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Differential Impacts of Floodplains on Home Prices: A Housing Submarket Approach*

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Abstract

Over the last 20 years, numerous studies have found that floodplains are negatively capitalized into the values of properties. These studies are generally based on the assumption that the housing market of the study area is a unitary single market for housing services. However, urban housing markets are composed of submarkets in which the structural and locational characteristics of housing units differ with regard to their functional relationships. Therefore, geographical features such as floodplains may represent various functions within submarkets and thus affect house values differently. Using a housing submarket approach as an analytical framework, this study investigates how the effects of floodplains on the sales prices of single-family houses vary among submarkets defined by median sales price of block groups (low-, middle-, and high-income). Then it will perform hedonic price analyses to estimate the differential impact of a floodplain on average house prices in Gwinnett County, Georgia, USA. The results show that the effects of floodplains on the sales prices of single-family houses vary across submarkets. Whereas average home sales prices in low- and middle-income submarkets are negatively influenced by the presence of a floodplain, those in high-income submarkets are positively influenced. The low-income submarket is the most negatively influenced.

Keywords ▪ Floodplains, Housing Prices, Housing Submarkets, Differential Impacts, Hedonic Analysis

Ⅰ. Introduction

Over the last 20 years, numerous studies have analyzed the effects of floodplain location on housing prices from a number of perspectives. Some researchers have studied the influence of actual flood events on housing values after major floods (e.g., Shultz & Fridgen, 2001; Skantz & Strickland, 1987). Others have examined the impact of potential flood risks, flood insurance, and floodplain land use regulation, which are induced by floodplain location, on prices (e.g., Bartošová et al., 1999; Bin & Polasky, 2004; Harrison et al., 2001; MacDonald et al., 1990; Shilling et al., 1985). The literature has suggested that floodplain location negatively affects housing prices because of the high potential for flooding and the cost of mitigation.

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The studies on the impact of floodplains on sales prices are generally based on the assumption that the housing market of the study area is a unitary single market for housing services (Watkins, 2001). However, urban housing markets are not unitary but instead are composed of submarkets with similar structural and locational characteristics for housing units (e.g., Bourassa et al., 1999, 2003; Grigsby et al., 1987; Goodman & Thibodeau, 1998). The functional relationship between housing and locational characteristics within any one submarket substantially differs from that within other submarkets. Thus, as floodplains may function differently across submarkets, they will have a different impact on housing prices among the submarkets. In addition, how households respond to flood risks and how much information they have about the risks depend on their socioeconomic characteristics (Browne & Hoyt, 2000; Fothergill & Peek, 2004; Sarmiento & Miller, 2006; Troy & Romm, 2004). As a result of these differences, housing prices in areas with floodplains can vary significantly.

This study tests the argument that floodplains influence the sales price of single-family housing units among submarkets. Hedonic price analyses are performed to estimate the variation in the impact of floodplains on prices in Gwinnett County, Georgia, in the United States. which can provide a rich case for this study. This study underscores the importance of spatial variation in the assessment of the impact of floodplain locations in the process of capitalization.

Ⅱ. Literature Review

1. Impacts of Flood Risks on Home Prices

The impact of the risk of flooding on housing values has been analyzed from various perspectives. Some researchers have studied the influence of actual flood events on housing values, investigating the difference in housing prices before and after a specific flood event (Bartošová et al., 1999; Shultz & Fridgen, 2001; Skantz & Strickland, 1987). Others, who have analyzed the capitalization of the floodplain location in housing prices, have mainly dealt with future flood risks and floodplain regulations such as flood insurance and land use/building regulations (Bartošová et al., 1999; Bialaszewski & Newsome, 1990; Bin & Polasky, 2004; Donnelly, 1989; Harrison et al., 2001; MacDonald et al., 1987, 1990; Park & Miler, 1982; Shilling et al., 1985, 1989; Shultz & Fridgen, 2001). Most studies using hedonic price analyses have found that floodplain locations are negatively capitalized into property values. These studies have suggested that expected flood risks and the cost of flood insurance are major factors that negatively influence home values in areas with floodplains. Other studies have found that floodplain land use regulations have a negative effect on undeveloped land (Holway & Burby, 1990) but

no significant impact on housing prices (Hwang, 2003).

In general, expected flood damage in floodplain areas decreases residential property values. Tobin and Newton (1986) provided a theoretical framework for flood-induced changes in urban land values, arguing that the negative aspects of the flood hazard are capitalized in the value of property because the flood risk will reduce the utility of the land. The findings of a majority of previous studies that use hedonic price regression to determine the impact of floodplains on prices were consistent with this framework: that floodplain location results in a decline in housing prices (Bartošová et al., 1999; Bialaszewski & Newsome, 1990; Bin & Polasky, 2004; Donnelly, 1989; Harrison et al., 2001; MacDonald et al., 1987, 1990; Shilling et al., 1985, 1989; Shultz & Fridgen, 2001). In particular, Bartošová et al. (1999), in their investigation of floodplains in 100-year increments from 100 to 500 years, found that as the risk of floods increases, the value of residential properties decreases. However, a few studies that analyzed the differences between the mean values of homes in floodplains and those outside of floodplains showed that the prices of housing units with flood risks were no different from those with no flood risk (Zimmerman, 1979).

