THE IMPACT OF SEVERE WEATHER EVENTS ON HAMPTON ROADS' HOUSING MARKET
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Timothy Komarek
Assistant Professor, Department of Economics,
Old Dominion University, 2023 Constant Hall Norfolk, VA 23529.
E-mail: tkomarek@odu.edu
Phone: (757) 683-4534

Larry Filer
Associate Vice President for Entrepreneurship and Economic Development, Old Dominion University, 1006 E Strome Entrepreneurial Center, Norfolk, VA 23529.
E-mail: lfiler@odu.edu

Timothy Hodge
Assistant Professor, Department of Economics,
Oakland University, 413 Elliot Hall, Rochester, MI 48309.
E-mail: thodge@oakland.edu

J. Derek Loftis
Assistant Research Scientist, Center for Coastal Resources Management
Virginia Institute of Marine Science, College of William & Mary, 1375 Greate Rd., Gloucester Pt., VA 23062.
E-mail: jdloftis@vims.edu

Jennifer Seay
Graduate Research Assistant, Department of Economics,
Old Dominion University
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This report examines how flooding in Hampton Roads impacts the housing market. In particular, it measures the impact of FEMA flood zone information and two severe weather events, a Nor’easter commonly referred to as Nor’Ida in 2009 and Hurricane Irene in 2011, on residential housing prices and time-on-market. For the purpose of this analysis, the 100-year floodplain, as delineated by Federal Emergency Management Agency’s (FEMA) Flood Insurance Rate Maps (FIRMS), was classified as high-risk and included Zones AE, A, AH, AO, and VE. The 500-year floodplain was classified as low-risk and included Zone X. While FEMA flood zone maps are not necessarily predictors of risk, they offer general insight into a given property’s flood risk and are easily accessible by the public.

First, the results show that the final sales price decreased by approximately 5% for properties in either a high-risk or low-risk flood zone after a severe weather event. Furthermore, the 5% reduction in sales price after Hurricane Irene (2011) persisted through the end of the sample period in 2016. The reduction in sales price appears to be driven by decreases in properties in low-risk flood zones. Our estimates suggest prices in low-risk zones decreased by 7% in the time period after Nor’Ida and Hurricane Irene (post-2009) and the reduction persisted for 5 years. This may be because high-risk properties already price in the flooding risk premium, and the severe weather events do not provide any additional flooding risk information to potential buyers. However, severe weather events informed buyers who were unaware of the risk of properties in low-risk zones of the associated flood risk, resulting in falling prices.

Second, our results indicate that homes in the high-risk flood zones remained on the market 5-8 days longer in the time period after Nor’Ida (2009-2016), but there is no evidence of an increased time-on-market for low-risk properties. Our results suggest the housing market in high-risk flood zones cools down after a severe weather event, demonstrating buyers’ fears of purchasing a home in a high-risk flood zone.

This study utilized data from the Real Estate Information Network (REIN), a southeast Virginia multiple listing service (MLS), which provided information residential properties sales, time-on-market and a wide range of housing characteristics including age, school district, architectural style along with interior features and exterior features. We employed geographical information systems (GIS) software to determine the flood zone of each residential property, as determined by the National Flood Insurance Program. Additionally, we utilized a hydrodynamic model created at the Virginia Institute of Marine Science (VIMS) to determine which properties experienced flooding during Hurricane Irene.
INTRODUCTION AND PREVIOUS RESEARCH

According to the Center for Research of the Epidemiology of Disasters (CRED, 2010), flooding accounts for over half of the natural disasters people experience worldwide. In the U.S. alone, flooding caused $2.8 billion in damages from October 1, 2013 to September 30, 2014. Furthermore, rising sea levels have made recurrent flooding events common in many coastal cities. Previous research has suggested that the housing market capitalizes information on severe weather events and flood risk, such as NFIP flood zone designation (Bin and Landry, 2013).

FEMA flood zone information is publicly available, but is not always known, partly due to buyers not seeking out this information. Research by Chivers and Flores (2002) suggests that some homebuyers would have lowered their original offer if they were aware a property was in a flood zone. Furthermore, Pope (2008) examines a North Carolina law that requires sellers to disclose whether or not a property is in a flood zone. He finds that the price of homes within flood zones decreases by 4-5% after the disclosure requirement. The prices diminish due to the information disclosure as potential buyers price in costly damages due to flooding and the potential need to purchase flood insurance.

There is also a robust literature on whether housing prices respond to information regarding flood risk following severe weather events (Skantz and Strickland 2009; Bin and Polasky 2004; Carbone, Hallstrom, and Smith 2006; Kousky 2010; Atreya, Ferreira, and Kriesel 2013; Zhang 2016; Bin and Landry 2013). In general, the literature has shown that homes within an NFIP flood zone following a severe weather event.

