MODELING SINGLE FAMILY HOUSING RECOVERY AFTER HURRICANE ANDREW IN MIAMI-DADE COUNTY, FL

A Dissertation

by

YANG ZHANG

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2006

Major Subject: Urban and Regional Science

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ABSTRACT

Modeling Single Family Housing Recovery after Hurricane Andrew in Miami-Dade County, FL. (August 2006)

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This research seeks to improve the current state of knowledge about housing recovery following a major natural disaster through examining single family housing recovery following Hurricane Andrew, a category 5 hurricane, which impacted southern sections of Miami-Dade County in 1992. This inquiry focused on two questions: (1) what is the recovery process for single family housing in a disaster impact area, and (2) how does the housing recovery process vary across households and neighborhoods? To answer these questions, the 1992-96 tax appraisal values for Miami-Dade County were used to measure housing damage and recovery after the storm. Hierarchical Linear Modeling (HLM) was used to quantitatively model this recovery process and identify the major factors in play.

With regard to the first question, our findings suggested that Hurricane Andrew caused extensive housing damage in the impact area, rendering an average loss to households of 50.4% of pre-disaster home value. Two years after the storm (1994), the average home value returned to its pre-disaster level. In the subsequent two years (1995-

96), the average home value continued growing, representing a 7.6% and 14.9% gain, respectively, over the pre-disaster average.

Regarding the second question, our analysis found that the housing recovery process varied significantly across households and neighborhoods. Owner-occupied homes recovered more rapidly than rental units. Household income had a positive effect on housing recovery. Our analysis also suggested that post-disaster home sales had a significant negative effect on housing recovery. Neighborhood race/ethnicity composition affected the housing recovery process. Homes in minority populated neighborhoods (both Hispanic and non-Hispanic Black) recovered more slowly than homes in majority populated areas (non-Hispanic White). When considering Cuban-Hispanics and non-Cuban Hispanics as two separate groups, neighborhoods with a higher concentration of Cuban-Hispanics, while having no clear advantage at the beginning of the recovery period, recovered more rapidly than other minority populated areas.

Previous studies suggested that the long-term impact of natural disasters at the aggregated level is minimal, and yet our results showed that the housing impact of Hurricane Andrew lasted at least more than four years. In fact, housing inequality in the impact area increased markedly during the recovery process due to the unequal nature of housing recovery.

DEDICATION

To my wife, Chunmei Wu

ACKNOWLEDGEMENTS

This study could not be done without the support I received from many people. First of all, I would like to thank Drs. Walter G. Peacock and Michael K. Lindell, chairpersons of my dissertation committee, for their guidance during this project. Dr. Peacock, with his expertise on disaster recovery and his encyclopedic knowledge about Miami-Dade County, was always available whenever I experienced any obstacle. Dr. Lindell taught me how to develop incisive research questions and write publishable articles. Every discussion with him was a joyful intellectual journey. I was also fortunate to have Drs. Daniel Z. Sui and Douglas F. Wunneburger on the advisory committee. Dr. Sui's emphasis on theory contribution kept me searching for the story behind the numbers and equations. Dr. Wunneburger led me into the exciting world of GIS, which played a critical role in data integration and analysis.

I also would like to thank Dr. Samuel D. Brody for his mentorship. He encourages me to be positive, persistent, and mentally tough. My special thanks to Ms. Carleen Cook for editing my manuscript with her thoughtful suggestions. I also wish to acknowledge many wonderful colleagues in the Hazard Reduction and Recovery Center. Dr. Carla Prater, Sarah Bernhardt, Liang Chang, Kim Galindo, Wesley Highfield, Jun Eun Kang, Jing-Chein Lu, and Zhenghong Tang all provided valuable help and support for my research.

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CHAPTER I

INTRODUCTION: THE PROBLEM OF HOUSING RECOVERY

2005 was one of the deadliest years in American disaster history as four major hurricanes (Dennis, Wilma, Katrina and Rita) devastated the United States Coast area. Hurricane Katrina's massive destruction in states of Louisiana and Mississippi made it the most costly natural disaster in the United States. A preliminary assessment of damaged housing stock estimated that about 302,000 units were damaged in the impacted areas (Table 1.1), which surpassed all previous major natural disasters. For weeks, the dramatic views of displaced victims and flattened neighborhoods were etched in the minds of Americans. However, the news coverage tailed off quickly as the immediate shock passed, and the recovery processes was just about to begin. Thus, in contrast to the immediate emergency response, Americans were left with no clear image of the recovery process following a major disaster.

Disaster recovery is a multidimensional phenomenon. For households, recovery involves recovering from psychological stress caused by the event as well as the process of regaining income, employment, household amenities, and household assets (Bates, 1982; Bolin, 1976, 1982, 1993; Bolin and Bolton, 1983; Peacock et al., 1987). For the impacted community, recovery involves restoring community businesses, population base, and government functions (Friesma et al., 1979; Haas et al., 1977; Lindell et al., 2006; Wright et al., 1979). Nevertheless, housing is perhaps the key element in understanding disaster recovery at both the household and community levels as it is the

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victims' most fundamental need to resume their normal activities (Bolin, 1991; Quarantelli, 1982). Timely reconstruction of damaged housing after a disaster is a common goal shared by residents, property owners, local businesses, and local government. Housing recovery is often a daunting task following a major natural disaster (Table 1.1) as a massive amount of damaged property needs to be repaired. The recovery process is often a time with immense potential for competition and conflict as impacted households, property owners, businesses, and local governments compete for resources to engage in the reconstruction process (Bates & Peacock, 1992; Schwab et al., 1998; Smith & Deyle, 1998). While there may be a relatively high degree of cooperation in the immediate aftermath of a major natural disaster, sometimes referred to as a therapeutic community, the recovery period can best be characterized as a contested terrain where a multitude of actors often compete for scarce resources in their efforts to return to some sense of normalcy. Researchers have begun to more fully explore disaster impact and various aspects of household recovery. Not surprisingly, they found that normal social processes and dynamics often find full play in the aftermath of a disaster. For example, minority populations and marginalized groups are often the hardest hit, and yet they tend to be excluded from the post-disaster decision making processes and have limited access to recovery resources (Bolin & Stanford, 1998; Peacock et al., 1997). While these findings have clear implications for housing recovery, little empirical research has focused on housing recovery processes themselves.

Table 1.1. Housing Damages of Major Disasters

	Hurricane Hugo	*Loma Prieta Earthquake*	*Hurricane Andrew*	*Northridge Earthquake*	*Hurricane Katrina*
Time	Sept. 1989	Oct. 1989	Aug. 1992	Jan. 1994	Aug. 2005
Physical Severity[1]	Category 4	Magnitude 7.1	Category 5	Magnitude 6.8	Category 4
Impact area	SC, NC	CA	FL, LA	CA	LA, MS, AL
Single Family	79, 627	19,600	86,250	13,000	NA[2]
Multi-family	11,908	23,500	38,603	49,000	NA
Total	91,435	43,100	124,853	60,000	302,000
Uninhabitable	32%	25%	59%	13%	NA

1: Hurricanes are measured on the Saffir – Simpson Scale when they make landfall; earthquakes are measured by Richter scale.
2: Not Available.
Source: National Low Income Housing Coalition 2005; Comerio 1998

This research seeks to improve the current state of knowledge about recovery processes through examining single family housing recovery following hurricane Andrew, a category 5 hurricane, that struck southern sections of Miami-Dade County in 1992, damaging over 124,000 homes in the area and leaving 74,000 uninhabitable. Specifically, the following two general research questions are the focus of this research. (1) What is the recovery process for single family housing in the disaster impact area? (2) How does housing recovery process vary across different households and neighborhoods?

This dissertation is organized as follows. Chapter II is the literature review that summarizes previous research on the housing recovery in the United States, recovery modeling and major determinants. This review concludes with a statement of seven research hypothesis. Chapter III is essentially methodological, discussing the general principles to be followed for compiling datasets and designing analytical models to assess housing recovery. It also discusses analytical approaches for addressing different levels of analysis – household and neighborhood. Chapter IV explains measurement, data source for independent and dependent variables. Chapter V describes the major analyses and hypothesis tests. Chapter VI summarizes the major research findings and also discusses research limitation, theoretical and policy implications.

