with data available[c]	15	15	127	127
N				
(No. of monthly data points)	390	330	3299	2767
Mean				
(% of properties with price reductions, LPR)	34.78%	32.33%	35.82%	28.15%
Median				
(% of properties with price reductions, LPR)	35.01%	32.78%	35.78%	27.87%
Standard deviation	7.81	8.24	7.82	9.19
Range	47.09	48.01	58.89	61.68
Variance	61.03	67.89	61.09	84.45

[a] List price reduction (LPR) is the percent of properties with reductions in list price during a month, within a specific zip code. These data yield one data point per month per zip code.
[b] The pre-BW12 period is from May 2010 to June 2012. The post-BW12 period is from July 2012 to April 2014.
[c] Market data for zip codes 77617 (Galveston) and 77010 (Harris) were incomplete so these zip codes were not included in the analysis.

Table 4
Results of paired *z*-tests comparing actual versus expected mean LPRs before and after enactment of the Biggert–Waters Act.[a]

Zip code	*z*-value Before BW12	*p*-value		*z*-value After BW12	*p*-value	
		<0.01	<0.05		<0.01	<0.05
77563	0.07323	–	–	0.03767	–	✓
77339	0.07071	–	–	0.00276	✓	–
77520	0.06239	–	–	0.00000	✓	–
77093	1.00000	–	–	0.01712	–	✓
77536	0.07228	–	–	0.00004	✓	–
77087	0.22677	–	–	0.02219	-	✓
77017	0.73549	–	–	0.00766	✓	–
77586	0.15662	–	–	0.00013	✓	–
77058[b]	0.02552	–	✓	0.00000	✓	–
77061	0.40247	–	–	0.00918	✓	–
77504	0.06926	–	–	0.00698	✓	–
77012	0.99205	–	–	0.00366	✓	–
77587	0.97235	–	–	0.00011	✓	–
77336	0.97651	–	–	0.01492	–	✓
77547	1.00000	–	–	0.00000	✓	–
77050	0.97889	–	–	0.00567	✓	–
77046	0.99969	–	–	0.00000	✓	–

[a] Zip codes that were not significantly different from the expected mean or that were not causally relevant are not shown.
[b] Zip code 77058 was significantly high before BW12 (at $p<0.05$), and was significantly higher still after BW12 (at $p<0.01$), indicating a causally relevant change.

and significantly higher than the expected population variance, and these were the zip codes of interest. Table 4 presents the results of performing paired *z*-tests under these constraints, and lists zip codes that were significantly different than the expected mean and that were also causally relevant. Causal relevance was determined by identifying zip codes that met condition #3 in the pretest/posttest trend analysis (i.e., low LPR before, high LPR after). Fig. 8 summarizes the results of the pretest/posttest analysis graphically. Seventeen zip codes met the conditions for both statistical significance and causal relevance. Figs. 9 and 10 map these zip codes.

All but two of the significant zip codes were located near the following water bodies: Galveston Bay, Marchand Bayou, San Jacinto River, Goose Creek, Spring Gully, Buffalo Bayou, Boggy Bayou, Armand Bayou, Greens Bayou, Sims Bayou, Braes Bayou, Berry Bayou, and Luce Bayou. Parts of all of the significant zip codes were located in flood zones AE, VE, and Coastal A. Figs. 9 and 10 show that most of the significant zip codes contain dense clusters of pre-FIRM properties. BW12 targeted older properties located in high-risk flood areas, so impacts to geographic areas with both of these characteristics were expected.

The findings thus far support the first hypothesis, and support the possibility that BW12 was associated with measurable real estate market impacts. The analysis has rigorously identified a small number of zip codes that experienced statistically significant market impacts only during the BW12 period and which contained a large number of properties targeted by BW12 (i.e., pre-FIRM and high-risk flood status). Of course, BW12 likely impacted additional areas and individual properties as well, but their impacts were not widespread enough to meet the strict criteria established for this analysis, and the analysis itself was not fine-grained enough to capture every impact.

To address the second and third hypotheses, the study compiled demographic information for the 17 significant zip codes. Descriptive information summarized in Tables 5 and 6 for Galveston and Harris Counties, respectively, reveals a wide range of socio-economic status among populations in the significant zip codes. Unemployment ranges from a low of 0% to a high of 12.3%, and median household income ranges from a low of $32,222 to a high of $86,800. The study used data from the US Census American Community Survey 2008–2012 to determine demographic ratios for income and race. Higher ratios indicated a potentially disproportionate impact, the higher the ratio the higher the potential disproportionality.

As presented in Table 7 for the Harris County significant zip codes, people in poverty were overrepresented by a factor of 11% compared to the county, and again overrepresented by 14% compared to the state. These differences were relatively large considering that the county and state poverty rates were nearly equal. The significantly impacted zip codes of Harris County contained a disproportionate percentage of people in poverty. Poverty rates in 10 of the 16 significant zip codes exceeded the county average, indicating that zip codes with high poverty levels bore the brunt of the impacts in Harris County. Minorities in the impacted zip codes were underrepresented compared to the county (by −25%) and overrepresented compared to the state (by 13%); but given that Harris County is a minority–majority county that is 50% more minority than the state, minorities in the Harris zip codes were not necessarily overrepresented. Percent minority in five of the 16 significant zip codes exceeded the county average. These results indicate that overrepresentation by poverty status was relatively more widespread than overrepresentation by minority status in Harris County.