Research has focused on the impact of information regarding flooding risk on housing prices. However, many homeowners are also concerned about the liquidity of their property, essentially the time it takes for a property to sell. Furthermore, the time-on-market is also a measure used by real estate agents during negotiations (Krainer, 2001; Knight, 2002). Our study analyzes the impact of the updated risk information that occurs due to weather events on both housing prices and time-on-market.

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A. National Flood Insurance Program (NFIP)

Private insurers had difficulty adequately determining flood risk and thus making a profit when providing flood insurance. As such, there was a great need for the federal government to step in to both determine flood risk and provide flood insurance. In 1968 the National Flood Insurance act established the National Flood Insurance Program (NFIP). The NFIP provides insurance for up to $250,000 for buildings and $100,000 for their contents against floods caused by hurricanes, tropical storms, and heavy rains. To receive flood insurance, the community a property is in must participate in the NFIP and enforce FEMA standards that reduce the risk of flooding. In exchange, FEMA provides flood insurance for structures in the community.

B. Study Area

The study is the Hampton Roads region in Southeast Virginia, displayed in Figure 1. We defined Hampton Roads as the Virginia Beach-Newport News-Norfolk metropolitan statistical area (MSA). Our analysis focuses on the cities with NFIP flood zones (Chesapeake, Hampton, Norfolk, Portsmouth, and Virginia Beach). Hampton Roads has become vulnerable to both significant weather events and nuisance flooding. This comes from a combination of the pervasive water and the underlying geology of the region resulting in sinking land. Furthermore, the location on the eastern seaboard leaves the region vulnerable to severe weather.

Hampton Roads experienced two extreme weather events over our study period (2007-2016). First, a significant Nor'easter, referred to as Nor’Ida, inundated the region with flooding in November 2009. Winds gusted up to 74 mph at Norfolk International Airport, and areas received between 5 and 8 inches of rain (The Virginian Pilot, 2009).
Hurricane Irene made landfall on August 2011. According to the Spatial Hazard Events Loss Database for the US (SHELDUS), Hurricane Irene resulted in damages for southeast Virginia of over $35.8 million. The storm surge flooding was most significant in Hampton Roads and along the Albemarle and Currituck Sounds in northeast North Carolina.

FIGURE 1

Study Area: Hampton Roads, Virginia

Note: Cities used in the analysis highlighted in grey

The data on tide readings offers insight as to why buyers may respond to flooding events. Since 2003, flooding in Hampton Roads has been both more frequent and historic. Table 1 presents the top 10 highest tide readings at Sewells Point, VA using data from the National Oceanic and Atmospheric Administration (NOAA). Seven of the top ten readings have occurred since 2002, while four of the top ten tide readings are related to our two events, three of which are from Nor’Ida. Therefore, it is not surprising that homebuyers in Hampton Roads are becoming more cognizant of flood prone areas when searching for a home, which may result in decreased housing prices and a longer time-on-market.

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2. More information can be found at: [http://hvri.geog.sc.edu/SHELDUS/](http://hvri.geog.sc.edu/SHELDUS/)
The real estate data is from the Real Estate Information Network (REIN), a southeast Virginia multiple listing service (MLS). It includes 137,384 sales, a wide range of housing characteristics, including the selling price and the time-on-market for each property. Table 2 contains data for selected housing characteristics for NFIP and Non-NFIP properties. We used the postal address to determine the NFIP FIRM zone of each property. In our dataset, 12% of homes sold were in high-risk zones and 14% in low-risk zones. We also incorporated a hydrodynamic model from the Virginia Institute of Marine Science (VIMS) to determine which properties experienced flooding during Hurricane Irene.
Table 2

