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Flood Risk Management: Exploring the Impacts of the Community Rating System Program on Poverty and Income Inequality

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ABSTRACT

Flooding remains a major problem for the United States, causing numerous deaths and damaging countless properties. To reduce the impact of flooding on communities, the U.S. government established the Community Rating System (CRS) in 1990 to reduce flood damages by incentivizing communities to engage in flood risk management initiatives that surpass those required by the National Flood Insurance Program. In return, communities enjoy discounted flood insurance premiums. Despite the fact that the CRS raises concerns about the potential for unevenly distributed impacts across different income groups, no study has examined the equity implications of the CRS. This study thus investigates the possibility of unintended consequences of the CRS by answering the question: What is the effect of the CRS on poverty and income inequality? Understanding the impacts of the CRS on poverty and income inequality is useful in fully assessing the unintended consequences of the CRS. The study estimates four fixed-effects regression models using a panel dataset of neighborhood-level observations from 1970 to 2010. The results indicate that median incomes are lower in CRS communities, but rise in floodplains. Also, the CRS attracts poor residents, but relocates them away from floodplains. Additionally, the CRS attracts top earners, including in floodplains. Finally, the CRS encourages income inequality, but discourages income inequality in floodplains. A better understanding of these unintended consequences of the CRS on poverty and income inequality can help to improve the design and performance of the CRS, and ultimately, increase community resilience to flood disasters.

KEYWORDS: Flood risk; poverty; Community Rating System; income inequality; National Flood Insurance Program

1. INTRODUCTION

Flooding has and continues to be a major problem for the United States, causing numerous deaths and damaging countless properties.(1,2) According to the National Weather Service,(3) from 1982 to 2011, the average annual flood-related deaths and flood damage in the United States were 95 fatalities and $8.20 billion, respectively. To reduce the risk and impact of flooding on communities, the United States government established the National Flood Insurance Program (NFIP) in 1968. Despite the creation of the NFIP, flooding still posed a major risk to communities. As a result, the Federal Emergency Management Agency (FEMA) implemented the Community Rating System (CRS) in 1990. The CRS is a voluntary program that aims to further reduce risk exposure and flood damages by incentivizing communities to engage in flood risk management initiatives that surpass those required by the NFIP. In return, communities enjoy discounted flood insurance premiums.(4) There are 19 creditable CRS activities such as floodplain management and planning that focus on helping communities to manage their flood risks. Through this activity, a community might develop ordinances that prevent the construction of buildings in floodplains. In so doing, the community is able to reduce its flood risk and flood-related damages.

Despite the recent increase in policy priority for equity engendered by a persistent increase in income inequality,(5) policy analyses, including those examining the CRS, a flood risk management program (e.g., Brody et al.(6); Fan and Davlasheridze(7); Sadiq and Noonan(2,8)), often overlook the equity implications of the program. Moreover, for policies aiming at protecting vulnerable populations (e.g., by reducing risk exposure) and improving infrastructure, apprehensions about the distributional impacts are paramount.(9) Indeed, the establishment of the

CRS raises concerns about the potential for unevenly distributed impacts across different income groups in communities—leading to equity concerns (e.g., the scoring and allocation of discounted flood insurance premiums).[10,11] Understanding the equity implications of risk management programs such as the CRS are important because minorities, and poor and rich people analyze risk differently.[12,13] Without considering such differences in risk analysis, well-meaning risk management programs may not achieve their programmatic goals, and may even lead to unintended consequences that might exacerbate poverty and inequality. In short, if we care about keeping inequality low and reducing poverty, it is important to understand the equity implications of risk management programs such as the CRS.

This study thus investigates the possibility of unintended consequences such as concerns over the fairness of the CRS by answering the following research question: What is the effect of the CRS on local poverty and income inequality? One mechanism through which the CRS could lead to inequities is by reallocating local migration of households at the bottom, middle, and the top of the income distribution. Moreover, discounted flood insurance premiums and building regulations likely have differential effects across the income distribution. Hence, we test whether participation in the CRS program will have implications for community-level poverty and income inequality. Our analysis also examines the impacts of high-risk areas and floodplains within CRS communities on poverty and income inequality.

This study argues that in order to improve the effectiveness of the CRS, especially its flood risk management component, there needs to be an evaluation of the unanticipated consequences of the CRS. By understanding such unexpected consequences such as on poverty and income inequality, the overall performance of the CRS, and in particular, its flood risk management component could be improved. In addition, this study would help the risk analysis community to better understand the relationship between risk and poverty as well as the role of risk analysis in addressing poverty.[14,15] Finally, our study addresses the deficit in equity-centered empirical research such as the environmental justice literature, where correlations are typically identified rather than policy impacts.[16,17]

To explore the relationship between poverty and income inequality and the CRS, we estimate panel regression models for a national dataset of neighborhood-level observations from 1970 to 2010. The results provide important information on the impacts of the CRS on poverty and income inequality; information that academics, policymakers, CRS evaluators, and other stakeholders can utilize to develop a holistic understanding of the overall impacts of the CRS on participating local communities. In the following sections, we provide background information on the CRS and review relevant literature. Then, our methodology is outlined, including the data and variables. Next, the results are presented and discussed. Finally, the paper concludes by offering suggestions for future research opportunities on the impacts of the CRS on community-level outcomes.

2. BACKGROUND ON THE CRS

To reduce the impact of flooding on communities, the United States government established the NFIP in 1968. The purpose of the NFIP—both then and now—is to reduce the impact of flooding on public and private infrastructures, provide affordable insurance to property owners, and promote the development of flood protection activities in communities throughout the United States.[19] The NFIP is a voluntary initiative between federal and state governments, private insurance companies, and local communities with a mission of reducing flood disasters by enacting and enforcing floodplain management activities in flood-prone areas.[19] Despite the creation of the NFIP, flooding still poses a major risk to communities. As a result, FEMA implemented the CRS in 1990 as a voluntary program designed to incentivize communities to surpass the expectations of the NFIP. The three goals of the CRS are to reduce flood damage to insurable property, strengthen and support the insurance aspects of the NFIP, and foster comprehensive floodplain management.[18] When communities develop flood management activities that reflect these three goals, they enjoy discounted flood insurance premiums commensurate with their CRS class, which ranges from Class 10 to Class 1.[4,18] Class 10 represents communities that do not participate or do not possess the minimum number of credit points to enter the program. As such, they receive no discount on flood insurance premiums. Class 1 represents communities with exceptional floodplain management activities who enjoy a 45% discount on flood insurance premiums as long as they are located in a Special Flood Hazard Area (SFHA) (see Table I). SFHA refers to a land area with a 1% or greater chance of flooding within any given year. Communities located outside of a SFHA only receive a discount of up to 10%. These rankings are based on the number of credit points a community has earned that range from 0-500—a Class 10 community—to 4,500(+)—a Class 1 community.

Table I. CRS Classes, Credit Points, and Premium Discounts Based on Location in or outside a SFHA.

CRS Class	Credit Points	Premium Reduction	
		In SFHA (%)	Outside SFHA (%)
1	4,500+	45	10
2	4,000-4,999	40	10
3	3,500-3,999	35	10
4	3,000-3,499	30	10
5	2,500-2,999	25	10
6	2,000-2,499	20	10
7	1,500-1,999	15	5
8	1,000-1,499	10	5
9	500-999	5	5
10	0-499	0	0

Source: FEMA[18].