CHAPTER II

LITERATURE REVIEW

Housing recovery following a major natural disaster is essentially a market-driven process in the United States. With the exception of the 1964 Alaska Earthquake when the federal government was actively involved in housing reconstruction, government does not traditionally play a major role in the housing recovery process (Kates, 1970; Quarantelli & Dynes, 1989). During the emergency response and early disaster recovery, the government, along with non-governmental organizations such as the Red Cross and some faith-based organizations, play important roles in temporarily accommodating displaced victims. In most cases, they provide temporary shelter and/or temporary housing in the form of tents, and during extreme situations, mobile homes and trailers (Bolin, 1993; Comerio, 1998; Lindell & Prater, 2003; Peacock & Ragsdale, 1997). On the whole, housing recovery generally depends upon the market. In the long term, individuals and property owners must obtain the necessary resources either to repair or rebuild. Similarly, renters bear the responsibilities for relocating themselves to other housing. For those seeking to rebuild, property insurance and private savings are their major financial resources for funding housing recovery. Government programs such as the Federal Emergency Management Agency's (FEMA) minimal home repair (MHR) and individual family grant (IFG), and the Small Business Administration's (SBA) low-interest loans, along with contributions from non-profit organizations supplement these private sources. After Hurricane Andrew, for example, private insurance funded almost 95% of housing repair and reconstruction, while funding from government programs and other sources accounted for less than 5% (Peacock et al., forthcoming). Of course, this does not mean that governmental financial resources have a negligible impact on the repair and/or reconstruction of all homes. Indeed, these funds may represent the only funding available for some households. However, for housing recovery as a whole, it is the private market that generally funds most housing reconstruction.

The market-based approach has resulted in a neglect of housing recovery in local communities' recovery policies (Bolin, 1985, 1994; Mileti, 1999; Peacock & Girard, 1997; Quarantelli, 1982; Wu & Lindell, 2004). As a number of researchers have suggested, market-based recovery is conservative in nature because the restoration of the status quo ante is often times the major goal in this process (Bates & Peacock, 1989; Bolin 1982, 1985). Other researchers have gone a step further by suggesting that market-based disaster recovery may in fact accentuate pre-disaster social inequality (Bolin, 1982, 1985; Bolin & Stanford, 1991, 1998; Hass et al., 1977; Peacock & Ragsdale, 1997). Pre-disaster social patterns in the housing market are believed to have a major influence in determining permanent housing recovery (Bates, 1982; Bates & Peacock, 1987; Blaike et al., 1994; Quarantelli, 1982). In this regard, it is worthwhile to review the social patterns embedded in the American housing market.

Housing Markets in the United States

Housing markets in the United States systematically fail to provide quality housing for low-income households and this failure disproportionately affects racial and ethnic minorities (Alba & Logan, 1992; Bratt et al., 1986; Horton, 1992; Lake, 1980). Low-income and racial/ethnic households tend to reside in poorer quality, less well maintained housing. Minorities, especially Blacks, still find major problems with racial discrimination when buying, selling, and renting housing because of racial steering, redlining, and hostile white attitudes. (Feagin & Sikes, 1994; Guy et al., 1982; Horton, 1992; Oliver & Shapiro, 1995; Sagalyn, 1983). Moreover, minorities, particularly Blacks, are more likely to be denied a mortgage. Even if they do obtain mortgages, they often have to make larger down payments and pay higher interest rates (Oliver & Shapiro, 1995). One of the major factors in successfully obtaining a mortgage is finding homeowner insurance, which is often a significant impediment for minorities. Thus, it is impossible for them to procure a home mortgage (Squires, 1998; Squires et al., 2001; Squires & Velez, 1987).

Residential segregation still remains at a very high level in the United States with low-income and minority households, especially Blacks, often clustering in low-valued neighborhoods (Logan & Molotch, 1987; Stinchcombe, 1965; South & Crowder, 1997). In addition, households in these areas are substantially less likely than Whites to escape poor neighborhoods (Iceland et al., 2002; Logan & Molotch, 1987; Massey & Denton, 1993; South & Crowder, 1997). This perpetual residential segregation has significant consequences for housing attainment. Predominantly minority neighborhoods often have undesirable conditions such as high crime rates, high poverty levels, low school quality, etc. (Harris, 1999; Jargowsky, 1997; Taub et al., 1984; Wilson, 1996). Consequently, homes in such areas are in lower demand and more likely to appreciate at low rates (Flippen, 2004).

Housing Recovery in the United States

In the context of market-based housing recovery, determinants of normal housing attainment such as income, race/ethnicity, class, and household composition are expected to take on added significance. Low income and minority households face many challenges when recovering from disasters. Because such households often live in structures that were built according to older, less stringent building codes, used lower quality designs and construction materials, and were less well maintained (Bolin, 1994; Bolin & Bolton, 1983; Bolin & Stanford, 1998; Peacock & Girard, 1997), they tend to suffer disproportionately higher levels of damage in natural disasters. In turn, the high level of damage can be anticipated to slow the recovery process unless supplemented with higher levels of resources. Yet, this population often lacks access to quality property insurance (Bolin & Stanford, 1998; Comerio, 1998; Peacock & Girard, 1997). In addition, low-income households are less likely to qualify for governmental/private reconstruction programs because of their limited capability to repay (Bolin, 1986; Bolin & Bolton, 1983; Tierney, 1997). Peacock and Girard (1997), for example, found that minority homeowners in Miami-Dade County were less likely to be covered by one of the top three insurance companies and hence were much more likely to report having insufficient insurance payments to initiate the reconstruction process. Households not covered by one of the top insurance companies were many times more likely to report insufficient insurance payments. Indeed, one of the most important correlates of insurance coverage was the proportion of minorities living in one block. In other words, there was a clear indication of insurance red-lining prior to Hurricane Andrew that resulted in lower insurance settlements in minority Hispanic and Black areas. Moreover, poor language skills and limited education can leave many minorities and low income households at a distinct disadvantage in the protracted negotiations necessary for housing reconstruction. Low income households often have limited transportation options which may even decrease following a disaster when public transportation is extensively disrupted. Lack of mobility may slow recovery efforts for these victims and even jeopardize their employment (Morrow, 1997; Peacock & Girard, 1997).

As discussed previously, low income households and minorities are often segregated into poor neighborhoods (Massey & Denton, 1993). With less economic power and political representation, these marginalized groups are often excluded from community disaster planning, hazard mitigation, and recovery activities (Blaike et al., 1994; Bolin & Bolton, 1983; Morrow, 1998; Phillips, 1993; Tierney, 1989). Neighborhoods that were poorer prior to disaster often fall far short of receiving the necessary aid to jump start the recovery process, particularly for housing (Berke et al., 1993; Bolin & Stanford, 1991, 1997; Comerio, 1998; Dash et al., 1997; Kamel & Loukaitou-Sideris, 2004; Phillips, 1993; Rubin, 1985). Kamel and Loukaitou-Sideris (2004), for example, found that low income neighborhoods and neighborhoods with high minority concentrations had limited resources for disaster recovery. In addition, these areas were further hindered by lower levels of governmental assistance relative to other neighborhoods that sustained similar damages following the Northridge Earthquake.

Instead of treating minorities as a single group, some disaster research began to look into the variations across different minority types, especially Blacks and Hispanics.

When studying home insurance coverage and payouts across homeowners in Miami-Dade County following Hurricane Andrew, Peacock and Girard (1997) found that minority households in general, both Blacks and Hispanics, were less likely to have home insurance than Anglos. Even when they had home insurance, they were less likely to receive sufficient payments to cover home repair/reconstruction costs. However, when dividing Hispanics into Cuban Hispanics and non-Cuban Hispanics, their findings suggested that there was no difference between Cubans and Whites with regard to having home insurance and receiving sufficient settlements. On the other hand, Blacks and non-Cuban Hispanics had significantly less accessibility to home insurance and insurance settlements compared to Whites.

Peacock and Girard's (1997) finding is consistent with the emergence of Cubans in Miami-Dade County, which is characterized by a powerful Cuban ethnic enclave in this area. The establishment of an enclave economy has allowed Cubans to move quickly into the political and economic hierarchy of the region and the nation (Perez, 1992; Portes & Bach, 1985; Portes & Stepick, 1993; Wilson & Portes, 1980). As a consequence, Cubans generally enjoy greater access to resources than do other "minority" groups (Grenier & Morrow, 1997; Geriner & Stepick, 1992;). Blacks, on the other hand, still struggle for economic and political status and hence have attenuated access to resources (Grenier & Morrow, 1997). In South Miami Dade County, particularly around Homestead and Florida City, a pattern similar to non-Hispanic Blacks holds for non-Cuban Hispanics who are more likely to be from Mexico.

Rental properties have unique recovery problems. Renters have little control over the homes in which they live and, as a consequence, have much fewer options for hazard adjustments than do homeowners (Burby et al., 2003; Morrow, 1998). The owners of rental properties are responsible for recovery functions such as inspecting buildings and repairing damages to ensure safe occupancy. Rental properties often take significantly longer to rebuild. In their research after the Whittier Narrows, Loma Prieta and Northridge earthquakes, Bolin (1986), Bolin (1993), and Comerio et al. (1994) found evidence that some landlords delay repairs to damaged housing because of limited financial assets. The typically slower reconstruction of rental properties places neighborhoods with a high proportion of these properties at risk of failing to recover and potentially becoming blighted areas.