Flood insurance is considered another important factor that has an impact on housing prices in floodplains. Park and Miller (1982) found that after the introduction of the National Flood Insurance Program (NFIP) in 1968, the sales prices of residential property in the floodplains had declined because of the cost of flood insurance in Logansport, Iowa. Skantz and Strickland (1987), who compared the changes in the sales prices of houses in flooded areas and in unflooded areas in Houston, Texas, found that the significant rise in insurance premiums one year after the flood resulted in a decline of house prices, while the flood itself did not immediately influence the value of the housing units flooded. A study by Harrison et al. (2001) also showed that the housing price differential between areas within and outside of floodplains has increased in Alachua County, Florida, since the passage of the U.S. National Flood Insurance Reform Act (NFIR) of 1994, which required the owners of properties in floodplains to purchase flood insurance. These findings indicate that flood insurance has a negative impact on housing prices in floodplains beyond that of the flood risk itself.

Other studies on the impact of flood insurance, focusing on testing the extent to which flood insurance premiums are capitalized into property values, compared the housing price differential within and outside of floodplains, with the present value of future flood insurance premiums (Harrison et al., 2001; MacDonald et al. 1987, 1990; Shilling et al., 1985, 1989; Speyrer & Ragas, 1991). The findings of these studies showed that the sales price reduction of homes in floodplains is less than the present value of future flood insurance premiums. Harrison et al. (2001)

explained that this difference between price reductions and insurance premiums is related to the low penetration rates of flood insurance. According to their findings, the cost of flood insurance is not fully reflected in housing prices because many home buyers simply do not purchase flood insurance due to the lack of both mandatory flood insurance participation and information about flood risk.

This argument is supported by the several studies that analyzed discrepant information in the NFIP (Chivers & Flores, 2003) and the effect of the flood disclosure policy (Pope, forthcoming; Troy & Romm, 2004). Chivers and Flores (2003), using homeowner surveys in Boulder, Colorado, found that most households located in floodplains did not fully understand the degree of flood risk or the cost of flood insurance when negotiating the purchase of their houses. Troy and Romm (2004) estimated the effects of flood hazard disclosure on property values in California under the 1998 California Natural Hazard Disclosure Law (AB1195). The study found that following AB1195, the average floodplain home sold for less than a comparable non-floodplain home while before the law there was no significant price differential. Pope (2008) also found similar results in a study on the flood disclosure policy of 1996 in North Carolina, arguing that the post-disclosure price differential likely resulted in the full capitalization of the costs of flood insurance once the information discrepancies of the NFIP were corrected.

In summary, the results of previous research have found that the existing flood risks and costs of insurance against the risk are negatively capitalized into housing prices in floodplains. These findings raise a possibility that discrepancies in information and the low penetration rate of flood insurance under the NFIP result in an inconsistency in the capitalization of floodplains into the values of properties. However, the literature does not deal with this inconsistency.

2. Housing Submarket Approach

The hedonic pricing literature on the impact of floodplains is generally based on an assumption that the study area consists of a single market for housing services (Watkins, 2001). That is, most of the previous studies have suggested that the effects of flood risks on housing prices are the same or similar across an entire study area. However, the urban housing market is composed of not a single market, but a number of submarkets with similar structural and locational characteristics of housing units (e.g., Bourassa et al., 1999, 2003; Grigsby et al., 1987; Goodmand, 1981; Goodman & Thibodeau, 1998; Watkins, 2001). The market value of a house is a function of the site, structural, neighborhood and locational characteristics of the property. This functional relationship varies substantially across submarket (Grigsby et al., 1987). In this context, floodplains are also likely to function

differently among the submarkets and finally, to be differently capitalized in housing prices across those submarkets, suggesting that the effects of existing flood risks and flood insurance costs on property values, which are induced by floodplain location, can vary according to the submarkets.

This argument can be justified by the findings of natural hazards literature, which posit that households respond differently to and have disparate information about flood risks according to their socioeconomic characteristics. Households with particular socioeconomic characteristics, specifically low-income households, are likely to be more exposed to flood hazards (Sarmiento & Miller, 2006), to be less prepared for future flood events (Fothergill & Peek, 2004), to purchase less flood insurance (Browne & Hoyt, 2000), and to have less information about flood risks (Troy & Romm, 2004). These discrepancies between responses and information among socioeconomic groups can affect homebuyers' decisions about whether or not they will purchase properties in floodplains, which may eventually contribute to the various effects of floodplain location on housing prices.