Credit points are given to communities as they implement any of the 19 creditable activities that advance the CRS's goals and span across one of the four categories: public information, mapping and regulations, flood damage reduction, and warning and response (see Table II).[18] Activities that promote public information include advising individuals about flood hazards and encouraging property owners to purchase flood insurance. Mapping and regulation activities center on preserving open spaces, protecting natural floodplain measures, enforcing standards, and managing stormwater. Credit points are also awarded to communities that endorse flood damage reduction activities such as creating a comprehensive floodplain management plan, relocating or retrofitting structures, and maintaining drainage systems, which help prevent repetitive losses.[20] Lastly, communities receive points for implementing measures that protect life and property in the event of a flood disaster through warning and response programs. The amount of credit points given to communities varies by the mitigation activity in each category.[10] Although the CRS attempts to identify a comprehensive list of credited activities, it recognizes that communities might engage in alternative approaches. These instances are reviewed on a case-by-case basis by an Insurance Services Office (ISO) specialist who also administers the day-to-day operations of the CRS program on behalf of FEMA, and assists communities in the CRS application process.

Table II. Credit Points Awarded for CRS Activities.

Activity	**Maximum Possible Points**	**Percent of Communities Credited***
300 Public Information Activities		%
310 Elevation Certificates	116	100
320 Map Information Service	90	93
330 Outreach Projects	350	89
340 Hazard Disclosure	80	71
350 Flood Protection Information	125	92
360 Flood Protection Assistance	110	41
370 Flood Insurance Promotion	110	0
400 Mapping and Regulations		

410 Floodplain Mapping	802	50
420 Open Space Preservation	2,020	70
430 Higher Regulatory Standards	2,042	99
440 Flood Data Maintenance	222	89
450 Stormwater Management	755	84
500 Flood Damage Reduction Activities		
510 Floodplain Mgmt. Planning	622	46
520 Acquisition and Relocation	2,250	24
530 Flood Protection	1,600	12
540 Drainage System Maintenance	570	77
600 Warning and Response		
610 Flood Warning and Response	395	37
620 Levees	235	0
630 Dams	160	0

Source: FEMA[18].

Participating in the CRS program is at no cost to communities, and communities can stop participating at any time. However, if communities decide to participate in the CRS program, they must recertify every year. Based on this recertification, communities who are adding additional credited activities can advance to a higher ranking. On the other hand, communities who are not properly or fully implementing credited activities may downgrade to a lesser ranking. Yet, regardless of a community's ranking, the benefits of participating in the CRS can be enticing for communities who are exceedingly vulnerable to flood disasters. One benefit of participation is the reduction in flood insurance premiums for private property owners located in SFHAs.[18] However, participation can also yield benefits that are not as easily captured in monetary terms.[14] The continued implementation of robust flood protection measures, for example, that can reduce the extent of damage to property and infrastructure, as well as minimize economic disruptions and reduce human suffering is arguably the most significant long-term benefit of participating in the CRS. Other benefits of participation that accrue more broadly include reduced flood risks, better information about flood risks, and better infrastructure for managing floods and responding to flood events. Participation may also result in stricter building codes and new land use rules. While some of these benefits are concentrated to SFHA communities, others are more proportional to local flood risks, and some are more diffused to the broader area.

3. LITERATURE REVIEW

3.1. Flood Hazards and Income

There is a robust literature on learning and adapting to flood hazards, although these either do not focus on income[21,22] or do not observe a significant explanatory role for income.[23] The related literature on the demand for flood insurance has found a positive effect on income on the likelihood of insuring.[24,25] A sizeable literature examines the property price variation associated with flood risk, flood information and experiences, and insurance policies.[26-28] As is common for property price hedonic studies, however, income is rarely explicitly considered. The mixed evidence of price differentials related to flood risk can partly be explained by different property types,[29] suggesting that information and incentives may differ substantially across income classes.

The connection between income and willingness to reduce flood risk exposure has been studied in several ways. Sekulova and van den Bergh[30] use survey data to find persistent negative effects of flooding on life satisfaction, effects that are irrespective of individuals' income. At a macro-level, Grames et al.[31] offer insights into how persistent flood risk can support multiple equilibria that sustain either a rich economy that invests in flood protection or a poor economy that consumes more and accumulates less capital to wash away. Daniel et al.[32] estimate a willingness-to-pay for risk reduction and observe that it is somewhat lower where income is greater. A common feature in this literature is that flood risk exposure is frequently correlated with other amenities, like recreational access, and demand for those amenities also generally depends on income.[33] Cordes and Yezer[34] show how rising income has increased development in risky coastal areas. Combining that finding with policies that subsidize rather than reduce risk suggests that wealthier homeowners may be disproportionately benefiting from those subsidies.

3.2. Community-Scale Flood Management, Flood Mitigation, and Income

Income has been positively linked with individuals' propensity to mitigate.[35,36] The role of income on collective, rather than private, flood mitigation activities, however, may be quite different. For instance, wealthier residents may free-ride more on collective flood mitigation efforts.[37] Nonetheless, community wealth may affect capacity to undertake public infrastructure investments (e.g., Sadiq and Noonan[8]) or access to national relief programs. Wealthier counties tend to attract more ex-ante FEMA disaster mitigation spending (e.g., mitigation planning, structural projects) as well as ex-post disaster relief.[38] The effects of mitigation and relief, in turn, on changes in wealth and poverty remain less well identified. Bagstad et al.[39] examine a set of policies, including some that promote local flood mitigation and management, and assess their distributional effects and influence on income inequality in the U.S. Gulf Coast. Their concern with perverse subsidies includes a concern that policies subsidizing floodplain development can increase transfers to the powerful and wealthy, although some mitigation programs (such as those in the CRS) can have positive effects by reducing taxpayer burdens for flood relief.

3.3. CRS Literature: What is Missing?

Researchers have studied various aspects of the CRS, focusing largely on the determinants of community participation,[2,20] adaptive capacity,[40] policy learning,[6] the non-linear incentive structure of the CRS,[8] the effects of the CRS on flood insurance demand,[10,19] and flood insurance claims.[41] Most recently, Fan and Davlasheridze[7] examined heterogeneity in demand for CRS activities by demographic groups, confirming differential responses to flood mitigation efforts. Although these and other CRS-based studies may provide valuable information about the consequences of the CRS on communities, there is a need to investigate the unintended consequences of the CRS such as concerns over the fairness of the CRS (e.g., the scoring and allocation of discounted flood insurance premiums).[10] It is important to note that while researchers have examined the income distributional effects of the NFIP,[11,42] the impacts of the CRS on poverty and income inequality is yet to be studied.

3.4. Determinants of Poverty

The problem of poverty remains a major challenge for researchers and policymakers[43] despite the myriad studies conducted to understand the antecedents of poverty.[42-45] Rather than review all the extensive work on the antecedents of poverty at the community level, we review the literature on the relationship between poverty and the control variables relevant to this analysis: housing value, vacancy rates, population density, non-migrants, unemployment, renters, and property damage.