While previous research shows that individual households differ considerably in their ability to marshal reconstruction financing, few studies have explored the implications of this finding on housing recovery. Indeed, housing impact and recovery have only been addressed with highly aggregated data such as community level data. In this research, housing recovery was usually characterized as generally being completed within two to three years after the event (Comerio, 1998; Wu & Lindell, 2004). When assessing the long term consequences of disaster, research concluded that disasters have no significant long-term impact on housing development in the impacted community, particularly when examining broader countywide or regional impacts (Friesma et al., 1979; Wright et al., 1979). However, this research was unable to show whether there were short-term housing disruptions, even though they are naturally expected based on previous research. Moreover, if short-term housing disruptions do exist, no research has documented the point at which such disruptions disappear. In addition, there has been no attempt to determine the extent to which the aggregate findings apply to the lower level of aggregation such as household and neighborhood levels. One might well expect that there are distributive effects at the household/neighborhood level that cannot be detected at higher levels of aggregation such as community and county.

Although housing recovery is rarely addressed in local community policies in the United States (Bolin, 1985, 1994; Mileti, 1999; Peacock & Girard, 1997; Quarantelli, 1982), it is believed that pre-impact recovery planning could facilitate disaster recovery (Berke et al., 1993; Rubin, 1991; Schwab et al., 1998) and housing reconstruction in particular (Spangle Associates, 1997; Wu & Lindell, 2004). Pre-existing relationships among government agencies and local organizations within a community and the integration of local government and state/federal agencies can enable the impacted community to effectively marshal external financial resources and address recovery needs (Berke et al., 1993). Recovery planning may also enable local government to anticipate potential confusion and conflict among different agencies during the recovery process. This ensures that local government has ability to act and also knows what to do when disasters strike (Rubin, 1991). In addition, pre-disaster planning can accelerate housing recovery by streamlining administrative processes regarding housing reconstruction. Schwab et al. (1998), for example, suggested that local government can plan how to accomplish a set of important tasks such as damage assessment, debris removal, infrastructure restoration, temporary repair permits, development moratoria and permit processing in order to get housing reconstruction started shortly following the disaster. Comerio et al. (1994) and Comerio (1998) found that the confusion and duplication of the application requirements for FEMA's reconstruction grants and SBA's low-interest loans caused considerable time delays for homeowners following the Loma Prieta Earthquake. For instance, the application could only be accepted if the victims had proof of rejection from other programs. As a result, the victims had to have their damaged homes inspected many times by different agencies before they could finally get into the line for grants or loans. The authors suggested that local government can work with insurance companies and state/federal agencies to expedite processing of insurance claims and delivery of governmental reconstruction funds.

Post-disaster Home Sales

No research has been done to examine the effect of post-disaster home sales on housing recovery. Anecdotal evidence suggests that housing sales became very active in the impact area following Hurricane Katrina. There are two plausible reasons that explain the unprecedented number of home sales in the impacted community following a major disaster. In the post disaster situation, sales may reflect abandonment as owners give up on a property, take their insurance money and move to another area. Indeed, a natural disaster may reinforce the pre-disaster demographic trend as some victims relocate to other places that they may have been contemplating before the disaster. One demographer has speculated that Anglo households would use Hurricane Andrew as an opportunity to move out of Hispanic areas and into Anglo communities in counties north of Miami-Dade (Girard & Peacock, 1997). In addition, home sales may also result from the lack of financial resources to repair or reconstruct the damaged homes. If a property sells after an event, it is likely to have been bought by speculators hoping to pick up properties at extremely low prices and either sell or repair them for later sales. Regardless of the reasons, the effect of home sales on the recovery process is remaining unknown.

Modeling Housing Recovery Process

Efforts to conceptualize the disaster recovery process can be dated back to Haas et al.'s (1977) case study of four cities in the United States and Latin America. Based on their study, Haas and his colleagues proposed a four-stage linear model of the community recovery process: the emergency period, the restoration period, the replacement reconstruction period, and the betterment period, with each period lasting approximately 10 times the previous period. Immediately after a disaster, a recovering community must undertake emergency responses, such as debris removal, search and rescue, and provision of shelters and temporary housing. At the following stage, the activities will be restoring public facilities and services. At the third stage, the affected community replaces or reconstructs capital stock to its pre-disaster level. Finally, the community initiates betterment and developmental reconstruction for further growth. Although Haas and his colleagues noted the possibility of considerable overlap among the four different phases, their recovery model is criticized for its inaccurate assumption of the homogeneous and linear nature of the recovery process (Berke & Beatley, 1992;

Berke et al., 1993; Quanrantelli, 1989). In fact, these four recovery stages can take place out of order or simultaneously within the same community because of different levels of institutional readiness and socio-economic characteristics of the impact area (Bates, 1982; Berke et al., 1993; Peacock & Bates, 1982; Rubin, 1985).

Quarantelli's (1982) case study of sheltering and housing after natural disasters in three communities led him to conceptualize housing recovery as four distinct stages of post-event sheltering and housing: emergency shelter, temporary shelter, temporary housing, and permanent housing. Emergency sheltering is the victims' immediate response to disaster impact based on chance availability, convenience, proximity, and perceived safety. Temporary shelters are places where victims can stay for a longer time before they can safely return to their own houses. These are often sought in the homes of friends and relatives, but mass public facilities (i.e. schools, stadiums) are used as well. The next stage is temporary housing in which victims reestablish their routine activities, but not in a permanent location. The demand for temporary housing after a disaster is usually met by filling vacancies in local housing stock, but the Federal Emergency Management Agency (FEMA) and Non Governmental organizations (NGOs) cope with excess demand by providing mobile homes. Permanent housing is the final stage of housing recovery during which victims either return to their rebuilt homes or relocate to new dwellings. This typology of distinctive forms of sheltering and housing has problems similar to Haas et al.'s model, particularly if these four stages are viewed as phases in which households are expected to progress. There can be many repetitive steps and jumps in the recovery process. Furthermore, the distinctions are not always clear as when temporary housing becomes permanent or when emergency shelter transitions into temporary shelter. In addition, in any one disaster, households may be at each of the stages simultaneously as some households, for example, move back to permanent housing while others still stay in temporary housing.

In fact, the path to permanent housing consists of a set of overlapped tasks that have to be fulfilled in order to move forward in the recovery process (Figure 2.1). Here, Quanrantelli's typology is expanded by the explicit consideration of typical household activities that are directly related to each phase of the reconstruction process. A household's ability to accomplish these tasks determines its pace of recovery toward permanent housing. In the immediate aftermath of a severe disaster (emergency sheltering and temporary sheltering), the affected households focus on saving lives and meeting basic life needs (i.e. sleep, food, water). As soon as the disaster diminishes, they begin to take steps toward returning home. Although individual households will be differently affected by the disaster, building inspection/damage assessment needs to be undertaken and then further decisions can be made to determine if the home is safe for immediate return, slight repair is required, or extensive reconstruction is necessary for occupancy. It is also possible that some victims may decide to relocate to other areas during this period.

If prolonged repair or reconstruction is needed, the victims then turn their attention to temporary housing arrangements in anticipation of the closure of the temporary shelter. Government and non-government agencies may have temporary housing programs (i.e. FEMA's temporary housing grants, rental reimbursement programs, or trailer homes) available for victims. Also, affected households can choose to stay with relatives or friends or in hotels. Other concurrent activities of households during this period include preparing for reconstruction. For reconstruction financing, households need to work with insurance companies to sort through insurance claims, inspection and final settlements. They may also take steps to apply for reconstruction grants or loans funded by governmental / non-governmental agencies (i.e. FEMA Minimum Home Repair (MHR) Grant, FEMA Individual Family Grant Program (IFGP) and SBA home owner loans). To the extent necessary, households may also need to use private savings, refinancing etc. for home reconstruction. In the meantime, homeowners need to find a contractor and also get a building permit approved by the county planning department for home repairs and reconstruction.