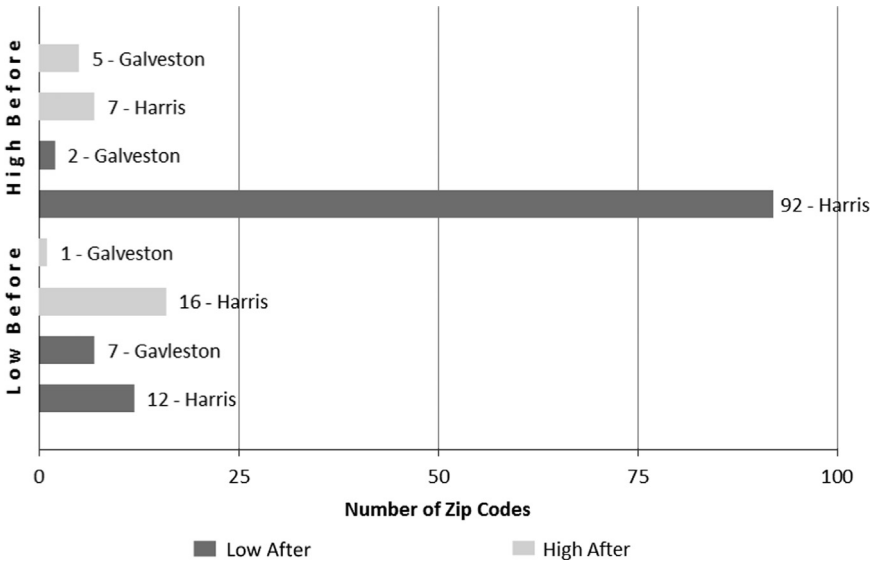

Fig. 8. Number of zip codes with change in list price reductions before and after enactment of the Biggert-Waters Act in Harris and Galveston Counties from May 2010 to April 2014. (Note: "Low" indicates a strong market and "High" indicates a weak market. There were a total of 142 zip codes with data available.).

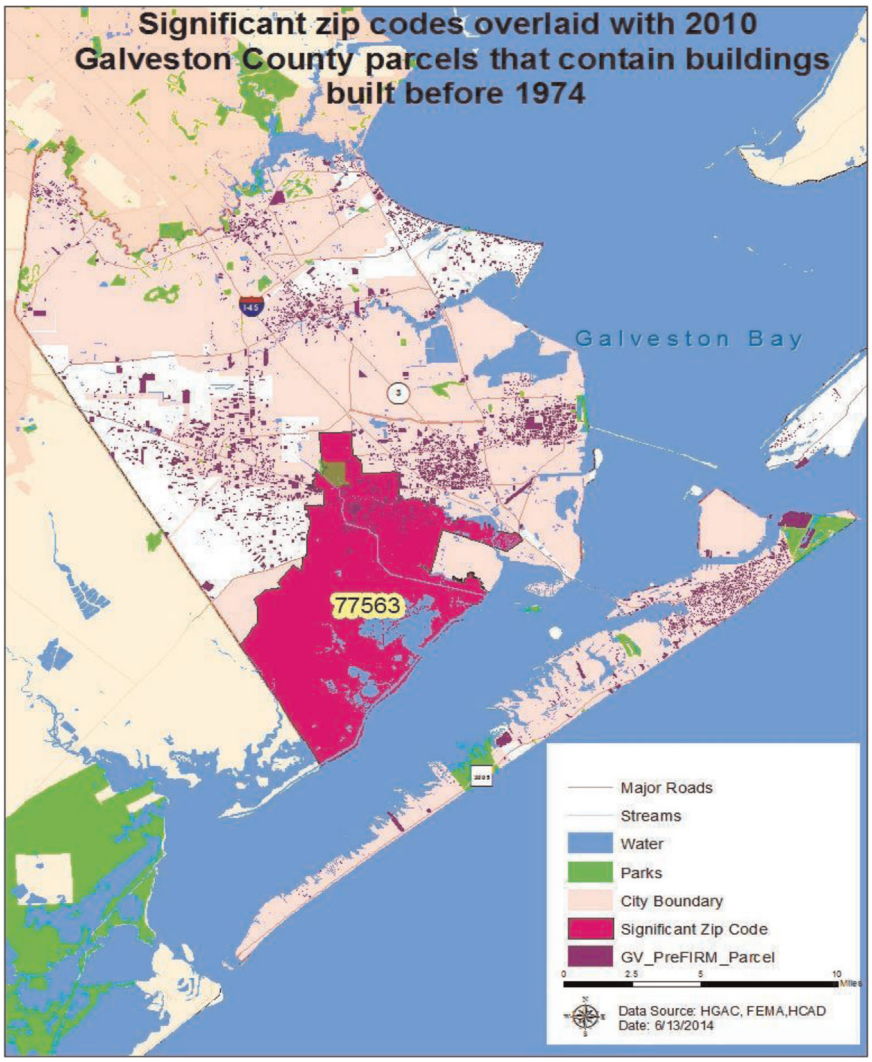

Fig. 9. Significant zip codes in Galveston County.