3.4.1. Housing Value

A majority of the studies examining the relationship between housing values and poverty have done so with a racial minority focus. Pandey and Coulton,[46] for example, explored racial changes in neighborhoods in Cleveland, Ohio to assess the factors influencing neighborhoods' poverty rates and social conditions. Upon analyzing 185 census tracts in Cleveland, the findings revealed a negative relationship between geographic concentrations of poverty and housing values. This negative relationship is conceivable because foreclosures, bankruptcies, and equity losses can lead to lower housing values, thus attracting poor people due to affordability.

3.4.2. Vacancy Rates

The proportion of vacant homes in a community can have adverse effects on its economy, and subsequently, on its level of poverty.[47] The presence of a high percentage of vacant homes in a community may be an indication of a lack of economic opportunity in that community, which can exacerbate its poverty level.[44] Furthermore, vacant homes can reduce property values, and lead to lower rent, which would ultimately increase the number of poor people moving into such neighborhoods.

3.4.3. Population Density

Impoverished areas tend to be concentrated to specific counties, neighborhoods, and regions.[48] Historically, rural areas have observed higher poverty rates compared to urban areas.[48] Hirschl and Rank[26] explored the effect of population density on welfare participation in rural and urban counties in the United States. The findings revealed that despite the fact that rural counties have higher poverty rates, they are less likely to participate in welfare programs. However, in assessing urban poverty, Cohen[50] suggests that despite a high and persistent poverty rate, individuals living in densely populated areas typically have better access to public services to include education, healthcare, water, and electricity. In sum, population density may influence poverty rates; however the relationship may be nonlinear.

3.4.4. Non-migrants

A limited number of studies have explored the relationship between the proportion of a migrating population and poverty rates. Rupasingha and Goetz [43] found a positive and statistically significant relationship between non-migrants (i.e., percent of population that did not move within last five years) and poverty rates among a sample of 3,047 counties in the United States. In short, the frequency with which residents migrate in a community is closely related to poverty rates, given the importance of location and development decisions in flood management, particularly important in this analysis.

3.4.5. Unemployment

The literature on the relationship between poverty and unemployment rate (the percentage of the work force that is currently not working)[51] has generally been positive. Blank,[52] for example, assessed the factors influencing poverty rates from 1960 to 1998. The findings revealed a significant and positive relationship between unemployment and poverty rates during the 1960s, 1970s, and 1990s. During the 1980s, however, the findings showed a negative relationship between unemployment and poverty. Similar results were found by Hoynes, Page, and Stevens[53] who explored the predictors of poverty from 1967 to 2003. The findings revealed that a 1% increase in unemployment resulted in a 0.5% increase in the poverty rate. Finally, McKernan and Ratcliffe[45] studied events that trigger entry into and exit from poverty. They found, among other results, that job loss by household members is an important factor.[45]

3.4.6. Renters

Scholars have consistently found that renters are more likely to experience poverty than homeowners. Caner and Wolff,[54] for instance, explored assets-based poverty in the United States and found that the assets-based poverty rate for homeowners was approximately 27% while the assets-based poverty rate for renters was nearly 67%. Haveman and Wolff[55] found similar results in their study of assets-based poverty in the United States. The findings revealed that assets-based poverty for renters increased from 52% in 1983 to 64% in 2001 and assets-based poverty for homeowners only increased from 4% in 1983 to 6% in 2001. Instead of exploring assets-based poverty, Kutty[56] explored housing-induced poverty, which refers to a situation where a household cannot afford basic necessities (e.g., food and clothing) after paying for their housing. Using data provided from the 1999 American Housing Survey, Kutty[56] found that nearly 50% of renters were not officially in poverty, but were experiencing housing-induced poverty.

3.4.7. Flood-related Property Damage

The literature on the relationship between property damage from natural disasters and poverty has been studied on a national and international scale. Nationally, Yoon[57] assessed the relationship between social vulnerability and disaster damages among counties along the Gulf of Mexico and the Atlantic coast. The findings revealed that counties with higher social vulnerability in regards to poverty, unemployment, education, occupation, and resource availability experienced greater property damages from natural disasters. In fact, poverty was found to be the most powerful predictor of property damage.[57] Internationally, Brouwer et al.[58] surveyed nearly 700 floodplain residents in Bangladesh to explore the relationship between risk, poverty, and vulnerability. The authors posited that floodplain residents living below the poverty threshold will suffer more from being exposed to environmental hazards compared to those living above the poverty threshold. Upon analyzing average flood damage as a share of household income, the findings revealed that those living below the poverty threshold experienced greater disaster damages. Similarly, Kahn[59] found that poorer individuals face greater exposure to and damage from natural disasters as they are more likely to live in hazardous areas.

4. METHODOLOGY

We analyze the effects of CRS participation on neighborhood-level dynamics, focusing in particular on local income distribution and poverty rates. Our primary attention is on measuring the impact of the CRS on the lower end of the income distribution, operationalized here as the poverty rate. The empirical analysis also examines the rest of the income distribution such as median income levels, the share of the population in the top percentile of income, and a GINI coefficient to characterize the variation in local income.

The regression model explains variations in local income distribution over time with participation in the CRS and a variety of controls that may directly affect local income dynamics as well as the likelihood of participating. Further, by examining units of observation at much smaller spatial scales than the community or local government that opts to participate, the model can identify CRS impacts both within-neighborhood income distributions and across-neighborhood income distributions. Given that underlying flood risk varies greatly within communities, just as income does, examining how participation at the community level affects the joint distribution of risk and income sheds light on important equity implications of the program.

4.1. Data

In order to assess the impact of the CRS and flood risk on poverty and income inequality, we merged five different data sources together (see Table III). The first data source is CRS participation from 1998 to 2013. These data contain basic information about participating communities such as the name of the county or place, its state, total CRS points, CRS class, and points awarded for each of the 18 creditable activities (excluding 370, Flood Insurance Promotion, due to the lack of information). See Fig. 1 for a map showing SFHAs and Communities Participating in the CRS in 2010.

