Catastrophe Capitalization: Estimating Changes in Perceptions of Extreme Natural Events over Time

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Abstract

This paper examines the housing price capitalization of reoccurring extreme natural events. While previous research has investigated the impact of rare or singular events, perceptions about frequent reoccurring events has not been extensively studied. To fill this void in the literature, I implement a repeated sales model to examine the capitalization of single and multiple occurrences of extreme natural events in Southern California. The results provide evidence that the negative capitalization of flood events increases with event frequency, while wildfire capitalization is stable across occurrences.

1. Introduction

Recurring extreme natural events threaten communities and are associated with significant economic consequences; therefore, it is important to understand household perceptions of extreme natural events, and how these perceptions may vary with the event frequency. This paper evaluates the response of housing prices to multiple occurrences of extreme events, including wildfires and floods, between 2000 and 2015 in Southern California. Results from a property fixed effects repeated sales hedonic model provide evidence that housing prices respond heterogeneously across extreme natural event types and reoccurrences. While this paper focuses on the local Southern California area, the outcomes have larger implications for measuring how homeowners respond to extreme natural events as their frequency varies with a changing climate.

Related studies have shown the degradation of home values from nearby wildfires (e.g. Stetler et al. 2010) and flood hazards (e.g. Bin et al. 2006), but have not addressed changes in capitalization across event occurrences. This research extends the existing literature on valuing extreme natural events in two key areas. First, I investigate multiple occurrences of similar extreme events over time to determine if household perceptions change with time and event reoccurrence. Second, the use of property fixed effects removes the impact of spatial unobservables that could bias estimates in other studies that use a traditional hedonic specification. Controlling for these unobservables is of particular concern in this setting, since there are many variables that can affect risk factors from extreme natural events and are not observed by the researcher. This paper uniquely estimates the extent that capitalizations have changed across occurrences, and these estimates provide new insights for determining the effects of environmental policies.

There has been a significant research into the impact of one-time natural disaster occurrences on housing prices. Beron et al. (1997) found that perceptions about earthquake risks were overestimated in the housing market prior to the actual earthquake occurring. In contrast, research on flooding risk from hurricanes found the price discount for a home located within a flood plain increased after an actual flood event (Bin and Polasky 2004). Similarly, Lei (2016) shows that home prices responded negatively to an occurrence of a flood for a year after the event, controlling for the historic flood plain.

In one of the few studies examining repeated events, Mueller (2007) investigates repeated occurrences of wildfires in Los Angeles County during the 1990's. The research determines that the second occurrence of a wildfire had a larger negative capitalization than the first occurrence. The author attributes the capitalization difference to changes in perceptions following the first event, and speculates that households may not accurately judge wildfire risk. I build on this research by implementing property fixed effects, investigating multiple natural extreme event types to determine the existence and extent of differences in risk perceptions.

To examine the capitalization of extreme natural events, I implement data from Orange County, CA in a repeated sales hedonic model. The use of repeated home sales eliminates the impact of unobserved spatial attributes associated with each home that could bias estimates. The results provide evidence that housing prices are negatively impacted by repeated flooding events. In contrast, there is no significant negative impact of fires, single or repeated occurrence, on housing prices. This difference is likely the results of the education and expectations of residents in the area.

As the frequency and location of extreme natural events changes, it is important to understand the economic consequences of these events. This paper provides evidence of homeowner responses to repeated natural events through housing prices: using a repeated sales model, the results suggest that the impact of reoccurring events is heterogeneous across event types with the negative capitalization of flooding increasing with the second occurrence. This insight is significant in considering and evaluating policies meant to address extreme natural events and their frequency.

2. Model

To empirically estimate the changes in perceptions of recurring extreme natural events, I apply the hedonic method (Rosen 1974) with repeated housing sales. This method disaggregates housing prices to estimate attribute values and housing prices responses to events following the logic from Tiebout (1956). Specifically, I identify the impact of multiple flooding and fire events on the price of homes located near those events.