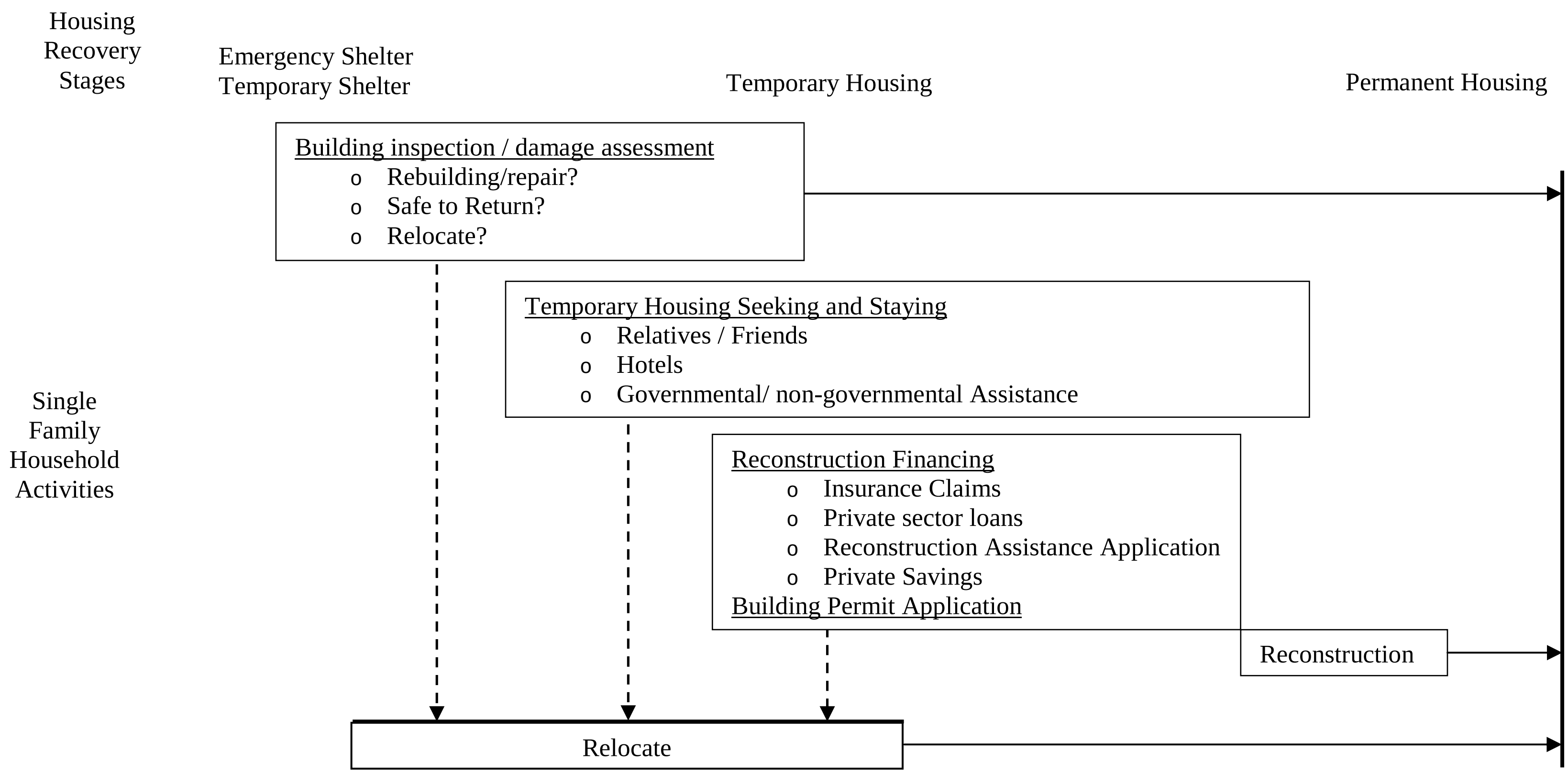

Figure 2.1. Illustration of Household Activities in the Housing Recovery Process

Impacted households may choose to relocate at each point in the process of moving toward permanent housing. Residential relocation following a disaster can either be a voluntary movement or a forced decision by the affected households. The voluntary relocation explains the theory that disasters often accelerate pre-impact demographic trends (Bates et al., 1963; Haas et al., 1977). The households that planned to move long before the impact have a good chance to relocate following the disaster. Forced relocation reflects the situation where some affected households cannot afford home repair and reconstruction or new rental units in the impacted area and are forced to relocate (Bolin & Stanford, 1998). For households that decide to move, the relocation process involves such activities as filing insurance claims for damaged property, home sale, and finding an alternative home.

While Haas et al.'s model (1977) and Quarantelli's typology (1982) are useful for understanding the recovery process leading to permanent housing, they focus on the commonalities of disaster recovery process rather than the differences across households. Based on previous studies, a causal model that focuses on variations in the housing recovery process can be constructed (Figure 2.2). This model illustrates the factors and relationships that affect the outcome of housing recovery. Among all the elements shown in the model, pre-disaster household and neighborhood characteristics are the key factors. These household characteristics (i.e., household income, race/ethnicity, and ownership) and neighborhood characteristics (i.e., race/ethnicity composition and overall income level) affect structural vulnerability, social vulnerability and the level and length of housing recovery. Here, structural vulnerability refers to the susceptibility of a building to natural disasters. The causal relationship between household/neighborhood characteristics and structural vulnerability is expected given the research findings that suggest that class and race/ethnicity are strong correlates of structural characteristics. Low income and minority households are more likely to live in structures that are old, built according to less stringent building codes with low quality design and construction materials, and are poorly maintained (Bolin, 1994; Bolin & Bolton, 1983; Bolin & Stanford, 1998; Peacock & Girard, 1997). Because of residential segregation, homes in poor and predominantly minority, especially Blacks, neighborhoods are in low demand and become similarly deteriorated in the long run (Flippen, 2004; Harris, 1999; Jargowsky, 1997; Taub et al., 1984; Wilson, 1996).

Social vulnerability refers to the differential capacity individuals and groups have to cope with natural disasters (Blakie et al., 1994, Cutter et al., 2003). Just as structural vulnerability is not randomly distributed, social vulnerability is not randomly distributed either. Rather, social vulnerability hinges upon those social factors that shape the susceptibility of individuals and/or groups to disasters and their ability to anticipate, cope with, and recover from the disaster impact (Blakie et al., 1994). Previous literatures have been consistent in identifying variables that influence social vulnerability. Among the widely accepted are age, race/ethnicity, gender, and socioeconomic status. These characteristics have direct consequences on one's accessibility to economic resources, education, information, and political power and representation (Blaikie et al., 1994; Cutter et al., 2003; Peacock & Ragsdale, 1997; Tierney et al. 2001). In the context of housing recovery, the causal relationship between household/neighborhood characteristics and social vulnerability in the model is expected based on research findings that suggest that class, home tenure, and race/ethnicity are important determinants of victims' ability to marshal reconstruction finance (Bolin, 1986; Bolin & Bolton, 1983; Peacock & Girard, 1997; Tierney, 1997). The causal relationship between household/neighborhood characteristics and level/length of housing recovery reflect the expectation that income, home tenure, and race/ethnicity affect the housing recovery process.

Disaster impact characteristics describe the physical threat of the event. A disaster agent may initiate a number of different threats (for a detailed discussion, please see Lindell & Prater, 2003). For example, hurricanes can cause damage through strong wind, storm surge, rain, and inland flooding. Regardless, disaster impact characteristics and structural vulnerability determine the level of housing damage. Given the same level of physical threat, more vulnerable structures are likely to experience a greater amount of damage. The relationship between damage and housing recovery illustrated in this model is straightforward. It is expected that housing with a higher level of damage will take a longer time to be fully reconstructed than others. Similarly, social vulnerability is expected to have an effect on housing recovery. Individuals and households that have difficulty obtaining sufficient financing are likely to have a longer housing recovery process.

Community characteristics act as contextual factors. As noted previously, the level of pre-disaster integration between the impacted community and other organizations/jurisdictions (Berke et al., 1993), effective leadership of local government (i.e. ability to act, knowing what to do) (Rubin, 1991), and pre-disaster housing recovery plan (Schwab et al., 1998) are able to improve the ability of a community to marshal external resources and accelerate the overall recovery process.

Research Hypotheses

To determine how the housing recovery process varies across households, the relationships illustrated in the model suggest the following research hypotheses:

H1: Rental housing units will recover significantly slower than owner-occupied housing.

The rationale for this hypothesis is that rental properties are usually less well maintained and less likely to have hazard adjustments. As a consequence, rental units are likely to experience higher levels of damage than owner-occupied housing net of other factors. In addition, damaged rental properties will take longer to be repaired or reconstructed because landlords are slower to initiate the recovery process.

H2: Post-disaster home sales will have a significant negative effect on housing recovery.

The rationale for this hypothesis is that home sales immediately following the disaster, for whatever reason, will prolong the time needed for recovery tasks such as building inspection, permit application, and housing reconstruction.