In this aspect, hedonic models that do not consider housing submarkets may not provide the correct econometric structural base with which to estimate the effects of floodplains. This raises a question: then, how can housing submarkets be defined to better explain the impact of floodplains? Despite the lack of consensus on the definition of housing submarkets, the results of recent studies show that spatial submarkets based on spatial contiguity and aspatial submarkets based on the similarity of structural characteristics without considering locational characteristics are similar in terms of predictive accuracy (Bourassa et al., 2003; Goodman & Thibodeau, 2007; Maclennan & Tu, 1996: Watkins, 2001). In particular, Bourassa et al. (2003) argued that the methods used to estimate submarket boundaries should be defined with regard to the intended application of the model being developed. Therefore, submarkets that consist of neighborhoods with similar income can be adopted as a working framework for efficiently estimating the difference between housing prices in floodplains and those outside of floodplains because, as mentioned above, households differ with regard to information about flood risk and flood insurance depending on their income.

Based on these findings, this study argues that the differences between the sales prices of homes within floodplain areas and those outside of these areas vary across housing submarkets. In particular, the negative impact of floodplains may be greater in high-income submarkets than in low and middle-income submarkets. Researchers have found that income has a positive effect on the purchase of flood insurance; that is, higher-income households are more likely to have flood insurance (Browne & Hoyt, 2000; Dixon et al., 2006; Kriesel & Landry, 2004). Evaluating the NFIP, Dixon et al. (2006) investigated about 5,500

single-family homes in floodplains in 100 communities nationwide and confirmed that home value, an indication of wealth, has a positive effect on market penetration rates. Information about flood risks tends to be better disseminated to higher-income homebuyers because they largely obtain mortgages through federally-regulated lenders that the NFIP requires to make flood determinations prior to issuing a mortgage. This sufficient information may be linked with the high penetration rate of flood insurance in the high-income submarket. Therefore, this high cost of flood insurance can result in a more negative capitalization in housing prices in the high-income submarket than in other submarkets.

Ⅲ. Research Design

1. Model

The focus of this study is to more effectively explain the impact of floodplains on housing prices in housing submarkets. Thus, this study will test two hypotheses concerning the impact of floodplains on prices in the various housing submarkets: 1) differences between the sales prices within floodplain areas and those outside of floodplain areas vary across housing submarkets, defined by income; and 2) the negative capitalization of floodplains is greater in high-income submarket than in other submarkets. The housing submarket is adopted as a framework for estimating the different impact of floodplains on housing prices. The housing market of the study area is divided into three submarkets (low, middle, and high-income submarkets), which have similar median home sales prices of a census block group. The sales price of housing units, as an indication of income, can help to efficiently explain the variation in the impact of floodplains because flood insurance premiums are based on the value of the structure of housing units.

This study uses a hedonic analysis to isolate the price effects of floodplains and the various effects among submarkets. Two hedonic models are used to assess the effects of floodplains. The first model, as a basic model, looks at the overall effect of a floodplain on a unitary housing market to confirm the findings of a previous investigation: a decline in the housing prices in floodplains. The second model, based on this basic model, examines the inconsistencies among the submarkets as to the effects of floodplain location by using interaction terms.

The hedonic price equation is estimated by regressing the observed market price on vectors of neighborhood, locational and the structural attributes, floodplain indicators, and a dummy variable for each submarket, and interaction terms representing submarkets. For this study, the purpose of the basic model is not only to confirm the findings of previous research, the negative effects of floodplain location on sales prices of single-family housing units in a unitary housing market, but also to test the similar impact of floodplains in the study area.

This model controls for structural, time, neighborhood, and locational characteristics.

Based on this model, the effects of floodplain location on submarkets are tested in two ways: by including interaction terms and conducting separated hedonic models for the three submarkets. The first model for the submarket effects is an extension of the basic model, including the interaction terms between floodplain location and low- and middle-income submarkets. The coefficient values of the interaction terms account for the relative effects of floodplain location on housing prices in low- and middle-income submarkets compared to high-income submarkets. The model can be represented in the following equation:

$$\log P_i = \beta_0 + \beta_1 S_i + \beta_2 T_i + \beta_3 N_i + \beta_4 L_i + \beta_5 LS_i + \beta_6 MS_i + \beta_7 F_i + \beta_8 F\_LS_i + \beta_9 F\_MS_i + \varepsilon_i$$

where

$\log P_i$ = logged sales price of single-family housing unit i;

β_0 = intercept;

S_i = structural characteristics of house i;

T_i = time characteristics of house i;

N_i = neighborhood characteristics of house i;

L_i = locational characteristics of house i;

F_i = the location of house i in the floodplains;

LS_i = dummy variable indicating the locatin of house i in the low-income submarket;

MS_i = dummy variable indicating the location of house i in the middle-income submarket;

F_LS_i = the interaction term between the flood indicator and the low-income submarket; and

F_MS_i = the interaction term between the flood indicator and the middle-income submarket.