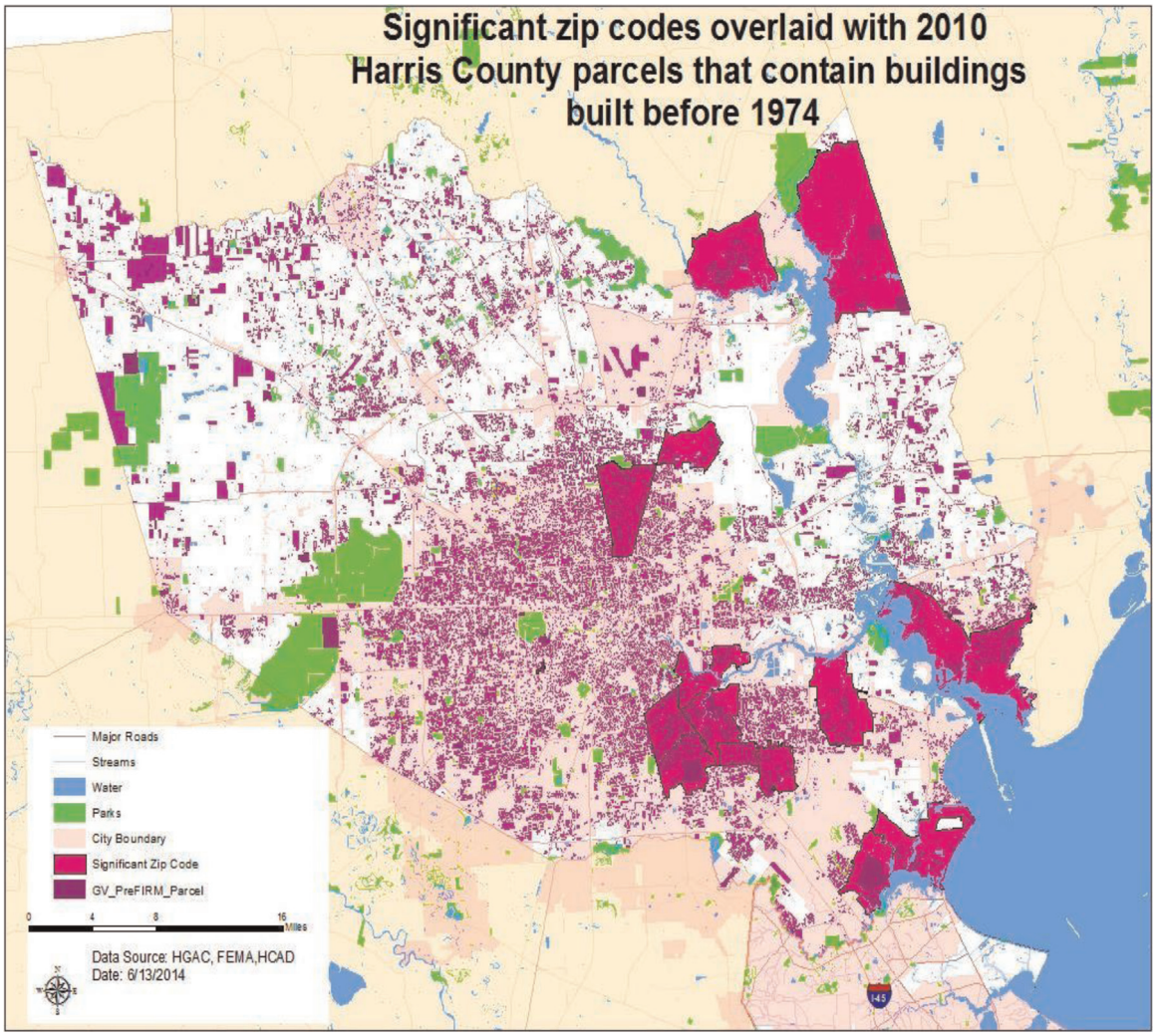

Fig. 10. Significant zip codes in Harris County.

Table 5
Demographic information for significant zip codes[a] in Galveston County.
Sources: Calculated or obtained from 2011 data from City-Data [32], 2012 data from the US Census American Community Survey 2008–2012 [39], and 2013 FEMA Flood Maps. All numbers in the table are from 2011 unless otherwise noted.

Galveston County significant zip code (77563)		**Galveston County** (all zip codes)
Total population	9488 (2012)	300,484 (2012)
Urban/rural areas	91.5%/8.5%	94%/6% (2012)
Pre-FIRM homes[b]	1455	45,219
Adjacent to water	1 of 1	16 of 16
Within 2 Miles of a flood zone	1 of 1 (2013)	16 of 16 (2013)
Median income	$49,017	$56,561 (2009)
Unemployment rate of the civilian labor force	10% (2012)	8.1% (2012)
Percent of residents who are renters	32%	34%
Residents with income below poverty level	18.6%	15.2% (2009)
White population	56%	59%
Latino population	20%	22%
Black population	24%	14%
Asian population	0.5%	3%

[a] "Significant" zip codes refer to zip code areas where there was a positive increase in List Price Reductions after the enactment of BW12, indicating zip codes that were impacted and therefore geographically significant.
[b] Pre-firm homes were estimated as the number of homes built before 1970.