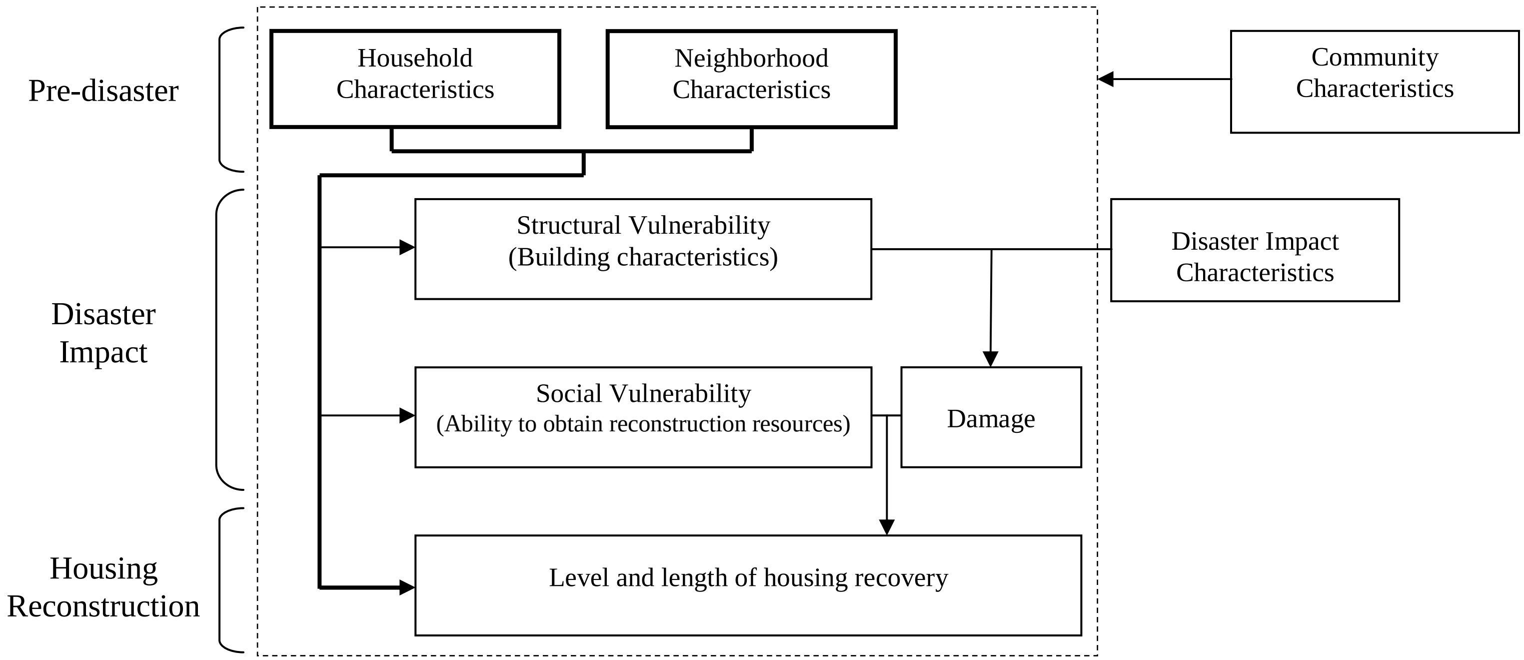

Figure 2.2. Causal Model of Permanent Housing Recovery

To examine variations in the housing recovery process across neighborhoods, the relationships illustrated in the model suggest the following five hypotheses:

H3: Neighborhood minority composition will have a significantly negative effect on housing recovery.

The rationale for this hypothesis is that minorities are often segregated into certain neighborhoods where homes are likely to be old housing that were built according to less stringent building codes using low quality materials, and were less well maintained. As a result, these homes are more likely to experience higher level of damages net of other factors. In addition, minority households face a great number of obstacles in marshaling sufficient recovery resources.

H4: Neighborhood income level will have a significantly positive effect on housing recovery.

The rationale for this hypothesis is that households with similar income levels are often clustered in certain neighborhoods. Homes in low-income areas are likely to be low quality, poorly maintained, and consequently experience high levels of damage net of other factors. In addition, income level also determines the likelihood of acquiring sufficient recovery resources.

H5: In Miami-Dade County, neighborhood Cuban composition will have a significantly positive effect on housing recovery.

H6: Neighborhood non-Hispanic Blacks composition will have a significant negative effect on housing recovery net of other factors.

H7: Neighborhood non-Cuban Hispanics composition will have a significant negative effect on housing recovery net of other factors.

The rationale for hypotheses 5 to 7 is that Cuban Hispanics have gained political and economic power in Miami-Dade County. As suggested by Peacock and Girard (1997), Cubans were no different from Anglos in terms of having quality home insurance and sufficient insurance settlements for reconstruction following Hurricane Andrew. On the other hand, non-Cubans and non-Hispanic Blacks are still experiencing great difficulties in obtaining recovery resources.

CHAPTER III

METHODOLOGICAL APPROACHES TO THE ASSESSMENT OF HOUSING RECOVERY

Proper datasets are essential to conduct a rigorous study of the housing recovery process and identify the major factors in play. Equally important are the analytical techniques used to conduct data analysis. In the following sections, the ideal datasets and analytical strategies are discussed without recognition of any practical constraints such as time and resources. There is a good reason for laying out this "ideal" approach because it sets a goal of what the research design should be and thus encourages researchers to narrow the gap between the "best available" and the "ideal". The last section discusses the analytical approach for data coming from different aggregation levels. This is a very common data issue in studying housing recovery as some variables are available at the household level, while others exist only at a higher level such as a neighborhood.

General Principles

A disaster is an interruption of the normal housing accumulation process. The research design for examining housing recovery must be able to identify the abrupt changes caused by the event and the following restoration process. When determining the major factors in play during the post-disaster recovery process, the design should be able to discern their baseline and recovery effects. This is because many variables (such as home ownership) that may drive the recovery process were already in play prior to the disaster. To fulfill these purposes, the following principles should be incorporated when compiling a dataset and designing an analytical approach.

Dataset

The dataset must be longitudinal. It can be either independently pooled cross sectional data or panel data on housing status in the impacted community for both the pre- and post- disaster periods. In addition to be longitudinal, data must be appropriately timed in order to accurately assess the abrupt changes caused by the disaster (damage) and the recovery process. Small, equal time interval between data points provides higher accuracy. Independently pooled cross-sectional data is obtained by sampling randomly at different points in time. Because samples are randomly drawn each time with no need to monitor the observations of previous time period, data collection in this design is easier to manage compared to panel data. However, repeated sampling introduces differences between samples drawn at each point in time. Panel data have an advantage over independently pooled cross-sectional data because data can track the same set of samples over time. The problem of unobserved heterogeneity for longitudinal research can be better controlled in a panel design.

A quasi-experimental design is an alterative strategy in which a control group of households is selected in a comparable community which did not experience the disaster. This control group provides an indicator of the “normal” process the experimental group (impacted households) would have reached had it not been for the disaster. Comparison between the “normal” community and the disaster stricken community reveals the disaster damage and the recovery level at each point of time. The success of a quasiexperiment design depends upon the comparability of the control group and the experimental group. Ideally, households should be randomly selected and assigned to the experimental group and the control group. In this way, households in both groups are statistically equal with respect to the relevant household characteristics. Then, the treatment (disaster impact) is introduced only into the experimental group. However, in the study of post-disaster housing recovery, the ideal conditions listed above are often impossible to attain. First of all, the household characteristics in the experimental group (impacted area) and those in the control group are not necessarily comparable to begin with. Second, it is well possible that households in the impact area may change at a different rate from those in the control group even before the disaster occurs. Thus the differences between two groups may not due to the disaster related effects. Third, it is likely that the impact of disaster may spillover to the control group even if this group escapes the direct damage. The influx of population from the disaster impact area (the experimental group) into the non-impact area (the control group) represents one example of this spill over effect. Thus, the treatment is not kept exclusively in the experimental group. As a result, part of change in the control group must be attributed to the disaster impact. Because of these difficulties, quasi-experimental design should be implemented with caution.

To understand housing recovery variations across households in the impact area, data on theoretically important explanatory variables such as household income, damage level, homeownership, race/ethnicity, education, occupation, insurance settlements, and the amount of government grants and low-interest loans need to be gathered. Similarly, understanding of housing recovery variations across neighborhoods requires information on variables such as race/ethnicity composition and neighborhood income level.