2. Study Area and Variables

Hedonic price analyses are performed to estimate the variation in the impact of floodplains on prices in Gwinnett County, Georgia, in the United States (Figure 1). which can provide a rich case for this study for several reasons. First, the great number of single-family houses in this area, which have been transacted within the short time period, provides an ample sample size that can improve the validity of the hedonic analyses. Second, since the floodplains in this area are evenly distributed across three submarkets, a more accurate estimation of the various effects of floodplains on the sales prices of the houses in the submarkets can be obtained.

Gwinnett County, located northeast of Atlanta, is a rapidly growing middle-income suburb in the Atlanta metropolitan area. Approximately 22,000 acres (about 7.8%) of 100-year floodplains evenly lie in the county. Of the total number of single-family housing units (192,875 in 2004), 2.1 percent (4,038) in the county were located in the floodplain areas, which is similar to 2.9 percent in the five major counties (Clayton, Cobb, Dekalb, Fulton and Gwinnett) of the Atlanta metropolitan area. In the county, roughly 30.5 percent (1,233 policies in forces) of single-family homes in floodplains have purchased flood insurance through the NFIP (FEMA, 2007). The rate is substantively lower than the estimated penetrationrate (49.7%) for the five major counties of the Atlanta metropolitan area.

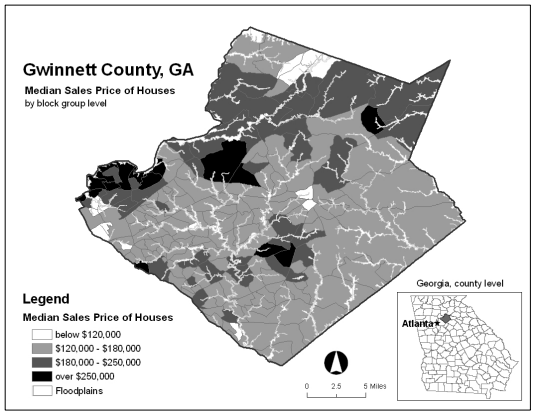

Figure 1. Floodplains and Median Sales Price of Single-Family Housing Units of Gwinnett County

Gwinnett County manages its floodplains through its floodplain management ordinance, which requires a permit for the new development, alteration, or disturbance of any property that lies in the 100-year floodplains. In particular, any new construction of residential buildings in the floodplains requires that the base flood or future condition flood elevation be raised so that it is equal to or greater than 0.01 feet above the floodplain (Gwinnett County, 2006).

Variables, descriptions, count proportions, mean values, standard deviation, and sources for Gwinnett County, which represent commonly utilized hedonic explanatory variables, are presented in Table 1. The logged values of sales prices for single-family housing units are used as dependent variables in the hedonic price models. Independent variables include the structure (i.e., size of a housing unit and its lot, number of bedrooms and bathrooms, age and squared age, number of stories, and dummy variables for basement and pool); neighborhood (i.e., median sales price, percent age of people with more than a bachelor's degree, percent age of African-Americans and Hispanics, school test scores, and a crime index); locational characteristics (i.e., distance from a highway, CBD, dummy variables for areas near major rivers or creeks, and unincorporated Gwinnett County area); floodplain location indicators (i.e., 100- and 500-year floodplains); dummy variables representing submarkets; and terms for the interaction between the floodplain location indicator and the submarkets.

Of the variables, the squared value of the age of housing units (AGE_SQUA) is based on an assumption that the relationship between age and housing prices is U-shaped; housing prices decrease as their ages increase, but as ages increase to high levels, prices begin to increase. In U.S.A., old houses's prices are generally high because the houses have the historic values and local governments efficiently manage the houses through historic preservation regulation. Thus, most research using hedonic price models hypotheses U-shaped housing prices pattern. The percentage of Hispanics (HISPANIC) is used in the study because Gwinnett County has a relatively large Hispanic population (10.8% in 2000, compared to 6.5% in Atlanta MSAs), which has contributed to rapid population growth in the county and which may have an impact on housing prices. The proximity to major rivers or creeks, which in general has a