Selected Summary Statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Non-NFIP Flood Zone</th>
<th>NFIP Flood Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td>Sales Price (dollars)</td>
<td>228,989</td>
<td>238,754</td>
</tr>
<tr>
<td>Full Baths</td>
<td>1.933</td>
<td>1.928</td>
</tr>
<tr>
<td>Half Baths</td>
<td>0.519</td>
<td>0.493</td>
</tr>
<tr>
<td>Bedrooms</td>
<td>3.273</td>
<td>3.188</td>
</tr>
<tr>
<td>Colonial</td>
<td>0.058</td>
<td>0.081</td>
</tr>
<tr>
<td>Contemporary</td>
<td>0.092</td>
<td>0.117</td>
</tr>
<tr>
<td>Ranch</td>
<td>0.303</td>
<td>0.227</td>
</tr>
<tr>
<td>Townhouse</td>
<td>0.136</td>
<td>0.096</td>
</tr>
<tr>
<td>Traditional</td>
<td>0.200</td>
<td>0.204</td>
</tr>
<tr>
<td>Age</td>
<td>36.69</td>
<td>43.93</td>
</tr>
<tr>
<td>New Construction</td>
<td>0.128</td>
<td>0.112</td>
</tr>
<tr>
<td>Short Sale</td>
<td>0.053</td>
<td>0.049</td>
</tr>
<tr>
<td>REO</td>
<td>0.127</td>
<td>0.125</td>
</tr>
<tr>
<td>Waterfront</td>
<td>-</td>
<td>0.164</td>
</tr>
<tr>
<td>100 Year Flood Zone</td>
<td>-</td>
<td>0.474</td>
</tr>
<tr>
<td>500 Year Flood Zone</td>
<td>-</td>
<td>0.526</td>
</tr>
</tbody>
</table>

Notes: The summary statistics are for 144,794 observations from January 1, 2007 to December 31, 2016.
We used a statistical model to measure the effect of significant flooding events and NFIP FIRM zones on the residential real estate market. The model compares homes sold within a particular flood zone (treatment group) with comparable homes outside of a flood zone (control group) before and after severe weather events. We also took steps to ensure that our results are due to the weather events and not other factors like the housing collapse during the Great Recession. The analysis captured the effects on housing prices and time-on-market for the time period after Nor’Ida (2009-2016), between Nor’Ida and Hurricane Irene (2009-2011) and after Hurricane Irene (2011-2016). We thus observed the impacts of the two storms individually and combined.
A. Effects on Housing Prices Between Flood Zones

We first measured the effects of Nor’Ida and Hurricane Irene on housing prices for properties located in either a high-risk or low-risk zone. We denote high-risk areas using the 100-year flood plain and low-risk areas with the 500-year flood plain. These maps do not perfectly measure risk but were the best indicator available.

Our results show that final sales price decreased by approximately 5% for properties in either a high-risk or low-risk flood zone after a severe weather event. Furthermore, the 5% reduction in sales price after Hurricane Irene (2011) persisted through the end of the sample period in 2016. This result differs from the work of Bin and Landry (2013) and Zhang (2016) which finds the price depreciation from severe weather dissipates over time. The information provided by Hurricane Irene also coincided with a broader regional dialogue on recurrent flooding. In 2009, the Hampton Roads State of the Region Report published by the Center for Economic Analysis and Policy at Old Dominion University discussed climate change and rising ocean levels. This shed light on the topic and increased media coverage. Thus, both factors could be driving the persistence of the fall in prices.

Our results show that final sales price decreased by approximately 5% for properties in either a high-risk or low-risk flood zone after a severe weather event. Furthermore, the 5% reduction in sales price after Hurricane Irene (2011) persisted through the end of the sample period in 2016. This result differs from the work of Bin and Landry (2013) and Zhang (2016) which finds the price depreciation from severe weather dissipates over time. The information provided by Hurricane Irene also coincided with a broader regional dialogue on recurrent flooding. In 2009, the Hampton Roads State of the Region Report published by the Center for Economic Analysis and Policy at Old Dominion University discussed climate change and rising ocean levels. This shed light on the topic and increased media coverage. Thus, both factors could be driving the persistence of the fall in prices.

We then measured the effects of the severe weather events on low-risk and high-risk properties separately to see if properties with different flooding risk levels reacted differently. Our estimates showed that the decrease in prices for properties in any flood zone, previously discussed, were driven primarily by changes in the low-risk zone. Our estimates indicated that in the period after Nor’Ida (post-2009), the low-risk zone experienced a 7% decline in sales price. On the other hand, the reduction in sales prices in the high-risk zones was only 2.7%, and not statistically significantly different from zero based on conventional measures. In this light, buyers in the high-risk zone may already price in the flooding risk premium, and severe weather events do not provide any additional flooding risk information. However, severe weather events informed buyers who were unaware of the risk of properties in low-risk zones of the associated flood risk, resulting in falling prices.

Furthermore, the magnitude of the price decline for the low-risk zone is larger after Hurricane Irene compared to the period between the storms. This could be because Hurricane Irene was a larger and more intense storm than Nor’Ida, or a multiplicative effect from 2 large storms in a close proximity to each other.