For the Galveston County significant zip code, people in poverty were overrepresented by a factor of 32% compared to the county, but when compared to the state the poverty rates were about equal. Minorities in the impacted zip code were overrepresented by 43% compared to the county, and again overrepresented by 17% compared to the state. Given that Galveston County had lower rates of poverty and a lower percentage of minority residents than the state, both poor people and minorities in the impacted zip code were overrepresented. These results indicate that overrepresentation by both poverty and minority status was a concern in Galveston County, although the geographical extent of the impact was contained within a single zip code.

5. Discussion

Despite marked improvement in the percent of post-BW12 list price reductions in the Houston-Galveston real estate market, 17 zip codes experienced significant ($>95\%$ probability at $p=0.01$ and 0.05) increases in LPRs during the BW12 period (7/2012–3/2014). This finding is statistically significant and based on large sample sizes of 330, 390, 2767, and 3299. These findings tentatively support (but do not prove) the hypothesis that BW12

Table 6
Demographic Information for Significant Zip Codes[a] in Harris County.
Sources: Calculated or obtained from 2011 and 2012 data from City-Data [32], 2012 data from the US Census American Community Survey 2008–2012 [39], and 2013 FEMA Flood Maps. All numbers in the table are from 2011 unless otherwise noted.

	Harris County significant zip codes (77093,77536,77087,77017,77586,77061,77504,77012, 77587,77336,77547,77050,77046,77339,77520,77058)	**Harris County** (all zip codes)
Total population	295,753	4,253,700 (2012)
Urban/rural areas	> 95%/ < 5% (except 77336 is 56% rural)	99%/1% (2012)
Pre-FIRM homes[b]	58,142	437,599
Adjacent to water	14 of 16 significant zip codes	Most of the 127 zip codes
Within 2 Miles of a flood zone	16 of 16 significant zip codes (2013)	127 of 127 zip codes (2013)
Median income	$32,222–$86,800	$49,392
Unemployment rate of civilian labor force	0.0%–12.3%	8.2% (2012)
Percent of residents who are renters	17%–66%	45%
Residents with income below poverty level	7.5%–31.5%	18.5%
White population	28%	33%
Latino population	62%	41%
Black population	8%	18%
Asian population	3%	6%

[a] "Significant" zip codes refer to zip code areas where there was a positive increase in List Price Reductions after the enactment of BW12, indicating zip codes that were impacted and therefore geographically significant.
[b] Pre-firm homes were estimated as the number of homes built before 1970; 97% of the pre-firm homes are clustered in 12 of the 16 significant zip codes.

impacts were associated with measurable changes in housing market strength in some communities. In general, most of the statistically significant zip codes had high densities of pre-FIRM properties and were located near water or in high-risk flood zones. However, the case study counties are riddled with flood zones, water bodies, and pre-FIRM properties, so this finding alone does not differentiate these areas. What does differentiate the areas of significant impact is that they tended to be poorer relative to Harris and Galveston counties, and more minority in the case of Galveston. These findings support the second and third hypotheses that BW12 impacts occur disproportionately in low-income and minority areas. The strength of these findings suggests this is a fruitful area for continued study. The paper has provided a straightforward approach for analyzing the real estate market impacts of flood insurance policy change, and it has provided a basis for recommending serious consideration of disproportionate impacts to low-income and minority population groups when implementing risk-based flood policies.

The methodology developed for this study is transportable to other communities that were impacted by BW12; in fact, the author intends to expand the current study to other Gulf Coast cities to identify areas in which case studies can be performed and to facilitate cross-state comparisons. It is relatively rare for a single law to contain so many sweeping changes at once, but in cases where other hazards are subject to similar legislative change the methodology developed in this paper could be adapted for use with other hazards. Adapting the methodology for use in other countries would simply require access to local level real estate and demographic data before and after the law change. If these data were available, within-country studies would be relatively straightforward. However, such a study would be significantly more complex if it were comparative, as it would require developing cross-nationally equivalent measures of impact.

5.1. US policy implications

The expected outcome of flood insurance reform is that the largest rate increases will occur in areas with the highest risk of flooding (in the lowlands, near water bodies, and along the coast), the highest number of pre-FIRM and repetitive loss properties, the greatest number of businesses, and recently updated maps. Indeed, anecdotal reports of spiking insurance rates were often associated with properties with many of these characteristics. This study has looked beyond individual rate increases to examine collective impacts, under the presumption that flood insurance reform has the power to trigger market change at the community level and leave some communities further economically segmented. Using the unique window of observation provided by the BW12 implementation period, the research results indicate that some local real estate markets (i.e., zip codes) that had been stable before BW12 did significantly worsen after the passage of BW12. As expected, most of these were located along the coast and near major bayous and rivers, and most contained clusters of several thousand pre-FIRM properties. Unexpectedly, these areas were disproportionately poor in Harris County, and disproportionately poor and minority in Galveston County. In its attempt to eliminate