The price of a house is given as a function of its attributes, *H*, neighborhood attributes, *N*, and nearby extreme natural events, *E*, as shown below:

$$(1) \qquad P_{it} = f(\boldsymbol{H_{it}}, \boldsymbol{N_j}, \boldsymbol{E_{jt}})$$

where *i, j,* and *t* index the house, neighborhood, and time, respectively. To estimate this relationship empirically, a log-linear function is used to empirically model this relationship according to the discussion in Cropper et al. (1988).

(2) $\ln P_{it} = \alpha + \beta H_{it} + \gamma N_j + \theta E_{jt} + \eta + \epsilon_i$.

In Equation (2) year fixed effects are given by η, and are implemented to control for the regional time trend in prices for the sample.

When applying the baseline hedonic model, spatial unobservables can impact estimates if they are correlated with the coefficients of interest. This concern is especially valid when investigating flood and fire risk, since unobserved characteristics of a property and its surrounding neighborhood can severely alter the risk of damage from these events. For example, a minor elevation increase, or flood mitigation systems, can have large implications for flood risk. A property fixed effects model (Palmquist 1982) is applied to address this concern. In this model, each property is assigned a fixed effect. These variables control for the time-constant observable and unobservable attributes associated with each house and its neighborhood (e.g. Kousky 2010; Livy and Klaiber 2016). As a result, identification is derived from changes in extreme natural events accrued by homes that sold more than once during the study period. The information for a home that sold once during the study period is controlled for by the fixed effect for that home.

To incorporate the property fixed effects, Equation (2) is altered to give

(3) $\ln P_{it} = \alpha + \beta age_{it} + \theta E_{jt} + \eta + \zeta_i + \epsilon_i$

where ζ_i is the property fixed effect. Age is the only housing attribute included in this regression because the other housing attributes are time-constant and subsumed by the property fixed effects. Each natural event coefficient signifies the impact of that event on the price of a home within the specified spatial-temporal range.

Because the identification method relies on the sample of homes that sold more than once during the study, the applicability of the results to the larger sample of homes depends on the similarity between the sample of homes with multiple sales and the population of homes. This issue is tempered with the use of many years of data, and is addressed in the proceeding discussion. While the property fixed effects control for the time-constant attributes of a house and its surrounding area, unobserved time varying attributes can impact estimates if they are correlated with the variables of interest and effect housing prices. This concern is decreased in this situation since the events occur naturally, and are not necessarily associated with other changes in policy concerning homeowners in the area.

3. Data

Data from Orange County, CA between 2000 and 2015 are implemented to investigate changes in housing price capitalization of extreme natural events. The county has a population of over three million residents, and is located between San Diego and Los Angeles. While most of the area is developed and composed of relatively flat terrain, there are zones of dense brush and significant elevation changes in the western and eastern portions of the county. In these areas, wildfires and flooding leading to mudslides are natural events that threaten residents and have been highly publicized. The data on extreme natural events is obtained from local news reports and matched with housing sales data are from Corelogic.

Local news reports are used to identify the existence, severity, and location of extreme natural events across the study period. There are four major floods and three major fires identified in the county between 2000 and 2015. These events were chosen because they resulted in damage to multiple homes and were widely reported in the local news; therefore, the sample of extreme natural events are those that are most likely to be observed and considered by homebuyers in the region. In addition to direct damage from flood waters, the flooding events were also associated with mudslides. These mudslides caused a significant amount of the damage associated with each event. The repeated occurrences of floods and fires all occurred in the Silverado Canyon area, a remotely located community in the Santa Ana Mountains with limited access from local roads. The single occurrence natural events in the sample occurred throughout the county, and were non-repeating spatially.