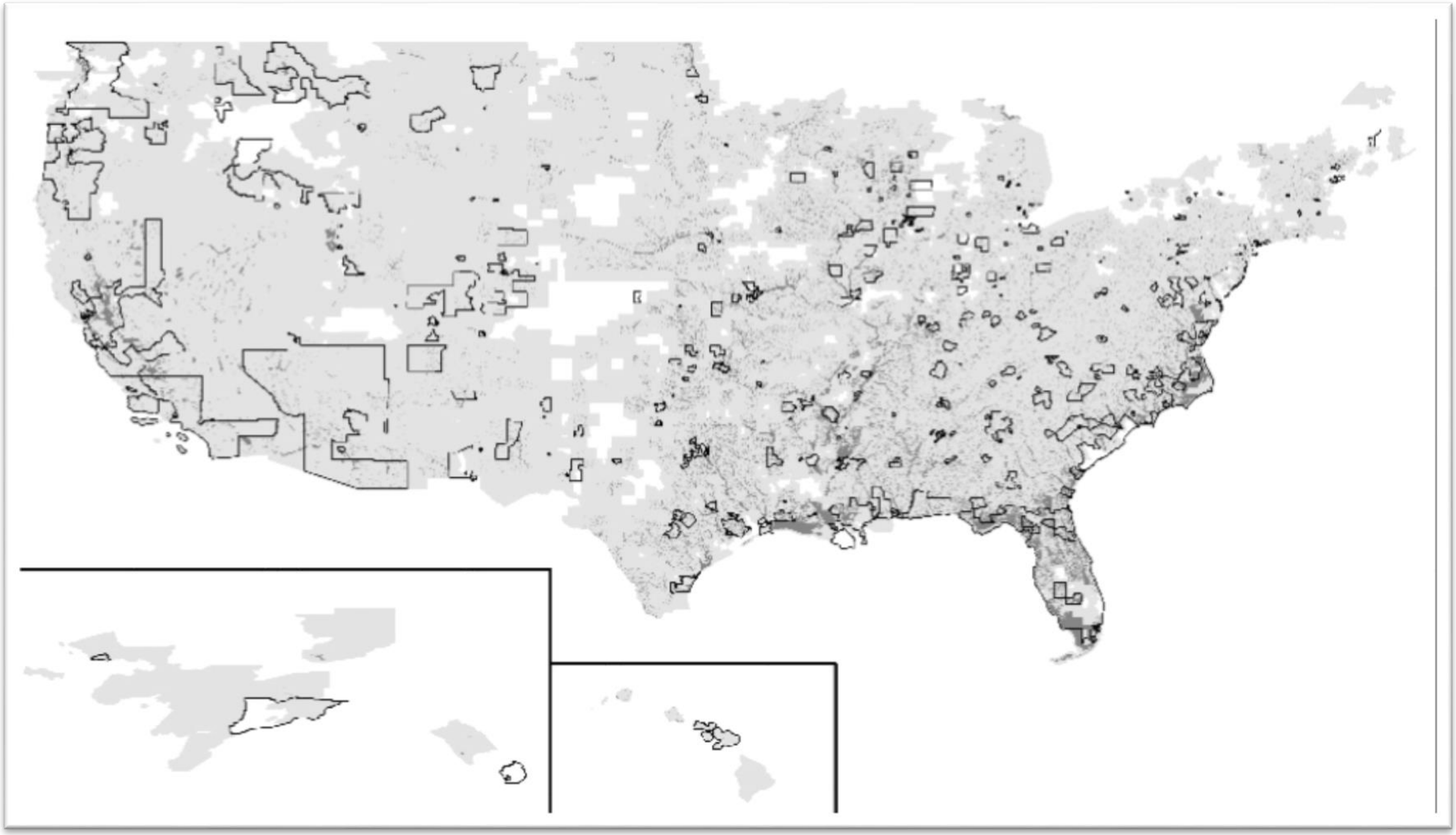

Fig. 1. SFHAs and Communities Participating in the CRS.
Note: Map of US data used in the analyses. Light gray represents the included tracts with digital FIRM data available. Medium gray indicates Special Flood Hazard Areas. Tracts inside black boundaries were in CRS-participating communities in 2010.

The second data source is the Neighborhood Change Database (NCDB) from Geolytics, Inc. The NCDB contains US Census information from 1970 to 2010 at the census tract level, normalized to use time-consistent 2010 tract boundaries across all 40 years. The NCDB includes variables about both the tract population and its housing stock. The third data source is the Spatial Hazard Events and Loss Database for the United States (SHELDUS). SHELDUS contains county-level information such as the date of hazard events, locations, fatalities, property losses, injuries, etc., for 18 different types of natural hazards, including floods, hurricanes, thunderstorms, and tornados. Only flood hazard data are taken from SHELDUS for this analysis.

Table III. Data sources.

Data	Unit	Year	Variable
CRS Participation	Place/County	1998-2013	Name of participant community, CRS class, credits earned, etc.
Neighborhood Change Database (NCDB) from Geolytics, Inc	Tract	1970-2010	Housing values, vacant housing, renters, non-migrants, etc.
The Spatial Hazard Events and Loss Database for the United States (SHELDUS)	County	1960-2013	Month, hazard type, damages, injuries, fatalities, etc.
Flood Insurance Rate Maps	Flood zones	Current	Base flood elevations, flood zones, floodplain boundaries, etc.
Flood Risk Data from the United States Department of Transportation (US DOT)	1km x 1km raster map, converted to census tract	1996	Index value/minimum, maximum, mean by tract, etc.[1]

[1] The USDOT flood risk data are converted from a 1km by 1km grid cell map onto census block groups, taking the mean value of the flood risk metric across the cells in each block group. Then, each census tract takes the mean value of these block groups' flood risk value. This mean-mean aggregation function was just one of many alternatives tried (e.g., min-max, max-max, max-mean). While the results vary somewhat, the basic findings are not very sensitive to the aggregation choice. The mean-mean approach is used here as it is the most straightforward. Other constructions are available upon request.

The fourth data source is the most current Flood Insurance Rate Maps (FIRMS). FIRMS contain information about SFHAs and the risk premium zones for 87% of the United States. This information is available from FEMA at the tract level. The fifth data source is flood risk data from the United States Department of Transportation (US DOT) (1996). The information contained in the flood risk data is of very high resolution (1 km grid cell), and based on a ranking of flood risk (on a 0-100 scale).

Table IV. Variables and their Descriptions.

Variable	**Description**	**Data Source**
Dependent		
Median family income	Log of median family income	US Census (Geolytics)
Poverty rate	Share of tract population below the federal poverty level last year	US Census (Geolytics)
Top earners	Percent of population with income in the highest census bin	US Census (Geolytics)
GINI	Gini coefficient	US Census (Geolytics)
Independent		
CRS	Dummy variable indicating tract resides in a community participating in the CRS	FEMA (2013)
Flood risk	Flood hazard risk, mean flood risk for the tract based on 1km by 1km grid cells	US DOT (1996)
CRS*Risk	Interaction between CRS and flood risk	FEMA (2013) and US DOT (1996)
SFHA share	Share of a tract in a Special Flood Hazard Area (i.e., 100-year floodplain)	FEMA (2013)
CRS*SFHA	Interaction between CRS and SFHA share	FEMA (2013)
Control Variable		
Property damage	Total flood damage over previous 5 years, per capita, adjusted to 2013 dollars	SHELDUS
Poverty rate	Tract poverty rate (10-year lag)	US Census (Geolytics)
Mean housing value	Log of mean housing value (10-year lag)	US Census (Geolytics)
Population density	Total tract population divided by total land area (10-year lag)	US Census (Geolytics)

County non-migrants	Proportion of households in the same county 5 years prior (10-year lag)	US Census (Geolytics)
Unemployment rate	Number of unemployed divided by total number in the labor force (10-year lag)	US Census (Geolytics)
Renters	Share of total housing units that are renter occupied (10-year lag)	US Census (Geolytics)
Vacancy	Share of total housing units that are vacant (10-year lag)	US Census (Geolytics)

4.1.1. Dependent Variable

The analysis considers four distinct dependent variables in separate models (see Table IV), but with the same basic model specification. These variables offer alternative ways to characterize the tract income distribution. The middle, bottom, and the top of the income distribution are captured by the (log) median family income, poverty rate, and the share of the population in the highest income bin in the Census, respectively. The top-coded income bin captures the highest earning 1-5% of households depending on the Census year. The fourth income measure, the Gini coefficient, characterizes the income inequality within the tract for a given year. The Gini coefficient varies between zero and one, with higher values indicating greater inequality. The Gini coefficient is calculated separately for each tract in each census year (1980 – 2010) based on the income distribution across the Census income bins, per the robust Pareto midpoint estimator described in von Hippel et al.[(60)]

4.1.2. Independent Variables

We are interested in three independent variables: CRS participation, flood risk of tracts in CRS communities, and the share of tract areas overlapping SFHAs in CRS communities. CRS participation is measured as a dichotomous variable. Those participating in the CRS in any particular year were coded 1, and those not participating in the CRS were coded 0. Mean flood risk for the tract, based on 1km by 1km grid cells, is a time-invariant control that drops out when tract fixed-effects are used. The interaction term between this flood risk measure and the CRS indicator variable (*CRS*Risk*), however, is a time-varying measure. The share of a tract's area within a 100-year floodplain, the alternative flood risk measure, also drops out with tract-level fixed effects. Again, the interaction term between *SFHA Share* and the CRS indicator is time-varying, and remains in the model.