Table 7
Percent in poverty and percent minority in the significant zip codes compared to the county and the state.
Source: Calculated using data from the US Census American Community Survey Demographic and Housing Estimates 2008-2012 [39]; and using the methodology of the EPA [38]. For the purposes of this table, the term "minority" refers to all individuals except Hispanic and non-Hispanic whites as defined by the US Census (https://ask.census.gov/faq.php?id=5000&faqId=6849). "Significant" zip codes refer to zip code areas where there was a positive increase in List Price Reductions after the enactment of BW12, indicating zip codes that were impacted and therefore geographically significant. This table presents aggregated data for all of the significant zip codes. "Overrepresented" zip codes are those significant zip codes whose populations of low-income and/or minority groups exceed the percent low-income and/or minority for the county and/or state in which they are located. For these instances the ratio is greater than one.

		Percent of population in signif. zip codes (%)	**Percent of population in the county (%)**	**Percent of population in the state (%)**	**County to state ratio**	**Zip code to state ratio**	**Zip code to county ratio**
Harris County	% Poverty	19.9	17.9	17.4	1.03	**1.14**	**1.11**
	% Minority	27.1	36.0	24.0	1.50	**1.13**	0.75
Galveston County	% Poverty	16.9	12.8	17.4	0.74	0.97	**1.32**
	% Minority	28.1	19.7	24.0	0.82	**1.17**	**1.43**

discounted and subsidized insurance policies to improve NFIP's financial soundness, BW12 may have introduced unintended consequences in micro real estate markets with pre-existing and concurrent vulnerabilities.

What do these findings say about the significance of changing the risk paradigm? The unspoken policy implication of flood insurance reform is that, at high enough levels, it acts to change land use in the name of reducing flood risk. Rather than by local decision-making, federal imposition of full-cost flood insurance, which is legally required for all federal-backed mortgages, acts to induce local land use change. As evidenced by the backlash against the Biggert–Waters Act and the subsequent semi-repeal of BW12 by the Grimm–Waters Act, 21 months of full-bore insurance reform did indeed have significant impacts on real estate markets and produce fears of potential land use changes, as publicized in a steady stream of newspaper accounts. If Congress did not intend to reduce flood risk via land use change by way of BW12, it certainly may have appeared that way to many people. The problem of imperfect information triggers market uncertainty [24]. Another possibility is that the purpose of flood insurance reform, which is here to stay in whatever form it takes, was to resolve the deep indebtedness of the NFIP program. Charging higher rates might allow the NFIP program to repay the US Treasury for money borrowed in the aftermaths of Katrina and Sandy. The Congressional author of the bill as well as the FEMA Administrator in charge of its implementation each declared that the immense debt triggered NFIP reform. Congresswoman Judy Biggert, speaking in 2011 after unanimous House passage of her bill, declared:

> We need to put the National Flood Insurance Program back on stable financial footing so that it can provide homeowners with reliable coverage without putting taxpayers on the line for billions in losses. This legislation will give the program long-term stability, help draw better flood maps, and initiate actuarially sound pricing [41].

FEMA Administrator Craig Fugate, in testimony to the Senate Committee on Banking, Housing, and Urban Affairs one year after the enactment of BW12, explained:

> [The] annual premium shortfall during catastrophic flooding events, such as Hurricanes Katrina and Sandy, required FEMA to use its statutory authority to borrow funds from the U.S. Department of Treasury. These funds were used to pay covered flood damage claims to policyholders. Although payments have been made to reduce this obligation, $24 billion in debt remains….Congress determined that further reforms were needed to make sure the NFIP was financially sustainable….To execute these reform, Congress passed the Biggert-Waters Act [42].

Still, the utter lack of Congressional debate and public discussion about the passage of BW12 likely contributed to misunderstandings about its purpose. NFIP reform was necessary to make the program fiscally sound by eliminating subsidies in about 20% of its policies. The National Research Council concluded that the "NFIP is constructed using an actuarially sound formulaic approach for the full-risk class of policies, but is financially unsound in the aggregate because of constraints (i.e., legislative mandates) that go beyond actuarial considerations. The Biggert-Waters Flood Insurance Reform Act "directs adjustment of fiscal practices to move the NFIP to a more fiscally sound approach" [43:4]. In other words, the real purpose of flood insurance reform is to purge subsidies and discounts in order to make the program financially sound, thereby preventing future increases to the existing debt.

But in purging discounts and subsidies, even on a multi-year timetable, BW12 unleashed concerns far beyond the discounted insurance premiums of 20 percent of NFIP policyholders—concerns that involved the compounding impacts of climate change and rising sea level; expansions of risk, flood zones, and flood maps over time; and the sustainability of existing urban settlements and economies. Gulf Coast cities that depend on their coastal locations for port commerce, energy extraction, and/or tourism (e.g., Houston, Galveston, New Orleans, and Pensacola) cannot simply move. The country depends on populations living and working in these cities, a fact that implies a rationale for past subsidies. While the paradigm has definitely shifted, adopting full-risk rates is no substitute for regional land use planning that addresses the fundamental tension between urban development and hazard risk. If there was a time when urban development was indirectly encouraged through insurance subsidies, with less concern for risk, that time no longer exists. We are now in a time where there is perhaps a willingness to restrain development out of concern that the risks and the costs are too great. In considering how to balance urban development and hazard risk, policymakers should seriously consider not only the affordability of flood insurance for individual property owners, but potentially disproportionate impacts to already vulnerable communities.