3. The 100-year floodplain. More information can be found at: http://hvri.geog.sc.edu/SHELDSU/
B. Effects on Housing Prices Within the High-Risk Flood Zone

Next, we studied differences in actual flooding during Hurricane Irene by using a hydrodynamic modeling (Figure 2) for Norfolk, VA created by the Virginia Institute of Marine Science (Loftis, Wang, and Forrest, 2015). The hydrodynamic model provided a measure of street-level flooding for properties in both the low-risk and high-risk zones.

![Figure 2](image)

33% of home sales in the high-risk area were inundated with some flooding and 310 properties had more than 1 meter of street-level flooding.

Table 3 shows the number of homes sold in each NFIP FIRM category in Norfolk based on the amount of flooding from Hurricane Irene. Properties outside of an NFIP FIRM zone experienced very little actual flooding with only 153 homes out of over 14,500 having any street-level flooding (0.4%). Only approximately 1% of the home sales in low-risk zones from our data experienced any level of flooding and only 2 properties had a meter or more of street-level flooding. On the other hand, 33% of home sales in the high-risk area were inundated with some flooding and 310 properties had more than 1 meter of street-level flooding. Thus, the actual flooding was largely contained within the high-risk NFIP FIRM zone.
Table 3

Level of Flooding from Hurricane Irene by NFIP FIRM Classification

<table>
<thead>
<tr>
<th>FIRM Classification</th>
<th>No Flooding</th>
<th>Any Flooding</th>
<th>Flooding 1 meter or more</th>
<th>% Experiencing Any Flooding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non NFIP</td>
<td>14,543</td>
<td>153</td>
<td>1</td>
<td>0.4%</td>
</tr>
<tr>
<td>Any-Risk</td>
<td>8,394</td>
<td>1,176</td>
<td>312</td>
<td>14.01%</td>
</tr>
<tr>
<td>Low-Risk</td>
<td>5,099</td>
<td>65</td>
<td>2</td>
<td>1.27%</td>
</tr>
<tr>
<td>High-Risk</td>
<td>3,295</td>
<td>1,111</td>
<td>310</td>
<td>33.72%</td>
</tr>
</tbody>
</table>

Interestingly, our results showed that housing prices in the low-risk zone responded more to high-risk prices even though flooding data suggests low-risk zones saw little actual flood inundation from Hurricane Irene. Thus, it seems that at least in terms of flood issues, buyers in the low-risk zones may have overreacted to Hurricane Irene.

We used the hydrodynamic modeling to examine whether there was a difference in the sales price after a severe weather event for properties inundated with flooding. Our results suggest that homes in the high-risk zone with either any or one meter or more of street-level did not sell for a different price than those that did not experience any street-level flooding. However, such properties sell for almost 15% less than other high-risk properties regardless of a weather event. Thus, these areas could conceivably experience recurrent flooding issues outside of hurricanes or tropical storms that caused a reduction in sales price.

C. Effects on Time-On-Market

Our analysis also examined the time-on-market for residential properties after Nor’Ida and Hurricane Irene. On average, the time-on-market for a property within a flood zone, either high-risk or low-risk, increased by 3.8 days after Nor’Ida (2009-2016). However, our estimate of the effect of residing in a flood zone on time-on-market is not statistically significant at conventional levels, and thus we are not confident it is actually different from zero.

In contrast, there is a marked difference in the time-on-market between high-risk and low-risk properties. Properties in the high-risk flood zones remained on the market approximately 5 - 8 days longer after Nor’Ida (post-2009) than properties not in a flood zone. On the other hand, we did not find a statistically significant effect for time-on-market for properties in the low-risk zone. We also examined if either Nor’Ida or Hurricane Irene had a disproportionate effect on the time-on-market. The properties in the high-risk zone displayed an increase in time on market of 7.6 days after Hurricane Irene, the more serious of the two severe weather events.
This report summarized work on how the residential real estate market responds to severe weather events in Hampton Roads, Virginia.

The results show that housing prices decline by approximately 5% for properties in either low or high-risk flood zones after a severe weather event. This difference was driven by a price decrease of 7% in the low-risk zones. Our estimates also showed that properties within the high-risk flood zones remained on the market for approximately 5 - 8 days longer than properties not in a flood zone, suggesting that the residential real estate market cools down at a localized level after a severe weather event.

Given the increasing prevalence of recurrent flooding in Hampton Roads, observing the effects of severe weather events on the residential real estate market provides a better understanding of how citizens are perceiving and responding to the region’s flooding risk. Based on our analysis, it appears buyers in the Hampton Roads real estate market are taking into consideration a property’s flood risk when purchasing a home. This provides yet another signal that the issue of flooding is one of significant importance in the Hampton Roads region of Virginia.
REFERENCES