Single family home sales data are obtained from Corelogic, a private data vendor. The sample includes all single-family homes that sold between 2000 and 2015 in the county. The data are cleaned to remove homes that sold multiple times in one year, homes that experienced abnormal appreciation, homes with missing information, and homes with other data anomalies. In total, there are 317,691 cleaned sales within the period and 193,405 observations of sales from homes that sold more than once.

Summary statistics for the housing sales observations are provided in Table 1. The table is separated into columns representing all housing sales, and sales of homes that sold more than once during the study period. In both samples, the mean sales price is similar and near $600,000, reflecting the relatively high cost of housing in this area compared to the national average. The mean home has 1,900 square feet with a lot size less than 0.20 of an acre. Across all housing attributes the two samples are comparable. This similarity is important because it reduces the concern that the sample of homes with multiple sales is significantly different from the overall sample of home in the area. If these two samples were significantly different, the relatability of the results to the entire population of homes would be limited.

The fire and flood variables are matched spatially to each home within the census tract, or tracts, of the event damage. Thus, the homes that are matched are those that were directly affected by the event. The events are also matched temporally to housing sales within 18 months of the event occurrence, and the impact of varying the 18 month time cutoff is investigated in the results section.

4. Results

Housing sales are spatially and temporally matched with extreme natural events to estimate the property fixed effects model. These estimates are provided in Table 2. Age is the only housing variable estimated because the other housing attributes do not vary with time. While year and property fixed effects are included in the regression, they are suppressed due to space concerns but available upon request.

Focusing on the flood variables, each of the estimates is negative. Across all locations the first occurrence of the flood has a similar magnitude, although the location one estimate is not significant. On average, the first flood event is associated with a price decrease of nearly 0.75%. Capitalization calculated at the mean housing price level of nearly $600,000 corresponds to a reduction in the sales price of $4,500 for homes sold within flooded neighborhoods within 18 months of the event.

The estimate for the second occurrence of flooding during the sample period is significantly larger than the first occurrence, and is associated with a sales price decrease of nearly 39%. A concern with this comparison is that the magnitude of the flood was different between the two occurrences in terms of damage. However, the property damage, both intensity and extent, was similar for each of the two events, and the first occurrence was associated with the loss of one life, while the second incident was not associated with any deaths. Therefore, it appears that the reoccurrence of the flood is driving the results instead of an increase in the damage severity.

Investigating the fire coefficients, each is negative but none are significant. Therefore, there is no evidence that wildfires have impacted housing prices in this area during the 18 months following the event date. There are a few explanations for this result: these fires typically lead to small amounts of property damage compared to flooding events; residents are educated about the fire risk through news reports and public outreach; and the burning of an area may provide a short-term reduction of the risk of another destructive fire in the same area by reducing the fuel for future fires.

The results represent the impact of single occurrence and repeated extreme natural events on housing prices during the 18 months following the event. However, it is possible that the time cut-off used can impact these estimates and provide evidence of the change in perceptions across time. To address this concern, Table 3 presents the results with 6, 12, 18, and 24 month intervals. Investigating all variables, the sign and magnitude of the estimates is stable across each of the columns. The insignificance at the 6 month period for the flood variables is largely driven by the lack of observations required for significance; although the time difference between offers and the sale record date may also impact this estimate. The estimates for the 12 and 18 month periods are stable.

There is a decline in significance at the 24 month interval for most of the variables compared to the 12 and 18 month intervals. This change suggests that the negative capitalization of flooding events is tempered with time. Together, the time intervals provide evidence that the results are not driven by a spurious correlations with other events during the 18 months following the event occurrence, and that the capitalization effects are generally limited in time.

5. Conclusion

This paper is unique in examining the impacts of multiple extreme natural events over time on housing prices. Importantly, this research explores the extent that perceptions, as channeled through the housing market, change as the number of extreme natural events varies. To investigate this issue, data from Orange County, CA are implemented within a repeated sales hedonic framework to control for the time-constant attributes of each home, eliminating a significant source of bias in hedonic models. This issue is particularly significant when examining extreme natural events, since these unobserved attributes often alter the impact of the event on the house and it surrounding area.