Table 1. List of Variables and Descriptive Analysis for Gwinnett County

Variables	Unitary Market		Submarkets defined by Median Sales Price					
			Low-Income		Mid-Income		High-Income	
	Mean	Std.D.	Mean	Std.D.	Mean	Std.D.	Mean	Std.D.
N [1]	72,272		715		67,050		4,507	
PRICE [1]	$194,013		$110,279		$186,625		$317,202	
Log(PRICE)	12.1	0.37	11.56	0.32	12.08	0.33	12.59	0.4
Structural and Time								
BLDG_SIZE [1]	7.65	0.32	7.14	0.3	7.63	0.31	7.94	0.28
LOT_SIZE [1]	-1.09	0.61	-1.42	0.65	-1.1	0.62	-0.96	0.5
BED [1]	3.57	0.7	2.91	0.53	3.54	0.68	4.04	0.78
BATH [1]	2.78	0.72	1.9	0.78	2.75	0.68	3.45	0.9
AGE [1]	7.16	9.96	31.07	22.01	6.93	9.54	6.78	8.43
AGE_SQUA [1]	150.55	482.48	1,449.22	1,984.54	138.95	432.19	117.01	243.73
STORY [1]	1.59	0.49	1.29	0.45	1.58	0.49	1.83	0.37
BASE [1]	0.39	0.49	0.12	0.33	0.37	0.48	0.63	0.48
POOL [1]	0.02	0.14	0	0.06	0.02	0.14	0.03	0.18
TIME [1]	41.23	20.42	40.55	21.19	41.4	20.38	38.77	20.8
Neighborhood and Locational								
M_SALESPRICE[1]	12.08	0.22	11.53	0.11	12.05	0.16	12.65	0.12
EDUCATION [2]	33.93	11.99	14.33	6.56	32.93	10.95	52.02	10.51
BLACK [2]	9.43	6.69	18.29	12.97	9.65	6.51	4.75	5.03
HISPANIC [2]	6.89	7.11	27.39	13.2	6.94	6.85	2.84	1.45
SCH_SCORE [3]	0.89	0.17	0.85	0.04	0.88	0.17	0.95	0.04
CRIME [4]	40.22	27	45.55	23.9	41.49	27.17	20.36	13.89
HIGHWAY [5]	5.43	3.1	8.04	2.67	5.44	3.15	4.89	2.04
CBD	25.8	5.72	22.44	8.64	25.96	5.64	24	5.84
RIVER [5]	0.24	0.43	0.21	0.4	0.24	0.43	0.29	0.45
GWINNETT [5]	0.17	0.37	0.37	0.48	0.17	0.38	0.06	0.24
Submarkets defined by Median Sales Price								
LOW_IN [1]	0.01	0.1						
MID_IN [1]	0.93	0.26						
Floodplains								
FLOOD100 [6]	0.02	0.14	0.018	0.13	0.021	0.14	0.015	0.12
FLOOD500 [6]	0.004	0.06	0.004	0.06	0.004	0.06	0.001	0.04
Interactions								
FLOOD100 : LOW	0.0002	0.01						
FLOOD100 : MID	0.019	0.14						

Sources: 1) Gwinnett County, GA, Tax Assessor's Office; 2) U.S. Bureau of the Census, American Factfinder, SF1 & SF3; 3) Georgia State Department of Education; 4) Private vendor; 5) Georgia GIS Data Clearinghouse; and 6) FEMA, Q3 data.

positive impact of the values of properties, is included to separate the values of the negative attributes of floodplains from the values of the positive attributes of rivers or creeks. A dummy variable (RIVER) presents properties within one-half mile from a major river or

creek. Another dummy variable of unincorporated Gwinnett County area (GWINNETT) is included in this study because the county has actively tried to mitigate flood hazards. Unincorporated Gwinnett County has participated in the NFIP Community Rating System (CRS), which is a voluntary program for classifying local government mitigation efforts and which has great number of policies in force for flood insurance compared to other municipalities in the county. These active efforts to mitigate flood hazards can have an impact on housing prices in the area.

The Gwinnett County housing market is divided into three submarkets (low, middle, and high-income) according to median sales price of single-family housing units of a census block group. The low-income submarket is defined as those census block groups with a median sales price below $120,000. The high-income submarket is characterized as those census block groups with a median sales price over $250,000, which is the NFIP's maximum coverage amount for a structure. The middle-income submarket, then, is all other census block groups. Dummy variables (LOW_IN and MID_IN) represent these low- and middle-income submarkets defined by the median sales price of the block group. The high-income submarket is the excluded category. A floodplain location is measured by whether the central point of a parcel lies in a floodplain. This definition, which has been used in most of the previous literature, is reasonable because flood insurance covers the structure and its contents, and the central point of a parcel efficiently represents the location of the structure on the parcel. To investigate the different effects of flood risks across floodplains, this study used 100-year floodplains (FLOOD100) and 500-year floodplains (FLOOD500). Interaction terms, FLOOD100:LOW and FLOOD100:MID, test the various effects of the floodplain location on housing prices among low-, middle-, and high-income submarkets. For example, FLOOD100:LOW means that a property located on a 100-year floodplain is in a low-income submarket and its coefficient value in a hedonic analysis presents the relative impact of the floodplain on housing prices in the low-income submarket to the high-income submarket. Interaction terms for 500-year floodplains are not included because of the small number of housing units located in the 500-year floodplains in the county.