This study has demonstrated the possibility of reductions in property values in areas subject to flooding as a direct result of BW12. Flood insurance reform may also result in fewer people choosing to purchase flood insurance because of its higher cost. With fewer people insured and major floods predicted to increase in frequency and severity, uninsured people who cannot afford to rebuild would likely be displaced. Flood insurance reforms proposed under BW12 may also result in increased interest in hazard mitigation activities, such as structure elevation, floodproofing, levees, and sea walls. This would result in more people being able to stay in place. BW12 may also cause some people to migrate away from areas at high risk of flooding. Such voluntary migration might leave behind a swath of lower cost properties that could attract lower income people back into the high risk flood areas, either as renters or owners. The dynamics are complex and are deserving of further study.

5.2. International implications

Many countries with areas at high flood risk are concerned about the loss of life and property and the high cost of mitigation. While the United Kingdom and France use the private insurance market to provide mandatory insurance against such losses, the Netherlands (which faces higher flood risk) offers no flood insurance at all and Germany offers private insurance only on a voluntary basis [44]. Recent reforms to the UK's flood insurance system added a surcharge to all homeowners to cover the high cost of damage to homes in high-risk areas. The amount of the surcharge varies with the size of the home to account for lower income residents [45]. The system in the Netherlands is based on government-funded structural protection against floods combined with government relief after a flood. These examples demonstrate a variety of approaches to insuring against flood losses, as well as universal concern about increasing costs resulting specifically from climate change.

Cross-country comparisons between the US and Europe are flawed because relative poverty rates in Europe are significantly lower than poverty rates in the US, according to a study by the Brookings Institute [46]. The study found that the US relative poverty rate (17.0%) was second only to Mexico's (20.2%). The issue addressed in this paper was whether flood insurance reforms undertaken to deal with increasing risk and cost will have disproportionate impacts on the poor. The US simply has a larger population of poor people, especially in the Gulf Coast, due to historical demographic conditions and social policies.

Consequently, flood reform in the US will likely impact more poor people than equivalent flood reform in European countries, but comparability remains problematic.

A new flood insurance model is being implemented in Mexico and Bangladesh in collaboration with the World Bank to insure poor people who live in high risk coastal areas [47]. Both programs offer catastrophe bonds to cover immediate payouts after a predetermined level of rainfall or flood height. By design, these reforms are not likely to induce a drop in property values, cause unaffordable insurance rates, or trigger real estate market instability. These policy reforms are designed to address poor people's immediate needs in a disaster by eliminating the delay in distributing relief.

Few if any countries outside the US follow the US model of government flood insurance. The reforms of BW12 were an attempt to increase insurance coverage and eliminate subsidized rates, thus (theoretically) bringing US flood insurance closer to the private model. These reforms were approved without consideration of impact or cost to poor people. An “affordability study” was tacked on under GW14 which simultaneously added a surcharge that makes the insurance even more costly to low-income people. Based on the analysis in this paper, the probability that BW12 reforms were associated with negative market impacts in vulnerable areas was significantly greater than chance. These findings offer evidence to justify further study as the reforms continue to be altered. The international implications of these findings are that countries with high poverty rates and with highly populated areas of high flood risk must consider the potentially disproportionate impacts of their decisions.

6. Conclusions

How can local decision-makers plan for vulnerable communities, such as the vulnerable communities identified in this study, under a new risk paradigm that has no place for discounts and subsidies? This paper developed a simple framework for identifying communities most impacted by the insurance reforms promulgated under the Biggert–Waters Flood Insurance Reform Act, using real estate market change as the impact variable and zip codes as the unit of analysis. The main finding—that low-income and minority areas were overrepresented in the impacted communities—raises questions about the possibility of disproportionate impacts from flood insurance reform in particular, and from the shift to risk-based flood policy in general. One benefit of statistically identifying the most vulnerable areas is that they can be included in ongoing policy adjustments as well as long-term planning efforts to balance flood risk and development. Additional research using the identified areas as case studies and applying qualitative or quantitative methods would provide a deeper understanding of flood risk vulnerability. Possible research projects include longitudinal trends in land use and migration, and cross-sectional studies on how different population groups are able to adapt to policy reform.

Acknowledgements

This research was supported by a Research Seed Grant from Texas Southern University (which is sponsored by the Texas State Legislature), and by the W. K. Kellogg Foundation. The author gratefully acknowledges Latisha Clark and Sandra Onyejekwe for providing research assistance; Subrity Rajbhandari, Nekya Jenise Young, and Mahdi Zare for providing mapping assistance; and Drs. Glenn Johnson, Denae King, and Carol Lewis for reviewing early drafts of the paper.