Results from the property fixed effects models show that extreme flooding events are negatively capitalized into housing prices, and these negative capitalizations increase when there is a reoccurrence. In contrast, fires do not have a statistically significant capitalized value by nearby housing prices. Together, the estimates suggest that perceptions of external natural events are not constant across type and occurrence, and provide an initial step in determining how possible changes in the frequency of extreme natural events will affect homeowner welfare.

6. References

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7. Tables

Table 1: Summary Statistics

	all sales		repeat sales	
	mean	standard deviation	mean	standard deviation
price	$604,881.50	$2,373,593.00	$609,429.10	$515,574.40
age	37.73	16.96	37.00	17.72
acres	0.17	1.90	0.16	0.98
living square feet	1925.07	1074.53	1911.39	874.99
stories	1.19	0.71	1.15	0.73
total baths	2.55	0.92	2.56	0.94
flood 1, location 1	0.00010	0.01019	0.00011	0.01066
flood 2, location 1	0.00010	0.01019	0.00011	0.01066
flood 1, location 2	0.00034	0.01835	0.00043	0.02084
flood 1, location 3	0.00015	0.01216	0.00013	0.01137
fire 1, location 1	0.00010	0.01019	0.00012	0.01114
fire 2, location 1	0.00009	0.00939	0.00008	0.00881
fire 1 , location 2	0.00011	0.01035	0.00014	0.01181
N	317691		193405	

Table 2: Property Fixed Effects Model

Variable	
Dependent Variable= ln(Price)	
age	0.053***
	(0.000)
flood 1, location 1	-0.017
	(0.048)
flood 2, location 1	-0.391***
	(0.087)
flood 1, location 2	-0.091***
	(0.027)
flood 1, location 3	-0.084**
	(0.040)
fire 1, location 1	-0.109
	(0.068)
fire 2, location 1	-0.045
	(0.048)
fire 1 , location 2	-0.050
	(0.065)
constant	11.005***
	(0.007)
N	193405
R-sq	0.735

Note: Property clustered standard errors in parentheses. Property and year fixed effects estimates suppressed due to space concerns.

Significance given by * p<0.10, **p<0.05, and *** p<0.01

Table 3: Time Robustness

Variable				
Dependent Variable= ln(Price)	6 months	12 months	18 months	24 months
age	0.053***	0.053***	0.053***	0.053***
	(0.000)	(0.000)	(0.000)	(0.000)
flood 1, location 1	0.005	0.025	-0.017	0.041
	(0.052)	(0.060)	(0.048)	(0.062)
flood 2, location 1	-0.193	-0.313***	-0.391***	-0.214
	(0.141)	(0.109)	(0.087)	(0.146)
flood 1, location 2	-0.113***	-0.082***	-0.091***	-0.050
	(0.030)	(0.030)	(0.027)	(0.032)
flood 1, location 3	-0.077	-0.084**	-0.084**	-0.084**
	(0.059)	(0.040)	(0.040)	(0.040)
fire 1, location 1	0.088	-0.085	-0.109	-0.015
	(0.071)	(0.089)	(0.068)	(0.046)
fire 2, location 1	0.018	-0.022	-0.045	-0.015
	(0.058)	(0.052)	(0.048)	(0.043)
fire 1 , location 2	0.031	-0.029	-0.050	-0.014
	(0.055)	(0.050)	(0.065)	(0.037)
constant	10.971***	10.970***	11.005***	10.971***
	(0.007)	(0.007)	(0.007)	(0.007)
N	193405	193405	193405	193405
R-sq	0.735	0.735	0.735	0.735

Note: Property clustered standard errors in parentheses. Property and year fixed effects estimates suppressed due to space concerns.

Significance given by * p<0.10, **p<0.05, and *** p<0.01