The total number of samples is 72,272 single-family homes sold between January 1999 and December 2004 in Gwinnett County with a mean sales price of $194,013. During the study period, a total of 715 (1.0%), 67,050 (92.8%), and 4,507 (6.2%) single-family houses in the low-, middle-, and high-income submarkets, respectively, were transacted. About 2.0 percent (1,464) and 0.4 percent (279) of the samples were located in 100- and 500-year floodplains, respectively. Relatively greater proportions (2.1%) of middle-income submarkets of Gwinnett County were located

in 100-year floodplains than those of the other submarkets (1.8% and 1.5% in low and high-income submarkets, respectively).

The data used in this study largely consist of 1) parcel data (including structural characteristics and sales prices of single-family residences) obtained from the Tax Assessor's Office of Gwinnett County; 2) neighborhood characteristics at the block group level from the Census Bureau; 3) spatial data on floodplains from FEMA; 4) other spatial data, such as highways and boundary maps of neighborhoods and the county from the Georgia GIS Clearinghouse; and 5) other data, school test scores and crime data from the Georgia State Department of Education and a private vendor.

IV. Results

The hedonic price analyses for the two hedonic models were performed for Gwinnett County. The purpose of Model 1 is to confirm the results of previous literature on the impact of a floodplain on home prices for a unitary housing market. Models 2 is used to investigate the impact in three submarkets (low-, middle-, and high-price submarkets) and to compare their impact on a unitary housing market.

The *R*-squared value of Model 1 for the unitary housing market was 0.767, and most of the variables were significant with the expected signs. Table 2 shows the results of hedonic analyses for the model. In Model 1, the 100-year floodplain location indicator (FLOOD100) was negative and significant at a 99% confidence level, with a value of -0.014. This means that the 100-year floodplain location reduced the price of floodplain homes by 1.4 percent relative to comparable non-floodplain homes. The price impact in the 500-year floodplain location (FLOOD500) was also negative, with a value of -0.007, but it was statistically insignificant. The solution to the Model 1 equation for the average property in FLOOD100 and FLOOD500 indicates that the 100-year floodplain location resulted in a $2,597 negative capitalization for floodplain homes, while the 500-year floodplain location did not have an impact on housing prices. That is, 100-year floodplains caused the average home to sell for $2,597 less, compared to a non-floodplain home. While the average sales price of a 100-year floodplain home was $178,384, that of a non-floodplain home was $180,901. This result, the negative capitalization of floodplains in Gwinnett County, is consistent with the findings of previous literature.

In Model 2, the various effects of the 100-year floodplain on the submarkets (LOW_IN and MID_IN), were tested by using an indicator for the interaction with a 100-year floodplain. Flood-submarket interactions for the low- (FLOOD100:LOW) and middle-income submarkets (FLOOD100: MID) were negative and significant at 95% and 99% confidence levels, respectively, and with coefficients of -0.126 and -0.114, respectively. That is, the negative impact on low- and middle-income

Table 2. Effects of Floodplain Location and Submarkets

Variables	Model 1				Model 2			
	B	β	t		B	β	t	
(Constant)	3.529		61.052	**	6.998		266.080	**
Structural and Time								
BLDG_SIZE	0.590	0.513	164.129	**	.616	.535	171.147	**
LOT_SIZE	0.055	0.092	40.726	**	.058	.097	42.013	**
BED	0.013	0.026	9.783	**	.014	.026	9.752	**
BATH	0.108	0.214	72.562	**	.110	.217	72.478	**
AGE	-0.007	-0.182	-43.863	**	-.007	-.196	-46.772	**
AGE-SQUA	0.000	0.109	32.829	**	8.76E-005	.116	34.085	**
STORY	-0.103	-0.137	-52.134	**	-.108	-.144	-54.081	**
BASE	0.127	0.169	84.710	**	.127	.170	84.163	**
POOL	0.110	0.042	22.825	**	.109	.041	22.324	**
TIME	0.004	0.203	108.283	**	.004	.204	107.667	**
Neighborhood								
M_SALESPRICE	0.308	0.185	62.206	**				
EDUCATION	0.002	0.077	24.782	**	.005	.157	59.860	**
BLACK	-0.002	-0.028	-11.891	**	-.002	-.035	-14.269	**
HISPANIC	0.005	0.101	35.641	**	.005	.093	31.581	**
SCH_SCORE	0.042	0.019	9.545	**	.091	.041	20.873	**
CRIME	0.000	-0.020	-8.990	**	.000	-.019	-8.135	**
Locational								
HIGHWAY	0.000	-0.004	-1.908	*	.001	.007	3.543	**
CBD	-0.003	-0.048	-16.168	**	-.001	-.011	-3.799	**
RIVER	0.014	0.016	8.723	**	.007	.009	4.665	**
GWINNETT	0.028	0.029	15.147	**	.037	.037	19.269	**
Submarkets defined by median sales price								
LOW_IN					-.173	-.047	-21.106	**
MID_IN					-.139	-.098	-43.483	**
Floodplains								
FLOOD100	**-0.014**	**-0.006**	**-3.038**	**	**.091**	**.035**	**4.187**	**
FLOOD500	-0.007	-0.001	-0.705		-.010	-.002	-.960	
Interactions								
FLOOD100 : LOW					**-.126**	**-.005**	**-2.303**	*
FLOOD100 : MID					**-.114**	**-.043**	**-5.106**	**
R^2		.767				.761		
Standard Errors		.176				.179		
N		72,272				72,272		

