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Flood hazards impact on neighborhood house prices: A spatial quantile regression analysis

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ABSTRACT

This study examines whether being located within a 100-year floodplain has an impact on the price of residential single-family house sales using house sales data in the Fargo-Moorhead Metropolitan Statistical Area between 2000 and 2013. A spatial quantile regression is applied to investigate the flood hazards impact on conditional higher- vs lower- priced homes, while accounting for spatial autocorrelation. The findings show that the location within a floodplain reduces property value. Furthermore, the negative impact of flood hazards on property values are stronger among lower-priced homes, and weaker among higher-priced homes. In addition, the study examines if a major flood in 2009 had an impact on the home buyers' perception about flood risk. The results show that about a year after the major flood, home buyers responded the most, however, the effect quickly diminished after 2010. Across quantiles, the 2009 flood had more effect on lower-priced than higher-priced homes.

1. Introduction

Flooding is the most common natural disaster in the world. "Any land area susceptible to being inundated by flood waters from any source" is classified by the Federal Emergency Management Agency (FEMA) as a floodplain. A 100-year floodplain is an area where a flood has a 1% chance of occurring in any given year. To reduce future flood damage, the National Flood Insurance Program (NFIP) provides insurance for participating communities. Properties located within the 100-year floodplain that carry a federally backed mortgage are required to obtain flood insurance. Many researchers have examined the price discount on house sales associated with location within a 100-year floodplain and evaluated the price discount and capitalized flood insurance premiums (Harrison et al., 2001; Bin and Polasky, 2004; Bin et al., 2008; Atreya et al., 2013; Bin and Landry, 2013; etc.). The general consensus is that location within a floodplain has a negative impact on house prices, but the magnitude of the price discount varies from 4% to 12%. In theory, the price discount reflects the home owner's willingness to pay to reduce the cost of flooding, i. e. the difference between the market value of a house located within a floodplain and the value of an equivalent house located outside a floodplain, should be equal to the present value of future flood insurance premiums. However, in practice, the price discount may deviate from capitalized flood insurance premiums.

The price discount may be larger than the capitalized flood insurance premiums since all structures within a floodplain are not fully insurable, especially for relatively expensive houses. The NFIP limits the coverage for: 1) Building property, up to $250,000, and 2) Personal property (contents), up to $100,000. Moreover, some building property or personal property are not insured, such as a swimming pool, decks, patios, etc. The price discount may be smaller than the capitalized flood insurance premiums under circumstances where home buyers underestimate the cost of flooding or are unaware of the flood hazards. Harrison et al. (2001) utilized a house sale transaction database in Alachua County, Florida, and found that the price differential is less than the present value of insurance premiums. Bin and Polasky (2004) used data from single-family house sales in Pitt County, North Carolina, and found that for an average valued house in normal years, the price discount is smaller than the capitalized insurance premiums, while in years after a major flood, the discount is larger than the capitalized insurance premiums. Bin et al. (2008) investigated the flood impact in Carteret County, North Carolina. They indicated the value of price discounts and capitalized insurance premiums are roughly equivalent.

The heterogeneity of past findings can be explained by geographic differences, spatial dependence, and/or quantile effects (Liao and Wang, 2012). Spatial dependence occurs when values observed at one location depend on the values of neighboring observations at nearby locations (LeSage and Pace, 2009). Basu and Thibodeau (1998) suggests that house prices are spatially autocorrelated for two reasons. First, simultaneous neighborhood development causes similar structures among neighborhood properties. Second, neighborhood properties

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share the same amenities. To solve the spatial autocorrelation issue, spatial econometric models have been applied to many studies. Anselin (1998) and LeSage and Pace (2009) provide a thorough review of the spatial econometric techniques.

Quantile effects examine how housing, and neighborhood characteristics are valued differently across the conditional distribution of house prices. The traditional ordinary least square (OLS) estimation is based on conditional means, which ignores the differential effects across the complete conditional (on the model covariates) distribution of house prices. Most of the previous studies on flood impact focus on the conditional mean effect of flood hazards on house prices, which assumes if other things hold constant, on a percentage basis flood risk has the same impact on higher- vs lower-priced homes. The present value of flood insurance premiums for a standard house is usually compared with the price differential between inside and outside the floodplain (Harrison et al., 2001; Bin et al., 2008; among others). The comparison is also based on the assumption that flood risk has the same percentage impact on houses at any price level. This assumption may not be true in the real world. Studies regarding the flood effect across a complete distribution of house prices are lacking.

In this study, a spatial quantile regression model is applied to determine the flood hazards impact on housing values. Rather than a conditional mean, researchers have found that quantile regression is particularly useful when examining the full characterization of the conditional distribution of house prices (e.g., Coulson and McMillen, 2007; McMillen, 2008; McMillen, 2015; Zietz et al., 2008; Mak et al., 2010; Ebru and Eban, 2011; Deng et al., 2012). A quantile model allows us to estimate the differential effect of the flood hazards on the conditional distribution of house prices. Spatial framework captures spatial dependence and heterogeneity in the housing market. Thus, using a spatial quantile model, I am capable of examining the impact of flood hazards across the complete distribution of house prices while taking into consideration the spatial effects. The results will inform the extent to which heterogeneity in the price effects of the floodplain exists within a single market.