Analytical Approaches

Ordinary least square (OLS) regression can be used to analyze pooled cross-sectional data. Because the data are independently sampled, it rules out correlations across different observations and time periods when pooling data of multiple time points (Wooldridge, 2003). In the regressions of predicting housing status, housing damage caused by a disaster and the following recovery process are estimated by including dummy variables for all but the time point right before the disaster. In this way, the estimated coefficient of the time dummy immediately following the disaster represents the housing damage. Similarly, estimates of the subsequent time dummies represent the recovery level at each time point. The effects of independent variables on housing recovery can be estimated by including the interactions of time dummies and explanatory variables into the regression model. The estimates of these interactions represent the effects of independent variables at each time point. Changes in the coefficient for a variable can be used to identify the major factors that determine housing recovery process. For example, if the positive coefficients for home ownership in the post-disaster period are significantly greater than those of the pre-disaster period, then one can say owner occupied housing recovers more rapidly than rental units.

For a panel dataset, analysis can be done in several ways. Because housing status is measured on the same set of samples over time, one has at least three options for the dependent variable: housing status, changes in housing status, and the percentage changes of housing status. The first option is to use housing status directly in the model. With the second option, changes in housing status are obtained by differencing the housing status at one point with that of the previous time point for all observations. In a slightly different way, percentage changes of housing status are change ratio instead of the absolute differences of housing status at one point from that of the previous time point. When using housing status directly as the dependent variable in the regression, the estimations of housing damage and recovery process can be achieved by including dummy variables for all but the time point right before the disaster. Similarly, the effects of explanatory variables on housing recovery can be estimated by interacting time dummies with these variables. The changes of the estimated coefficients over time provide evidence for the effect of a particular independent variable on housing recovery. On the other hand, when using the changes of housing status, both absolute changes and percentage changes, as the dependent variable, the coefficients of the explanatory variables are themselves the effects of these variables on housing recovery. Both fixed effect model and random effect model (Baltagi, 2005; Halaby, 2004; Wooldridge, 2003) can be used to conduct the estimation. However, unlike the independently pooled cross-sectional data, serial correlation is likely existing in panel datasets because the same group of households is sampled over time. Currently, advances in dynamic panel analysis and autoregressive panel analysis provide solutions for addressing this problem (Baltagi, 2005; Halaby, 2004).

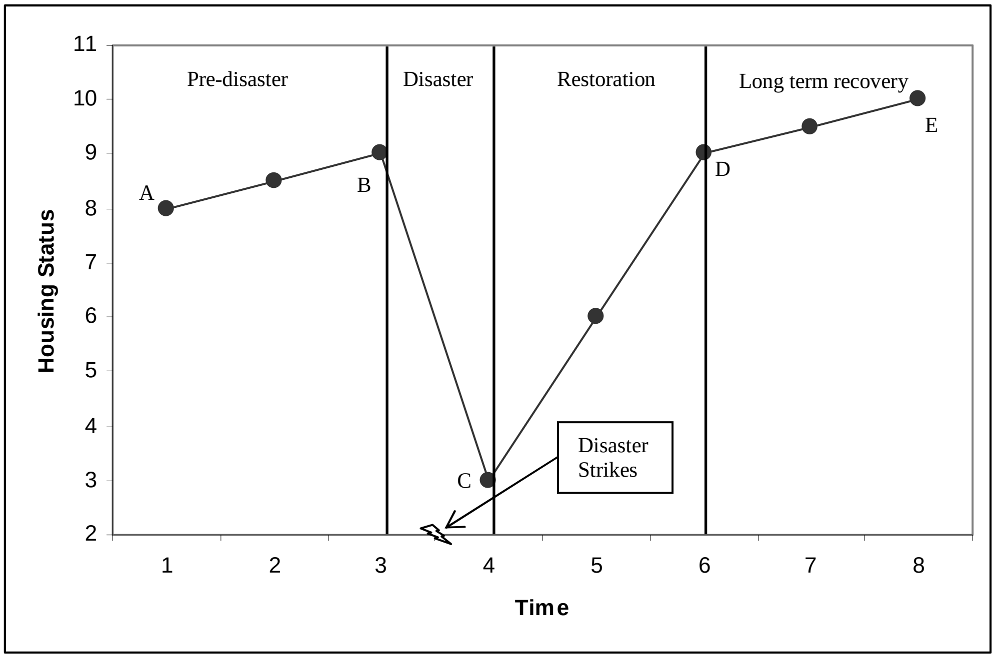

Figure 3.1. A Hypothetical Housing Recovery Trajectory

Panel data also make it possible to explicitly identify the housing trajectory for each sample, which describes the changing housing status at different time points before and after the disaster. This leads to another analytical approach. To construct the housing trajectories, the dependent variable that describes housing status is regressed on the time variables. Figure 3.1 provides a hypothetical case, although the reality may vary from household to household. Here the black dots are observed housing status and the solid line is the fitted housing trajectory. The timeline is categorized into four consecutive periods: pre-disaster, disaster, restoration and long-term recovery, where the housing trajectory shows distinctive pattern during each period.

For the convenience of discussion, the pre-disaster (segment AB) housing status is assumed to be moving monotonically upward (although this is not a necessary assumption because the trend could be monotonically downward or even nonmonotonic). The housing status is assumed to drop to a lower level after the disaster impact (segment BC; this is obviously a necessary assumption). The difference between point B and point C represents the abrupt change (damage) caused by the disaster as they are the two closest observations that bracket the disaster. The next period is called restoration (segment CD) which represents the post-disaster period when major home repairs or reconstructions are undertaken. The housing status change in this period is assumed to have a steeper slope compared to the pre-disaster period (of course, some homes may have a flatter or even downward curves suggesting slower home restoration or even further deteriorations). The last period is called long-term recovery (segment DE) during which the pace of housing status change is assumed to stabilize. The effect of disaster impact fades away gradually from this period on and the line between recovery and normalcy becomes blurred.

Having defined the parameters of the housing trajectory, the next stage of the analysis is to identify the factors that explain the variation of these trajectories among households in the disaster impact community. The estimated parameters in the first step become the dependent variables at this stage, which are regressed on other theoretically important explanatory variables (i.e. household income). As an example, Figure 3.2 illustrates two hypothetical trajectories showing the effect of household income while other variables are held constant. In this highly simplified model, segments CD_1 and CD_2 represent the restoration processes of high income households and low income households respectively. High income households have the higher rate of recovery (slope of CD_1). The inequality between high income households and low income households increase during this period. Similarly, segments D_1E_1 and D_2E_2 represent the long term recovery process for high income households and low income households respectively. Both trajectories become flatter as major reconstruction is finished. However, the inequality between these two groups still exists. Presumably, the effects of other factors (i.e. home ownership, damage level, and household race/ethnicity) on the characteristics of housing trajectories can be depicted in a similar way.

The analytical approach described above has been widely used in educational research under different labels. The model is a hierarchical model (Bryk & Raudenbush, 1992) in a sense that the parameters estimated at the first stage are, in turn, dependent on variables at the second stage. The model is also known as a multi-level model (Goldstein, 1995) because it describes data that vary at two levels: within households and between households. In particular, this model is also a random coefficients model (Longford, 1993) because the parameters of the first stage vary randomly over households at the second stage.

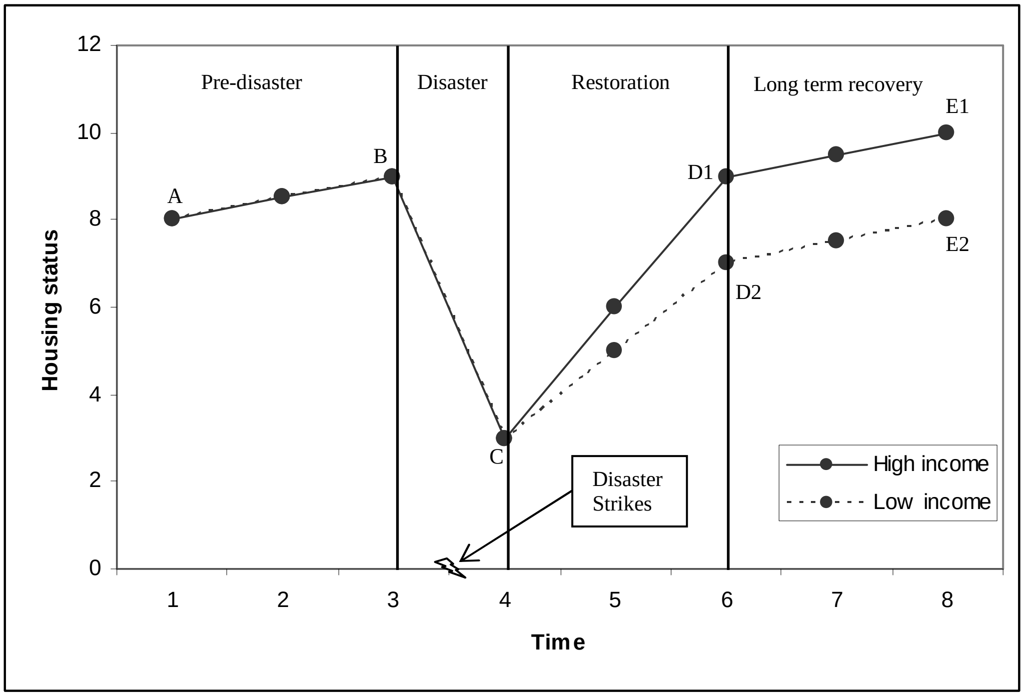

Figure 3.2. Hypothetical Housing Recovery Trajectories for Household with Different Characteristics