Note: ** Significant at 99% confidence level; * Significant at 95% confidence level

submarkets was greater than that on the high-income submarket, 12.6 percent and 11.4 percent, respectively, indicating that the 100-year floodplain location was more negatively capitalized in the sales prices of home in the low- and middle-income submarkets than it was in the high-income submarket. With these submarket-flood interactions, the 100-year floodplain location indicator (FLOOD100), which was positive and significant at a 99% confidence level with a value of 0.091, was offset by two

submarket-flood interactions. On the other hand, the 500-year floodplain location (FLOOD500), which was negative with a value of -0.010, was as statistically insignificant as it was in Model 1. That is, while the 500-year floodplain did not significantly influence sales prices, the 100-year floodplain significantly affected the sales price at a 99% confidence level with a value of 0.091. Solving Model 2 at mean attribute values results in a $4,626 relative price decrease for 100-year floodplain homes. In particular, 100-year floodplains reduced housing prices by $7,879 and $5,864 in the low- and middle-income submarkets, respectively, compared to an $18,750 positive price increase in the high-income submarket. This model found that the negative impact of the 100-year floodplain on housing prices was greatest in the low-income submarket but that the positive impact of the same floodplain on home prices was the greatest in the high-income submarket with over $250,000 of median sales price. That is, in Gwinnett County, the negative impact of floodplains on housing prices in submarkets decreases as the median sales price increases.

V. Conclusions

1. Findings and Discussion

This study examined the effects of floodplain location on the sales prices of single-family housing units using a housing submarket approach. The results of the hedonic price models used to investigate the effect of floodplain location on price among submarkets in Gwinnett County can be summarized as follows. First, the results of the hedonic price models were consistent with the findings of previous literature that floodplain location, especially the 100-year floodplain, has a negative impact on housing prices. However, the sales prices of 500-year floodplain homes were not significantly different from those of non-floodplain homes. Second, the effects of floodplains on the sales prices of single-family housing units vary across submarkets, defined by median home sales prices. Both the models using the interaction terms of floodplains and submarkets and the model conducting separate hedonic analyses for the three submarkets showed the varying impact of 100-year floodplains on the average home sales prices in low-, middle-, and high-income submarkets. Third, the average home sales prices of properties were negatively influenced by 100-year floodplains in low- and middle-income submarkets, but they are positively influenced in the high-income submarket, and the negative price impact of 100-year floodplains was the greatest in the low-income submarket. That is, the negative impact of the 100-year floodplain decreases as the median sales price increases, and then the floodplain had a positive impact in the high-income submarket in Gwinnett County. These findings confirm the results of previous research: that the higher potential for floods and the costs of flood insurance in 100-year

floodplains lower the value of properties located in 100-year floodplains but have no effect on properties located in 500-year floodplains. Regarding the differential impact on the submarkets, this study hypothesized that because higher-income households are more likely to have information about flood risks and to purchase flood insurance, which have a negative impact on housing prices, the negative impact of floodplains increases as the housing price increases. However, this hypothesis was not supported by the findings of this study. On the contrary, the findings showed that the impact of floodplains on housing prices is the most negative in the low-income submarket and positive in the high-income submarket. This finding suggests that factors other than (or together with) information about flood risks and flood insurance significantly affect housing prices in low- and high-income submarkets.