To the best of my knowledge, this is the first paper that investigates heterogeneity in the flood hazards impact on the full conditional distribution of house prices. It also contributes to the scarce existing literature about the flood hazards impact on the housing market in the Fargo-Moorhead area.

The study finds that the flood hazards impact on house prices is quite diversified across the conditional distribution of house prices. Conditional lower-priced houses are more prone to be affected by flood risk. In general, most local flood mitigation programs focus on well-established high income neighborhoods. The finding suggests it may be more beneficial if the local government adopts programs that intend to reduce flood risk in neighborhoods where most lower-priced homes are located, since flood hazards has the strongest negative impact on lower-priced homes.

2. Study area

The study area consists of the Fargo-Moorhead metropolitan area (henceforth, FM area), and is comprised of Fargo, North Dakota; Moorhead, Minnesota, and the surrounding communities. The FM area, located in the Red River Basin, has always been threatened by flooding from the Red River of the North (the Red River). The 550-mile Red River drains an area of >50,000 mile^2, from western Minnesota and eastern North Dakota, and discharges into Lake Winnipeg in Canada.

The unique topography of the Red River Basin contributes to the frequent flooding experienced in the FM area. The valley portion of the basin has a slope of 1–2 ft per mile. At the basin's margin, the subwatersheds draining into the Red River have an elevation drop of up to 950 ft in 80–100 miles (Red River Basin Board, 2000). This topography can easily cause flooding when stream banks are full to capacity. In addition, the Red River flows northward. The spring thaw proceeds steadily northward through the valley. The southern end of the Red River Basin can be melting, while the northern end and Lake Winnipeg may still be frozen. Thus, runoff from the south meets with freshly-melted waters from the north, which can cause localized flooding.

In addition, the increase in global warming and climate change, and the reduction in flood storage capacity, can also increase the expectation of future flood risks in the Red River Basin.

Since the beginning of a wet climatic cycle in 1993, floods have been more frequent and more severe. In 1997 the Red River crested at 39.7 ft, and in 2009 the river set a new high water record of 40.8 ft. During 2009 flood, residents in the FM area filled over 1 million sandbags, emergency dikes were built. Even though a vast majority of the residential houses were intact, the 2009 flood did raise people's awareness of floods, and change flood hazards perceptions.

3. Review of recent studies

Many researchers have investigated the flood hazards impact on house prices. Among others, Harrison et al. (2001) used a traditional hedonic model to examine the effect of flood risk on the valuation of homes in Alachua County, Florida. The results suggested that location within a floodplain significantly lowers house values. However, Harrison et al. (2001) did not consider the spatial effects, which is crucial in the housing market as residential houses are usually clustered and exhibit spatial dependence.

An improvement has been done by Bin et al. (2008), who employed a spatial hedonic model to investigate the effect of flood risk on a coastal housing market from Carteret County, North Carolina. The data covered real estate transactions from 2000 to 2004. With the control of spatial effects, the study found that location within a flood zone lowers property value. Furthermore, for lower value houses, the sales price differential between inside and outside the flood zone is lower than the present value of flood insurance premiums. For an average value house, the sales price differential is approximately the same as flood insurance premiums. While for a higher value house, the former is higher than the latter. These comparison results in Bin et al. (2008) were calculated based on the assumption that flood risk has the same percentage effect on houses in any price level. However, if the flood risk has a different impact across the distribution of house prices, the results may be misleading.

In a more recent study, Atreya et al. (2013) used residential property sales data in Dougherty County, Georgia between 1985 and 2004 to analyze the flood risk discount over time. A spatial hedonic model, incorporated within difference-in-difference frame work, was utilized to investigate if a consumer's willingness to pay for a decrease in flood risk is affected by a flood event. The results showed that the price of houses located within the 100-year floodplain fell significantly after the major flood in 1994, and the effect disappeared between four and nine years after the flood.

Bin and Landry (2013) used a similar framework as in Atreya et al. (2013) to investigate the impact of flood risk on housing values after multiple storm events in Pitt County, North Carolina. They found the price differentials are significant after major flood events, while the effect is not persistent, essentially diminishing after flood events.

None of the existing literature employs quantile regression techniques to measure heterogeneity in the flood impact on housing across the complete distribution of house prices. Shultz and Fridgen (2001) used house sales data between 1995 and 1998, and applied a traditional hedonic model to examine the impact of the floodplain location on housing values in the FM area. However, they failed to control the spatial impact and a recent study on flood hazards impact in the FM area is missing.

4. Models

To control for spatial features caused by unobservable characteristics of nearby properties which may bias results in hedonic house price