The Issue of Multi-Level Data

When both household data and neighborhood data are used in the analysis discussed in the above section, the regression is likely to be contaminated by misestimated standard errors and the existence of heterogeneity. Consequently, the hypothesis tests could be misleading. Misestimated standard errors occur because of the similarity among individual households within the same neighborhood. For example, residential segregation in most American cities still remains at a very high level (Massey & Denton, 1992). Households very often are surrounded by other households with similar income level or race/ethnicity. Heterogeneity of regression occurs when the relationship between household characteristics and housing recovery vary across neighborhoods.

One approach to resolve such problem is to run the models with the Huber-White robust standard error (Huber, 1967; White, 1980, 1982). In this way, the estimation becomes robust to the threat of autocorrelation and heterogeneity when incorporating both household data and neighborhood data in the model at the same time. The hierarchical model (sometimes also named as multi-level model, random coefficients model) (Bryk & Raudenbush, 1992; Goldstein, 1995; Longford, 1993) offers another solution. It resolves the problem of misestimated standard errors by incorporating a unique random effect for each neighborhood into the model. The variability in these random effects is taken into account when estimating standard errors, thus the standard error estimates adjust for the intraclass correlation. For the problem of heterogeneity, hierarchical models enable the investigator to estimate a separate set of regressions for each neighborhood. The variation among the neighborhoods is then explained by neighborhood level variables.

To study housing recovery following Hurricane Andrew, this research collects a panel dataset on single family housing in Miami-Dade County for both pre-event and post-event periods. While several options are available for analyzing such a dataset, as discussed previously, this research will adopt the hierarchical method. First, housing trajectory of each household in the sample is modeled. This part of analysis describes the changing housing status of each sample at different time points before and after the disaster. At the next stage of analysis, household variables and neighborhood variables are used to identify how housing recovery trajectory varies across households and neighborhoods.

CHAPTER IV

METHODS

Data Preparation

The data used in this research comes from three sources: the Miami-Dade County housing tax appraisal database from 1992 to 1996, the Miami-Dade County 1990 census data at both block level (the Summary File 1, SF1) and block group level (the Summary File 2, SF2), and the census TIGER/Line data for Miami-Dade County. The tax appraisal data covers every single land parcel in Miami-Dade County. For residential parcels, it provides detailed information on housing characteristics such as number of bedrooms and bathrooms. It also includes appraised building value for each year. In addition, the status of home tenure can be derived from the appraisal tax data as well. Census SF1 and SF2 files contain socio-demographic (i.e. percentage figures of population composition for each unit) and socio-economic data (i.e. median household income). The TIGER/Line data contains geographic boundary definition for both census block and census block group.

Data preparation using these three data sources was conducted using the following steps. The census TIGER/Line file was first imported into the geographic information system (ARCGIS 9.1). Then a census block boundary GIS layer and a block group boundary GIS layer were generated. In the following step, block census data (SF1) and block group census data (SF2) were merged into these GIS layers. Finally, tax appraisal data from different years were merged[*], geo-coded and then merged into these GIS layers using ARCGIS 9.1. In this way, each parcel in the tax appraisal data was assigned the block/block group information in which it was located. In addition, the location of each parcel relative to the hurricane path was generated in GIS by overlaying the geo-coded tax appraisal data with the impact zone map of Hurricane Andrew (Figure 4.1).

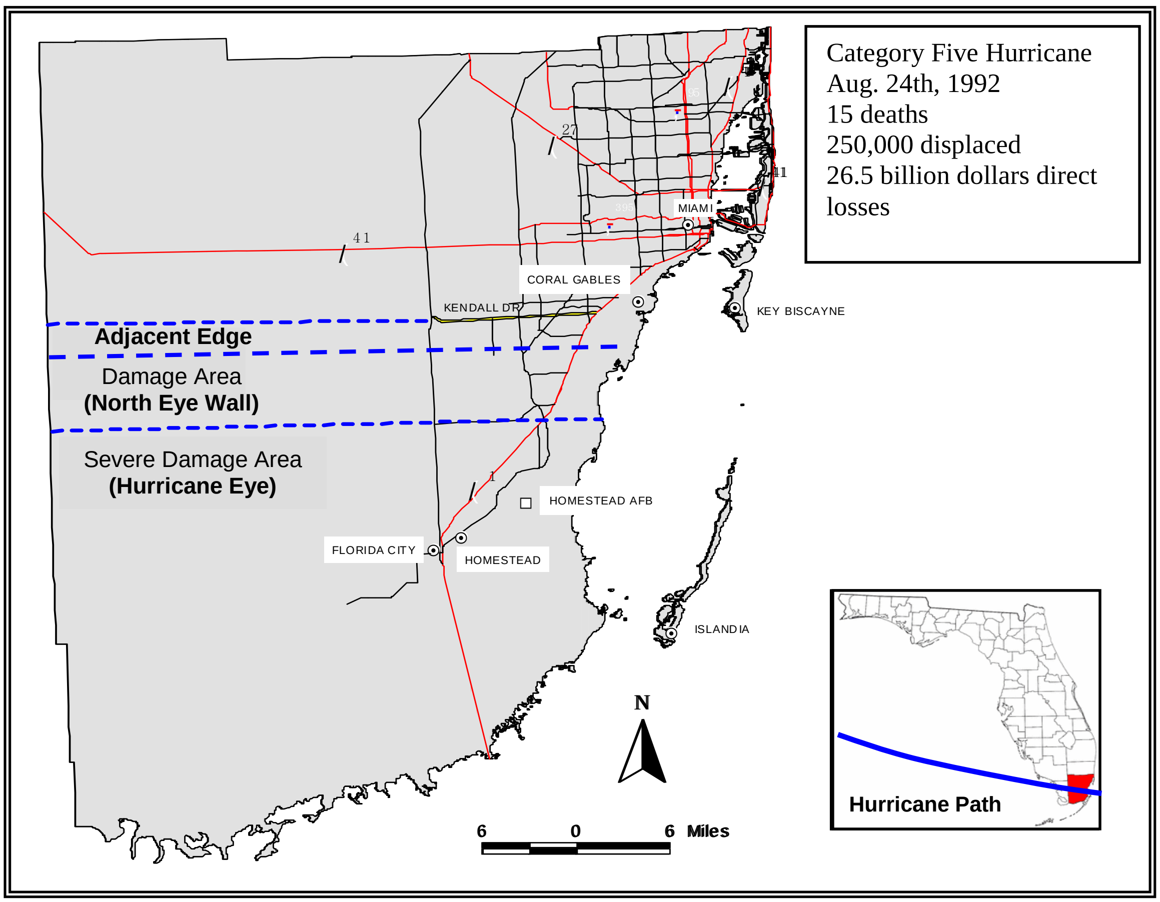

Figure 4.1. Hurricane Andrew Impact Zones (sources: Peacock & Girard, 1997)

[*] This part of data preparation was mainly done by Dr. Walter G. Peacock.

Measuring Housing Recovery

Very few attempts have been done in the literature to measure housing recovery directly. Nevertheless, housing is a critical element of overall household recovery. Household recovery has been measured in a number of ways in previous research. In Bolin and his colleagues' research on household recovery following a disaster in the United States and in Nicaragua (Bolin, 1986, 1993; Bolin & Bolton, 1983; Bolin & Trainer, 1978), income recovery, house-size recovery, and recovery of household conveniences were used to measure the level of household recovery. Hence, a household was said to have achieved housing recovery if their home returned to the same size and had the same conveniences. Bates and his colleagues introduced the Domestic Assets Index, a more expanded measure of recovery for studying household recovery following the Guatemalan earthquake (Bates, 1982; Bates & Peacock, 1992; Peacock et al., 1987). They suggested that household damage and recovery should be measured by first determining the value of the material assets employed by a household to carry out normal household functions (i.e., shelter, sleeping, food preparation, food storage, etc.). Taken as a whole, these assets were termed the Domestic Assets Index (Bates & Peacock, 1992). Recovery was then defined as obtaining the level of assets a household could be expected to have had the disaster not occurred. Simply reaccumulating the level of assets a household had prior to an event was, however, termed restoration. In order to measure recovery conceptualized in this manner, they developed a model of normal accumulation and then contrasted the assets a household accumulated by a particular time with the level of assets they would have been expected to accumulate had no impact occurred.