While *Flood Risk* and *SFHA Share* are alternative ways to measure flood risks, in the context of the CRS, their interaction terms take on crucially different meanings. Discounted flood insurance premiums in particular apply to properties in SFHAs, making *CRS*SFHA* a tract-level measure of focused benefits of the CRS program. Conversely, controlling for *CRS*SFHA*, the *CRS*Risk* interaction identifies the effect of flood *risk* in tracts in CRS-participating communities, which might not map onto insurance discounts (even among tracts in CRS communities, *SFHA* and *Risk* correlation is only 0.14). Thus, while the main effect of *CRS* indicates the average effect of CRS participation across the community—regardless of the tract's flood risks—the interaction terms pick up whether CRS participation is different in tracts that are more in floodplains or have greater flood risks.

4.1.3. Control Variables

We control for the following variables: property damage, poverty rate, mean housing value, population density, county non-migrants, unemployment rate, renters, and vacant homes. *Property damage* is measured as the total flood damage over the previous 5 years, per capita, adjusted to 2013 dollars. *Poverty rate* is measured as the 10-year lag of the tract poverty rate. *Mean housing value* is measured as the log of mean housing value for the community (10-year lag), while *population density* is measured as the total tract population divided by the total tract land area (10-year lag). We measured *county non-migrants* as the proportion of persons residing in the same county five years ago (10-year lag). Further, *unemployment rate* is measured as the number of unemployed divided by the total number of people in the labor force (10-year lag). *Renters* is the share of total housing units that are rentals (10-year lag). Finally, *Vacancy* is measured as the share of total housing units that are vacant (10-year lag).

Posey's[(40)] study suggests a potential simultaneity between poverty rate and CRS. Using data from the US Census to measure municipalities' socioeconomic status, and participation in the CRS as a proxy for adaptive capacity, Posey[(40)] found a negative and statistically significant relationship between poverty rates and CRS participation in both a national dataset and one of New Jersey's coastal communities. While Posey[(40)] used poverty rate as an independent variable, we use it as a dependent variable. We address this reverse causality issue by using fixed effects models and lagging the control variables, as discussed above. The lagged control variables reflect socioeconomic conditions of the previous decade, and help to protect against concerns of simultaneity bias. The use of lagged values in the model means that the dependent variable ranges from 1980 – 2010 (four different censuses). Year fixed effects are also included in the model to capture general time trends.

Table V: Descriptive Statistics.

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Median Family Income	327,273	10.956	0.428	1.610	12.546
Poverty rate	276,001	0.112	0.109	0	1
Top earners	327,231	0.027	0.057	0	1
GINI	327,231	0.348	0.061	0	0.757
CRS	327,658	0.077	0.267	0	1
Flood risk	327,597	41.076	27.466	0	99
CRS*Risk	327,597	2.959	12.822	0	99
SFHA share	283,886	0.118	0.190	0	1
CRS*SFHA	283,886	0.011	0.072	0	1

Mean housing value	251,492	11.531	0.744	-6.151	14.490
Property damage	327,658	71.966	2697.344	0	901,987.6
Population density	275,432	0.002	0.004	0	0.084
County non-migrants	327,534	0.588	0.194	0	1
Unemployment rate	276,001	0.056	0.048	0	1
Renters	254,862	0.311	0.209	0	2
Vacant	254,862	0.079	0.084	0	1.5

Table V presents the descriptive statistics for all variables. The mean poverty rate for the sample is 11.2%, and 2.7% of the sample are top earners. The average GINI coefficient is about 0.35, and 7.7% of tracts are in CRS participating communities. Furthermore, average flood risk is approximately 41 (on a scale of 0-100), and about 12% of tract areas are in SFHAs. In addition, county non-migrants constitute about 59% of the sample, and the average unemployment rate is 5.6%. Finally, 31.1% and 7.9% of the sample are renters and vacant housing units, respectively.

5. RESULTS

Table VI presents the results of four tract-level fixed-effects models. All the models employ robust standard errors in addition to tract-level fixed effects. The models have good explanatory power, explaining 13.6% to 23.2% of the variation in the dependent variable. With regard to median income, the results indicate median income decreases by 2.2% in tracts located in CRS participating communities holding all other variables constant. While CRS community tracts with no floodplains experience a decline in median family income, that negative effect largely disappears for tracts that are 20% in floodplains. Table VI also indicates that, within CRS communities, tracts that are mostly within floodplains (*SFHA Share* > 0.5) would see median incomes rise by 3% or more as *SFHA Share* grows. Thus, we immediately see a differential effect of the CRS on median incomes in a CRS participating community: incomes are lower around the community except near floodplains, where median incomes rise. In addition, the relationship between median income and high flood-risk tracts in CRS communities is positive and insignificant.

The results of the poverty rate model (column 2) show the corresponding results for the bottom of the income distribution. Specifically, poverty rate is higher by almost a full percentage point in CRS participating communities in comparison to non-CRS participating communities, holding all other variables constant. Conversely, for CRS tracts, higher floodplain shares decrease poverty rates. The net effect of CRS participation on poverty rates is roughly positive for tracts until they are mostly in floodplains, and then it turns negative. The relationship between poverty rate and *CRS*Risk* is negative, and again, insignificant.

Table VI. Fixed-Effects Model Results for Median Income, Poverty Rate, Top Earners, and Gini.