References

[1] Federal Emergency Management Agency, *National Flood Insurance Program Fact Sheet*, May 2011. Available at ⟨http://www.fema.gov/pdf/media/factsheets/2011/mit_natl_flood_ins.pdf⟩.
[2] National Flood Insurance Program Reextension Act of 2010. 42 U.S. Code Chapter 50 § 4001 (2010).
[3] Walter Rosenbaum, The Developmental and Environmental Impacts of the National Flood Insurance Program: A Review of the Literature, American Institutes for Research, Washington, DC, 2005.
[4] Whitney Hodgin, FEMA Releases Updated Floodplain Maps: Changes Could Lead to Increases in Flood Insurance for Some, The Daily News, Galveston County, TX, 2013, Available at ⟨http://www.galvestondailynews.com/news/local_news/article_ 96bb2af8-5e0c-11e2-97ee-0019bb30f31a.html⟩.
[5] Biggert–Waters Flood Insurance Reform Act of 2012, Pub. L. No. 112-141 (2012).
[6] Grimm-Waters Homeowner Affordability Act of 2014, Pub. L. No. 113-89 (2014).
[7] National Oceanic and Atmospheric Administration. Available at ⟨http://www.habitat.noaa.gov/ protection/wetlands/impacts.html⟩, (accessed 03.06.14).
[8] National Oceanic and Atmospheric Administration. Available at ⟨http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml⟩, (accessed 03.06.14).
[9] Government Accounting Office, *National Flood Insurance Program: Continued Attention Needed to Address Challenges*, GAO-13-858T: Published: Sep 18, 2013. Publicly Released: Sep 18, 2013.
[10] Raymond J. Burby, Flood insurance and floodplain management: the US experience, Glob. Environ. Change Part B: Environ. Hazards 3 (Issues 3–4) (2001) 111–122, September–December.
[11] Federal Emergency Management Agency, Biggert-Waters Flood Insurance Reform Act of 2012 Fact Sheet. April 2013. Available at ⟨http://www.fema.gov/media-library-data/20130726-1909-25045-0554/bw12_sec_205_207_fact sheet4_13_2013.pdf⟩, (accessed 26.06.14).
[12] J.C. Gerbasi, Jennifer C, Manager of Recovery Assistance and Mitigation Planning for Terrebonne Parish, LA, personal communication, May 8, 2014.
[13] Kiah Collier, Study Finds Flood Insurance Law to Cost Coastal Communities Millions, Houston Chronicle, 2013, October 18.
[14] Caitlin Berni, Coalition for Sustainable Flood Insurance Marks Passage of Flood Insurance Reform, Greater New Orleans, Inc., 2014, March 24, 2014. Available at http://gnoinc.org/news/publications/press-release/coalition-for-sustainable-flood-insurance-marks-passage-of-flood-insurance-reform/.
[15] C. Kousky, H. Kunreuther, Addressing Affordability in the National Flood Insurance Program. Resources for the Future and the Wharton Risk Management and Decision Processes Center, Washington, DC.Issue Brief, 13-02. (2013) Available at ⟨http://www.wharton.upenn.edu/riskcenter⟩
[16] Committee on the Analysis of Costs and Benefits of Reforms to the National Flood Insurance Program. Available at ⟨http://www8.nationalacademies.org/cp/projectview.aspx?ke⟩ y=49584, (accessed 07.06.14).
[17] S.C. Bourassa, F. Hamelink, M. Hoesli, B.D. MacGregor, B.D., Defining housing submarkets, J. Hous. Econ. 8 (1999) 160–183.
[18] S.C. Bourassa, M. Hoesli, V.S. Peng, Do housing submarkets really matter, J. Hous. Econ. 12 (2003) 12–28.
[19] D.N. MacDonald, J.C. Murdoch, H.L. White, Uncertain hazards, insurance, and consumer choice: evidence from housing markets, Land Econ. 63 (4) (1987).
[20] James D. Shilling, C.F. Sirmans, John D. Benjamin, Flood insurance, wealth redistribution, and urban property values, J. Urban Econ., 26, 43–53, July 1989.
[21] D.M. Harrison, G. T. Smersh, A.L. Schwartz, Environmental determinants of housing prices: the impact of flood zone status, J. Real Estate Res. 21 (1) (2001) 3–20.
[22] O. Bin, S. Polasky, Effects of flood hazards on property values: evidence before and after hurricane floyd, Land Econ. 80 (4) (2004) 490–500.
[23] N.E. Coulson, J.E. Zabel, What Can We Learn from Hedonic Models When Housing Markets Are Dominated by Foreclosures? Annu. Rev. Resour. Econ. 5 (1) (2013) 261–279.
[24] Austin Troy, Jeff Romm, Assessing the price effects of flood hazard disclosure under the California natural hazard disclosure law, J. Environ. Plan. Manag. 47 (1) (2004) 137–162.
[25] L.K. Comfort, T.A. Birkland, B.A. Ciglar, E. Nance, Retrospectives and prospectives on hurricane Katrina – five years and counting, Public Adm. Rev. 70 (5) (2010) 669–678.
[26] T.G. Frazier, M.H. Walker, A. Kumari, C.M. Thompson, “Opportunities and constraints to hazard mitigation planning, Appl. Geogr. 40 (2013) 52–60.
[27] D. Godschalk, T. Beatley, P. Berke, D. Brower, E.J. Kaiser, Natural Hazard Mitigation: Recasting Disaster Policy and Planning, Island Press, Washington, DC, 1999.
[28] Samara F. Swanston, Race, gender, age, and disproportionate impact: what can we do about the failure to protect the most vulnerable? Fordham Urban Law J. 21 (1993) 577 1993-1994.
[29] Bureau of Economic Analysis. Regional Economic Accounts. Available at ⟨http://www.bea.gov/regional/index.htm⟩, (accessed 23.02.15).
[30] Bureau of Economic Analysis. Regional Economic Accounts/BEARFACTS. Available at ⟨http://bea.gov/regional/bearfacts/action.cfm?fips=48167&areatype=48167⟩, (accessed 23.02.15).
[31] Bureau of Economic Analysis. Regional Data/GDP and Personal Income. Available at ⟨http://www.bea.gov/iTable⟩, (accessed 23.02.15).
[32] City-Data. Available at city-data.com, (accessed 14.06.14).