Some researchers have showed that low-income homebuyers are less likely to have sufficient information about flood risks because they disproportionately obtain home financing from less regulated sources, including subprime lenders, which are subject to less regulatory oversight for designations and disclosure (Calem et al., 2004; Troy & Romm, 2004). This finding relates to the relatively low penetration rate of flood insurance for low-income households. Therefore, it appears as if the negative impact of floodplains on average home prices in the low-income submarket cannot easily be attributed to a simple lack of either information or a demand for flood insurance. Another possible reason for the negative impact of floodplains in the low-income submarket is the greater exposure of the poor to flood hazards in that submarket. Past experience with floods, such as the Midwest Floods of 1993 and Hurricane Katrina of 2005, has revealed that the poor are more vulnerable to flooding (the Interagency Floodplain Management Review Committee, 1994; Muro et al., 2005). Data from Gwinnett County show that although the proportion of homes in floodplains is slightly lower in the low-income submarket than it is in the middle-income submarket, the average percent age of floodplains in a property is higher in the low-income submarket (90.8%) than in the middle (77.1%) and high-income (82.1%) submarkets. This finding raises the possibility that homes in the low-income submarket have more seriously or frequently been damaged by flooding. The physical damage of houses caused by flooding can lower housing prices even though homebuyers are not provided with information about flood risks by homeowners or lenders.

This explanation is supported by the finding by other studies that after a flood event, the recovery pattern of housing prices in the low-income submarket is slower than in the other submarkets as a result of the isolation of residents during the recovery process. Zhang and Peacock (2005) investigated the recovery process of single-family households

in Miami-Dade County, Florida, after Hurricane Andrew. They found the considerable differential between the damage and recovery curves of homes in the low-income submarket and those in the high-income submarket. The findings indicated that homes in lower-income areas lost disproportionally more value than those in high-income areas because of damage and that they also recovered to the pre-impact levels more slowly. This slow recovery in housing prices in the low-income submarket is reflected in long-term housing prices.

On the other hand, this study posits two different hypotheses for the positive capitalization of floodplains in the high-income submarket. First, in this submarket, homebuyers are less likely to purchase flood insurance even though they have information about flood risks. The NFIP limits the amount of available coverage to $250,000 per structure. In the submarket of Gwinnett County, over 67 percent of homes sold during the study period were valued at more than $250,000. Since a large number of homes in the submarket are undercompensated for losses due to flooding by the NFIP, the demand for flood insurance by homeowners may be relatively low. Finally, the low penetration rate of flood insurance is less likely to result in the negative capitalization in housing prices in the submarket. Second, the amenities of floodplains, such as proximity to rivers or creeks and aesthetic views, are likely to increase the values of homes in high-income submarkets. In Gwinnett County, over 46 percent of floodplain homes in the high-income submarket compared with only 0.9 percent and zero percent in the low- and middle-income submarkets, respectively, are located along the Chattahoochee River, which affords scenic views. This amenity of floodplains, in addition to the relatively low penetration rate of flood insurance, is likely to lead to the positive capitalization of housing prices in the high-income submarket in the county.

While the proposed explanation for the differential effects of floodplains is tenable, it should be] noted that the explanation for the causality behind these perceived effects is still poor, given the available data. In particular, the effects of such factors as the cost of flood insurance, the level of flood risk, and the impact of positive amenities must be tested separately or together to determine how they capitalize into housing prices in the submarkets. Another important consideration for future research is to define the housing submarkets more precisely so that the impact of floodplains on the prices in the submarkets can be more efficiently examined. Housing submarkets can be defined according to the relationships among many factors, including not only structural, locational, and neighborhood characteristics but also various spatial scales, not just sales price. Once thes factors are considered, their effects of floodplain location can be better understood.

2. Policy Implications

It is important to note that housing submarket models can better explain the effects of floodplain locations on housing prices than a unitary housing market model. Using the submarket approach, one can observe that the impact of floodplains on the submarkets clearly varies: from their negative impact in low- and middle-income submarkets to their positive impact in the high-income submarket in GwinnettCounty. Therefore, by using the housing submarket approach, planners can implement policies related to natural hazard mitigation not only methodologically but also strategically. First, they can adopt the submarket approach as a working framework for a detailed empirical analysis of the dynamic operation of an urban housing market. Planners can use this approach to identify neighborhoods that have housing units with similar characteristics in physical, locational, and social aspects as targets of policy implementation (Bates, 2006; Grigsby et al., 1987), and then apply the hedonic technique for property valuation when they evaluate urban policy initiatives (Tu, 2003). Second, the results of the submarket approach underscore the need supported by this study for different hazard planning and practice strategies for implementing flood mitigation in the submarkets due to the various effects on different sub-populations (Dash et al., 1997; Deyle, 1998; Godshalk et al., 1999; Mileti, 1999). In particular, Godshalks et al. (1999) argued that "special sensitivity to equity in disaster assistance and mitigation is needed and special strategies, such as mitigation targeted to certain neighborhoods and based in the community, may also be necessary." Therefore, the housing submarket approach can play an important role in identifying how threats from natural hazards affect neighborhoods with different socioeconomic characteristics differently.

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