Variable	**Median Income**	**Poverty Rate**	**Top Earners**	**GINI**
CRS	-0.022***	0.008***	0.001*	0.005***
CRS*Risk	0.00003	-0.00003	-0.00003*	-0.00003*
CRS*SFHA	0.103***	-0.018***	0.007***	-0.016***
Property Damage	-1.784	0.237	0.058	2.040**
Poverty Rate	-0.459***	0.082***	-0.021***	0.018***
Mean Housing Value (log)	0.076***	-0.012***	0.014***	-0.002***
Population Density	-12.087***	2.289***	-0.769***	0.701***
County Non-migrants	-0.042***	-0.003	0.009***	0.020***
Unemployment Rate	-0.315***	0.041***	-0.036***	0.006
Renters	-0.189***	0.066***	-0.018***	0.045***
Vacancy	0.039*	0.011**	-0.027***	0.011***
Year=1980	-0.120***	-0.037***	-0.032***	-0.027***

Year=1990	-0.017***	-0.022***	-0.031***	-0.013***
Year=2000	0.039***	-0.022***	-0.020***	0.002***
N	216,778	216,884	216,645	216,645
R-Squared	0.188	0.136	0.232	0.136

Note: *p<.1, ** p<.05, *** p<.01

With respect to the relationship between top earners and the CRS, the results show that there is an increase of 0.1 percentage points in top earners in CRS communities relative to non-CRS communities, holding all other variables constant. Similarly, CRS tracts with a high floodplain share and high-risk tracts in CRS communities see an increase and a decrease in the share of top earners, respectively. The alternate measures of flood risk appear to be working at cross-purposes here. While a CRS tract with no flood risk or overlap with SFHAs may see its *Top earners* grow by 0.1% (even as its median income falls and poverty rate rises), a CRS tract with 30% in a floodplain and a mean flood risk score of 0 sees that *Top earners* growth jump from 0.1% to 0.3%. Conversely, a CRS tract outside of floodplains but with a mean flood risk score of 80 would expect a decline in *Top earners* of around 0.1%. While small in absolute value, the median *Top earners* value of 0.8% puts into perspective substantial 0.1-0.3 percentage point change. Tracts in CRS communities appear to attract top earners, but less so where the flood risk is actually greatest and more so in the floodplains where flood insurance premiums are discounted.

Finally, the income inequality model indicates a positive association between the CRS and income inequality as the Gini coefficient rises by 0.005, holding all other variables constant. Yet, unlike previous models, the flood risk interaction terms appear to complement each other. CRS tracts with higher floodplain shares and higher flood risks tend to see a decrease in income inequality. Thus, while tracts with no floodplains or flood risk in CRS communities witness increasing income inequality, elsewhere in that CRS community a tract that is 30% in floodplains and has a flood risk score of 80 would expect its Gini coefficient to fall by 0.002.

With regard to the control variables, the results are neither interesting nor surprising. For example, property damage is insignificant in all but the income inequality model. According to the income inequality model, higher flood damages are associated with CRS tracts with higher income inequalities.

6. DISCUSSION

Across the income distribution, the results here tell a fairly consistent—if unexpected—story. Neighborhoods in CRS communities have tended to see their poverty rates and shares of residents in the highest income brackets climb while median incomes have fallen. This growth in the top and the bottom of the income distribution is relative to tracts in communities not participating in the CRS.

Yet the story becomes more nuanced for those neighborhoods more associated with flood risk in CRS communities. In short, the "high ground" neighborhoods in CRS communities are seeing more income inequality. Neighborhoods with more floodplains in them, unlike the rest of their CRS community, actually see their incomes rise across the distribution (greater median income, less poverty, more top-earners) and even declining income inequality. Neighborhoods around CRS floodplains attract wealth (or deter poor people from settling there) and possibly more income equality. Conditional on *SFHA Share,* greater *Flood Risk* for CRS neighborhoods is not significantly related to changes in the income distribution at the median or at the lower tail, although it does appear to discourage top earners from living there. This effect brings more income equality to the neighborhood, relative to other tracts in the U.S.

The incentives in the CRS program design can account for these interaction effects quite easily. As the discounted insurance premiums have greatest effects as *CRS*SFHA* grows, and may disproportionately affect wealthy property owners,[61] it is not surprising that CRS floodplains are attracting more wealth. In fact, some flood-prone areas have experienced gentrification. For example, a significant level of gentrification has been observed in New Orleans in the aftermath of Hurricane Katrina.[62] Furthermore, other flood management practices may also lead to poorer residents relocating elsewhere in the community (e.g., tighter building codes raising housing costs). Another mechanism by which poorer residents are moving out of the floodplains could be through the implementation of acquisition and relocation (e.g., relocating mobile home parks), which is a CRS activity engaged in by 24% of participating communities (see Table II).

The findings here complement the relatively thin literature on the effects of community-scale flood management programs on income distributions. Notably, Bagstad et al.'s (2007) concerns about perverse subsidies leading to unjust income distributions may not apply to the CRS. Rather, their recommended programs (e.g., tighter building standards, relocation assistance, and wetland conservation) are all activities that the CRS can reward. The resulting negative effects (in floodplains) of CRS participation on local Gini coefficients and poverty rates points to some favorable results for income inequality consistent with Bagstad et al.[39] That CRS participation also attracts high-income households to floodplains areas is also consistent with prior evidence of income-driven new development in flood-prone areas.[34] Further, the CRS-discounted insurance premiums are attractive to those purchasing insurance, who tend to be wealthier[24], and the wealthier households have greater capacity and propensity to mitigate (e.g., Osbergerhaus[35]).

Similarly, the effect of *CRS*Risk* on the wealthiest CRS residents, who shy away from residing in high flood risk areas suggest that the deterrent effect of CRS flood management effort is working in at least one segment of the income distribution. Wealthier residents are apparently responsive to the incentives: take a discount to live in the safer parts of floodplains, but eschew high-risk areas, especially if they do not come with discounted premiums. Poorer residents are kept out of floodplains, likely receiving more of the "scarecrow" effects of CRS activities (and not as much positive incentive) as they disperse elsewhere in the community.

If the CRS is attracting poverty rather than creating it, then there may be some solace taken here. Communities most actively managing their flood risks are also disproportionately drawing people in poverty to live there. This may bode well for the "next Hurricane Katrina," and it might reflect the greater capacity of wealthier residents to essentially self-insure against flood risks outside of CRS communities. The notion that CRS communities may be pushing these new poor residents outside of floodplains is particularly heartening for those concerned about protecting vulnerable populations from natural hazard risks. In a sense, the "system" is working for the poor, and the wealthiest residents may be finding ways to "game the system" by seeking discounts and lower risks. CRS communities may be having more and faster success at relocating poor residents away from flood risk than they have for wealthy residents.

The results have implications beyond just the communities participating in the CRS. Insofar as CRS-discounted insurance premiums are consistent with risk-based premiums, the results here build on Hudson et al.'s [(63)] findings that risk-based insurance premiums could promote adaptation to flood risk but conflict with affordability. Thus, the CRS may be incentivizing more individual policyholder adaptation while non-CRS communities' higher premiums present an affordability problem where low-income individuals do not insure. The results here suggest that floodplain areas enjoying CRS-discounted premiums also house fewer poor residents, which shifts the affordability challenge to flood-prone areas outside the CRS. A temporary voucher plan for low-income households[64] could address this unaffordability concern.

The results here point to several ways to improve the effectiveness of flood risk management efforts in the U.S. The evidence that residents respond to flood risk differently than (SFHA) floodplain designations reinforces the value of risk-weighted insurance premiums and other more graduated flood management activities. A binary approach that treats things inside floodplains equally and mostly ignores things outside official floodplains leaves room for improvement, and at least the wealthy residents discern the difference and strategically react. Furthermore, even seemingly income-neutral flood risk management can, and does, have differential effects across the income distribution. Policymakers may seek to explicitly address or reward efforts that target key parts of the income distribution. For instance, the information and incentives provided in communities that join the CRS appear to only discourage the wealthy from residing in high-risk areas; the poor do not respond to those incentives (perhaps, because they do not get the message or get the message, but do not have the resources to relocate from high-risk areas). A more effective flood-risk management program could make sure that the information and incentives are accessible and actionable across the income distribution. Finally, that joining the CRS is followed by fewer poor and more very wealthy residents in SFHAs may be seen as a partial success, but does raise concerns about greater exposure of high-value property to flood risks—an unintended consequence of the CRS that is worth managing carefully.