[33] Forbes. “Two Key Real Estate Indicators Demonstrate Housing Performance.” September 19, 2012. Available at ⟨http://www.forbes.com/sites/realtorcom/2012/09/19/two-key-real-estate-indicators-demonstrate-housing-per/⟩, (accessed 23.02.15).
[34] National Association of Realtors. “Real Estate Data Trends.” June 2012. Available at ⟨http://www.realtor.com/news/realtor-com-real-estate-trends-june-2012-data/⟩, (accessed 23.02.15).
[35] NuWire Investor. “How to Use Economic Indicators in Residential Real Estate Investing.” May 2012. Available at ⟨http://www.nuwireinvestor.com/howtos/how-to-use-economic-indicators-in-residential-real-estate-investing-59245.aspx⟩, (accessed 23.02.15).
[36] D. Berg-Schlosser, G. de Meur, B. Rihoux, C.C. Ragin, Qualitative Comparative Analysis (QCA) as an Approach, Sage Publications, Inc., 2008.
[37] R.K. Yin, Case Study Research: Design and Methods, fifth ed.,. Sage Publications, Inc., 2013.
[38] Environmental Protection Agency. 2011. *Environmental Justice Analysis of the Definition of Solid Waste Rule*, Available at ⟨http://www.epa.gov/osw/hazard/dsw/rulemaking.htm⟩, (accessed on June 10, 12, 18, and July 2, 2014).
[39] US Census, American Community Survey Demographic and Housing Estimates, 2008-2012. Available at ⟨www.factfinder.census.gov⟩, accessed on June 9, 27 and July 3, 2014.
[40] Zillow Real Estate Network. Available at ⟨Zillow.com⟩, accessed on May 30, June 2, 8, and 30, 2014.
[41] McCormick, G.E. “US House Panel Backs Flood Insurance Overhaul.” Reuters, May 13, 2011. Available at ⟨http://in.reuters.com/article/2011/05/13/flood-insurance-congress-idINN1323586120110513⟩ (accessed 22.09.14).
[42] C. Fugate, “Implementation of the Biggert-Waters Flood Insurance Reform Act of 2012: One Year After Enactment.”, Written testimony for a Senate Banking, Housing, and Urban Affairs Subcommittee on Economic Policy hearing, 2014, September 18, 2013. Available at ⟨http://www.dhs.gov/news/2013/09/18/written-testimony-fema-administrator-craig-fugate-senate-banking-housing-and-urban⟩.
[43] National Research Council, Levees and the National Flood Insurance Program: Improving Policies and Practices, The National Academies Press, Washington, DC, 2013.
[44] J. Czajkowski, H. Kunreuther, E. Michel-Kerjan, A Methodological Approach for Pricing Flood Insurance and Evaluating Loss Reduction Measures: Application to Texas,, The Wharton School, University of Pennsylvania, 2012, White Paper ♯4.
[45] UK Department of Environment, Food, and Rural Affairs, Policy: Reducing the Treats of Flooding and Coastal Change. (2013) Available at ⟨https://www.gov.uk/government/policies/reducing-the-threats-of-flooding-and-coastal-change⟩ (accessed 20.09.14).
[46] G.B. Burtless, T.M., Smeeding, Poverty, Work, and Policy: The United States in Comparative Perspective. The Brookings Institute. Prepared for the Subcommittee on Income Security and Family Support Committee on Ways and Means Congress of the United States (2007).
[47] World Bank, Building Resilience: Integrating Climate and Disaster Risk into Development, The World Bank, Washington, DC, 2013, Available at ⟨http://www.worldbank.org/content/dam/Worldbank/document/SDN/Full_Report_Building_Resilience_Integrating_Climate_Disaster_Risk_Development.pdf⟩.
[48] Federal Emergency Management Agency, Number of Severe Repetitive Loss Properties per County, January 2007. Available at ⟨http://www.fema.gov/media-library-data/20130726-1608-20490-8734/5_repetitivelosses_low.pdf⟩.