7. CONCLUSION

In order to have a comprehensive understanding of the impacts of the CRS on participating local communities, there is a need to examine both its intended and unintended consequences. While the former has been the subject of previous research,[2,8] the latter has yet to be explored despite evidence suggesting that the CRS may have differential impacts on communities.[10] To address this research gap, the current study explores how the CRS—a program designed to mitigate flood disasters—impacts poverty and income inequality in participating CRS communities. The analysis raises and answers some questions about the impacts of flood mitigation activities on and across the income distribution. This is especially important not just as we assess the fairness of public investments in flood risk management, but also because vulnerability to those risks is closely tied to income and household resources.

Our study is the first to provide empirical evidence on the impacts of the CRS on poverty and income inequality. Specifically, the results indicate that median incomes are lower in a CRS participating community, but rise in floodplains. Additionally, the results suggest that the CRS may be attracting poor people, perhaps as a result of a community's investments in flood management measures as part of the requirements for participating in the CRS. However, once poor residents move in, the CRS program seems to be relocating them away from areas that are highly prone to flooding. With regard to income inequality, the CRS is attracting top earners (perhaps due to the availability of flood insurance premium reductions), including CRS areas that are vulnerable to flooding. Finally, the CRS is encouraging income inequality, but discouraging income inequality in areas that are highly susceptible to flooding.

To fully assess the consequences—both intended and unintended—of the CRS, policy makers, planners, emergency managers, and those in charge of evaluating the CRS should find our results insightful. Our study suggests that the CRS has unintended impacts on poverty and income inequality and that these unexpected consequences should be taken into account when evaluating the CRS program. By including information on the unintended impacts of the CRS on poverty and income inequality, CRS evaluators and other stakeholders would be able to have a holistic understanding of the benefits and costs associated with the CRS. The use of national-level data allows the results to be more generalizable. Nevertheless, it is important to note that this study did not control for other variables such as prior flood experience and political affiliation.

Despite this limitation, our study lays the foundation for future work on the unintended consequences of the CRS on participating communities. A good understanding of the unexpected consequences of the CRS on poverty and income inequality can help policymakers improve the overall performance of the CRS, and in particular, its flood risk management piece. Nonetheless, further inquiries are urgently warranted. First, it is important for researchers to examine whether the CRS, as currently implemented, will be able to reduce flood-related impacts on communities in the future amid the growing challenges engendered by climate change. Second, an examination of the CRS's impacts on issues such as migration, housing development, housing prices, and building codes merits further investigation. And the distribution of those impacts over different subpopulations and income levels, again, deserves special attention. Third, the relationship between CRS participation and the type of government deserves attention. For instance, does CRS participation depend on whether a local community is governed by a mayor or city council? Finally, amid a low CRS participation rate by communities, there is a need to study the factors that motivate local communities to participate in the CRS and other voluntary federal government risk mitigation programs. This study is a crucial step in helping the risk analysis community to better understand the relationship between risk and poverty as well as the role of risk analysis in the quest to alleviate poverty and reduce income inequality.

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REFERENCES

1. Gopalakrishnan C. Water and disasters: A review and analysis of policy aspects. International Journal of Water Resources Development, 2013; 29(2):250-271.

2. Sadiq AA, Noonan DS. Flood disaster management policy: An analysis of the United States Community Ratings System. Journal of Natural Resources Policy Research, 2015a; 7(1):5-22.

3. National Weather Service. United States flood loss report-water year 2012, 2013. Available at http://www.nws.noaa.gov/hic/summaries/WY2012.pdf, Accessed on January 12, 2015.

4. Kunreuther H, Roth RJ. Paying the price: The status and role of insurance against natural disasters in the United States. Washington, DC: Joseph Henry, 1998.

5. Luhby T. Obama decries income inequality in final State of the Union address. Cable News Network, 2016. Available at http://money.cnn.com/2016/01/12/news/economy/obama-state-of-the-union/index.html, Accessed on October 20, 2016.

6. Brody SD, Zahran S, Highfield WE, Bernhardt SP, Vedlitz A. Policy learning for flood mitigation: A longitudinal assessment of the Community Rating System in Florida. Risk Analysis, 2009; 29(6):912–929.

7. Fan Q, Davlasheridze M. Flood risk, flood mitigation, and location choice: Evaluating the National Flood Insurance Program's Community Rating System. Risk Analysis, 2016; 36(6):1125-1147.

8. Sadiq AA, Noonan DS. Local capacity and resilience to flooding: Community responsiveness to the community ratings system program incentives. Natural Hazards, 2015b; 78(2):1413-1428.

9. Cutter SL, Emrich CT. Moral hazard, social catastrophe: The changing face of vulnerability along the hurricane coasts. The Annals of the American Academy of Political and Social Science, 2006; 604(1):102-112.

10. Zahran S, Brody SD, Highfield WE, Vedlitz A. Non-linear incentives, plan design, and flood mitigation: The case of the Federal Emergency Management Agency's Community Rating System. Journal of Environmental Planning and Management, 2010; 53(2):219-239.

11. Bin O, Bishop JA, Kousky C. Does the National Flood Insurance have Redistributional Effects? Paper presented at the 86th Annual Meeting of the Southern Economic Association, November 19-21, 2016.

12. Fothergill A, Maestes EGM, Darlington, JD. Race, ethnicity and disasters in the United States: A review of the literature. Disasters, 1999; 23(2):156–173.

13. Johnson BB. Gender and race in beliefs about outdoor air pollution. Risk Analysis, 2002; 22(4):725–738.

14. Banerjee A, Duflo E. Poor economics: A radical rethinking of the way to fight global poverty. New York: PublicAffairs, 2012.

15. Cox LA Jr. Poverty and Risk: A Review of Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty by Abhijit V. Banerjee and Esther Duflo. Risk Analysis, 2012; 186(32):1104-1108.

16. Noonan DS. Evidence of environmental justice: A critical perspective on the practice of EJ research and lessons for policy design. Social Science Quarterly, 2008; 89(5):1153-1174.

17. Noonan DS. Assessing the EPA's experience with equity. Pp. 85-116 in Konisky D (ed.). Failed Promises: Evaluating the Federal Government's Response to Environmental Justice. Cambridge, Massachusetts: MIT Press, 2015.

18. Federal Emergency Management Agency. National Flood Insurance Program (NFIP) Community Rating System (CRS) coordinator manual, 2013. Available at http://www.fema.gov/media-library/assets/documents/8768?id=2434, Accessed on July 7, 2015.

19. Dixon L, Clancy N, Seabury SA, Overton A. The National Flood Insurance Program's market penetration rate, estimates and policy implications. Arlington, VA: RAND, 2006.

20. Landry CE, Li J. Participation in the community rating system of NFIP: Empirical analysis of North Carolina counties. Natural Hazards Review, 2011; 13(3):205-220.

21. Kousky C. Learning from extreme events: Risk perceptions after the flood. Land Economics, 2010; 86(3):395-422.

22. Atreya A, Ferreira S, Kriesel W. Forgetting the flood? An analysis of the flood risk discount over time. Land Economics, 2013; 89(4):577-596.

23. Gallagher J. Learning about an infrequent event: evidence from flood insurance take-up in the United States. American Economic Journal: Applied Economics, 2014; 6(3):206-233.

24. Petrolia DR, Landry CE, Coble KH. Risk preferences, risk perceptions, and flood insurance. Land Economics, 2013; 89(2):227-245.

25. Landry CE, Jahan-Parvar MR. Flood insurance coverage in the coastal zone. Journal of Risk and Insurance, 2011; 78(2):361-388.

26. Holway JM, Burby RJ. The effects of floodplain development controls on residential land values. Land Economics, 1990; 66(3):259-271.

27. Bin O, Polasky S. Effects of flood hazards on property values: Evidence before and after Hurricane Floyd. Land Economics, 2004; 80(4):490-500.

28. Pope JC. Do seller disclosures affect property values? Buyer information and the hedonic model. Land Economics, 2008; 84(4):551-572.

29. Meldrum JR. Floodplain price impacts by property type in Boulder County, Colorado: condominiums versus standalone properties. Environmental and Resource Economics, 2016; 64(4):725-750.

30. Sekulova F, van den Bergh JC. Floods and happiness: Empirical evidence from Bulgaria. Ecological Economics, 2016; 126:51-57.

31. Grames J, Prskawetz A, Grass D, Viglione A, Blöschl G. Modeling the interaction between flooding events and economic growth. Ecological Economics, 2016; 129:193-209.

32. Daniel VE, Florax RJ, Rietveld P. Flooding risk and housing values: An economic assessment of environmental hazard. Ecological Economics, 2009; 69(2):355-365.

33. Bin O, Crawford TW, Kruse JB, Landry CE. Viewscapes and flood hazard: Coastal housing market response to amenities and risk. Land Economics, 2008; 84(3):434-448.

34. Cordes JJ, Yezer AM. In harm's way: Does federal spending on beach enhancement and protection induce excessive development in coastal areas?. Land Economics, 1998; 74(1):128-145.

35. Osberghaus D. The determinants of private flood mitigation measures in Germany—Evidence from a nationwide survey. Ecological Economics, 2015; 110:36-50.

36. Bubeck P, Botzen WJW, Kreibich H, Aerts JCJH. Detailed insights into the influence of flood-coping appraisals on mitigation behaviour. Global Environmental Change, 2013; 23(5):1327-1338.

37. Sarkhel P. Flood risk, land use and private participation in embankment maintenance in Indian Sundarbans. Ecological Economics, 2015; 118:272-284.

38. Davlasheridze M, Fisher-Vanden K, Klaiber HA. The effects of adaptation measures on hurricane induced property losses: Which FEMA investments have the highest returns?. Journal of Environmental Economics and Management, 2017; 81:93-114.

39. Bagstad KJ, Stapleton K, D'Agostino JR. Taxes, subsidies, and insurance as drivers of United States coastal development. Ecological Economics, 2007; 63(2):285-298.

40. Posey J. The determinants of vulnerability and adaptive capacity at the municipal level:Evidence from floodplain management programs in the United States. Global Environmental Change, 2009; 19(4):482–493.

41. Kousky C, Michel-Kerjan E. Examining flood insurance claims in the United States: Six key findings. Journal of Risk and Insurance, 2015. DOI: 10.1111/jori.12106.

42. Bin O, Bishop JA, Kousky C. Redistributional Effects of the National Flood Insurance Program. Public Finance Review, 2012; 40(3):360-80.

43. Rupasingha A, Goetz SJ. Social and political forces as determinants of poverty: A spatial analysis. Journal of Socio-Economics, 2007; 36(4):650–671.

44. Duncan GJ. Years of poverty, years of plenty. Ann Arbor, MI: Institute for Social Research, University of Michigan, 1994.

45. McKernan SM, Ratcliffe C. Events that trigger poverty entries and exits. Social Science Quarterly, 2005; 86:1146–1169.

46. Pandey S, Coulton C. Unraveling neighborhood change using two-wave panel analysis: A case study of Cleveland in the 1980s. Social Work Research, 1994; 18(2):83-96.

47. Whitaker S, Fitzpatrick IV TJ. Deconstructing distressed-property spillovers: The effects of vacant, tax-delinquent, and foreclosed properties in housing submarkets. Journal of Housing Economics, 2013; 22(2):79-91.

48. United States Department of Agriculture Economic Research Service. Geography of Poverty, 2015. Available at http://www.ers.usda.gov/topics/rural-economy-population/rural-poverty-well-being/geography-of-poverty.aspx, Accessed on June 7, 2016.

49. Hirschl TA, Rank MR. The effect of population density on welfare participation. Social Forces, 1991; 70(1):225-235.

50. Cohen B. Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. Technology in Society, 2006; 28(1):63-80.

51. Bureau of Labor and Statistics. Glossary. Available at http://www.bls.gov/bls/glossary.htm, Accessed on November 15, 2016.

52. Blank RM. Distinguished lecture on economics in government: Fighting poverty: Lessons from recent US history. The Journal of Economic Perspectives, 2000; 14(2):3-19.

53. Hoynes HW, Page ME, Stevens AH. Poverty in America: Trends and explanations. Journal of Economic Perspectives, 2006; 20(1):47-68.

54. Caner A, Wolff EN. Asset poverty in the United States, 1984–99: Evidence from the panel study of income dynamics. Review of Income and Wealth, 2004; 50(4):93-518.

55. Haveman R, Wolff EN. The concept and measurement of asset poverty: Levels, trends and composition for the US, 1983–2001. The Journal of Economic Inequality, 2005; 2(2):145-169.

56. Kutty NK. A new measure of housing affordability: Estimates and analytical results. Housing Policy Debate, 2005; 16(1):113-142.

57. Yoon DK. Assessment of social vulnerability to natural disasters: A comparative study. Natural Hazards, 2012; 63(2):823-843.

58. Brouwer R, Akter S, Brander L, Haque E. Socioeconomic vulnerability and adaptation to environmental risk: A case study of climate change and flooding in Bangladesh. Risk Analysis, 2007; 27(2):313-326.

59. Kahn ME. The death toll from natural disasters: The role of income, geography, and institutions. Review of Economics and Statistics, 2005; 87(2):271-284.

60. von Hippel PT, Scarpino SV, Holas I. Robust estimation of inequality from binned incomes. Sociological Methodology, 2016; 46 (1):212-251.

61. McGuire C, Goodman M, Wright J. Subsidizing risk: The regressive and counterproductive nature of national flood insurance rate setting in Massachusetts. Working Paper Series: Paper No. ENV-2015-01. University of Massachusetts Dartmouth: Public Policy Center, 2015.

62. Bond GD. The New Orleans that race built: Racism, disaster, and urban spatial relationships. Souls, 2007; 39(1):4-18.

63. Hudson P. Botzen WW, Feyen L, Aerts JC. Incentivising flood risk adaptation through risk based insurance premiums: Trade-offs between affordability and risk reduction. Ecological Economics, 2016; 125:1-13.

64. Kousky C, Kunreuther H. Addressing affordability in the national flood insurance program. Journal of Extreme Events, 2014; 1(1):1