Hence, reaching the expected level of assets accumulation represented recovery, reaching higher levels amounted to over-recovery, and falling below expected levels was under-recovery (Peacock et al., 1987). To operationalize this conceptualization, Bates and colleagues utilized data from two panels of households, one panel impacted by a disaster and the other, comparison panel, not directly impacted by the event. Normal accumulation was modeled using the ‘comparison’ panel of households.

In many respects, the Domestic Assets Index represents an ideal measure of household recovery. While the researchers had to rely on retrospective data, they were able to model normal accumulation processes in order to measure recovery levels for a specific point in time following a disaster. However, the success of this approach depends upon the availability of a comparison group of households, which, as discussed in previous section, could be a challenge.

In research conducted at an aggregated level, community overall housing recovery, instead of household housing recovery, was measured. When studying housing reconstruction following the Northridge Earthquake in the city of Los Angeles and the Chi-Chi Earthquake in Taiwan, Spangle Association (1998) and Wu and Lindell (2004) used the number of housing rebuilding permits issued per month above the normal baseline level as an indicator of the post-disaster recovery process in the impacted community. The number of permits issued per month took several months to reach a peak which indicated that a massive housing reconstruction was underway. Then, the number trailed off and gradually fell back to the baseline level. In this way, faster housing reconstruction means that the number of issued permits takes a shorter period of time to return to the normal level. Wright et al. (1979) used total number of housing units in census tracts or counties in 1960 and 1970 to track long-range housing recovery.

Measuring Housing Recovery Using Appraised Housing Value

This research employs the appraised value of a home from 1992 to 1996 to access disaster damage on housing and the recovery process following Hurricane Andrew. The annual appraisal process in Miami-Dade County begins during the first half of the year when the tax assessor's office appraises the value of real property throughout the county. Land value of each parcel and the value of any structures located on the property are appraised separately and then combined. In late August and early September, initial property appraisals are sent out to all property owners. During the following months property owners can challenge the appraisals and adjustments are made through December. In January the tax bills are sent out and the state is provided with the official assessments for real properties within a county.

It just so happened that the appraisal notices for the 1992 property tax were in the mail and were being delivered at about the same time Hurricane Andrew hit on August 24, 1992. Many homeowners received a property appraisal notice that was far above the value of the home after Hurricane Andrew struck. And yet, despite the sometimes incredible disparities, these assessments stood. However, the county did promise that assessments in subsequent years would accordingly reflect the state of their property. In the aftermath of Hurricane Andrew, the Miami-Dade tax assessors office undertook a detailed inspection of homes in South Dade during 1993 and many years after in order to properly capture property values. Indeed, there was an extra incentive to insure that assessments in the county accurately reflected the value of property because an amendment was passed that would cap property tax increases from 1996 to a maximum of 3% for current homeowners. Since the property appraisal includes a separate value for the building located on the parcel, and this value can be use to track the change in its value due to damage and subsequent rebuilding, it was decided to attempt to use the property appraisal to track disaster damage and recovery following Hurricane Andrew.

The appraisal data lists the value of all types of parcels, which are classified by the county into land use codes reflecting the nature of the property and how its value is distributed among the owners of the property. For example, residential parcels are categorized into single family, duplexes, multi-family housing, cluster homes, condominiums, town houses, mixed residential, etc. This research focuses on single family housing primarily because the complexity of property ownership for other forms of housing can complicate the recovery process (Comerio, 1998; Wu & Lindell, 2004) and because single family housing represented a dominant form in Miami-Dade County at the time of the hurricane.

Utilizing tax appraisal data is not without problems. First, the timing of the assessments was not consistent with the disaster event itself, as mentioned above. The 1992 building value actually reflects the value of the home several months (2-8 months) prior to the event and the 1993 value, which will be used to measure the housing damage, may include 5 to 10 months of rebuilding and repair. However, anecdotal evidence in the impact area after Hurricane Katrina and previous research on housing reconstruction following the Northridge Earthquake (Wu & Lindell, 2004) suggest that it takes 4-5 months or longer before mass reconstruction begins following a major natural disaster. Also taking into account the fact that the tax appraisal office adjusted the appraised value to reflect the effect of Hurricane Andrew, the timing of the 1993 tax appraisal value becomes a lesser problem when estimating housing damage.

Another major problem was determining which single family parcel actually had a single family structure located on it. A parcel may be classified as “single family” but that does not mean that it actually has a complete home on the parcel. The home may be in the process of being built, may have existed earlier but now is only a foundation or a utility hook-up, or may exist in any of a seemingly infinite number of conditions. For our purposes, the structure on a parcel was considered a single family if the parcel had a county land use code or CLUC code of single family in 1992 and remained single family through 1996. The only exception to this rule were parcels whose CLUC changed from single family to vacant lot; these were included, but all other changes such as shifts to duplex, apartment buildings, law offices, etc, were excluded. In addition, to be considered as single family housing, the parcel’s building must, 1) have a value of $5,000 or more in 1992, 2) have at least one bedroom, 3) have at least one bathroom, 4) have more than 500 square feet and 5) have at least one floor. In addition, parcels with obvious data errors are excluded from the dataset as well. For instance, it is not possible that a single family house was already 3998 years old in 1992.

This research includes only single family homes located in the area south of Kendal drive (south Dade County) which is the area where the main hurricane force -- hurricane eye, eye wall, and adjacent edge (Peacock & Girard, 1997) -- struck (Figure 5-1). Based on these criteria, the final sample consisted of a maximum of 55,268 single family homes in which the data from 1992 through 1996 were merged. The single family homes located in the area north of Kendal drive (north Dade County) where Hurricane Andrew caused little damage are excluded from the analysis. One may think that this information could be used as the comparison group in a quasi-experimental design to construct a normal housing attainment process. However, the conditions of housing attainment in north Dade County and south Dade County are very different. North Dade County was essentially a mega-metropolitan environment as the majority proportion of single family homes in this area was within Miami-Metropolitan Area. On the other hand, south Dade County was consisted of rural areas and small cities when Hurricane Andrew occurred. This systematic difference between north and south Dade county makes the quasi-experimental design problematic.

Independent Variables

The independent variables fall into two broad classes The first contains attributes of the individual housing units themselves, which are suggested by the recovery literature. Because our data is not an ideal random sample in which homes must be random and equal with regard to disaster exposure, structural characteristics that are normally associated with hedonic analysis and housing damage variables are included as well. These variables were either directly derived from the appraisal data records or generated by integrating tax data with other data sources. The variables include: the pre-disaster (1992) home characteristics (i.e. number of bedrooms, bathrooms, age), the pre-disaster tenure status of the home (i.e., owner or renter occupied), the number of sales between the time of the hurricane and the assessment year, and the location of the property relative to the hurricane path (i.e. hurricane eye, eye wall, adjacent edge).

Number of bedrooms, number of bathrooms, and home age are all continuous variables. Tenure status is entered into the analysis as a dummy coded variable where 1 equals owner-occupied and 0 equals renter occupied. Housing damage is measured by the location of a property relative to the hurricane path, as the physical force of the hurricane varies by the distance and direction from the hurricane eye. The entire study area is divided into three zones -- hurricane eye, eye wall, and the adjacent edge as used by Peacock and Girard (1997). These variables enter the analysis as dummy coded variables where 1 represents the property within a certain zone, and 0 represents the property is outside of a certain zone.

The second broad class of independent variables relates to neighborhood characteristics, which are generated from 1990 census block and block group data. These neighborhood level variables include median household income, racial/ethnic characteristics such as percent non-Hispanic White, percent Hispanics, and percent non-Hispanic Blacks. In addition, detailed Hispanic classifications of the percent Cuban and non-Cuban Hispanics will also be included in the analysis.

Table 4.1 presents a full description of the variables included in this analysis. The data sources that are used to generate these variables are also listed.

Table 4.1. List of Variables and Their Description

Concept	*Variable*	*Description*	*Data Source*
Pre and Post-disaster Housing Condition			
	Value92	1992 Housing appraisal value (Pre-disaster housing value—8 to 2 months before Hurricane Andrew)	Directly from tax appraisal data
	Value93	1993 Housing appraisal value (Post-disaster housing value—5 to 10 months after)	Directly from tax appraisal data
	Value94	1994 Housing appraisal value (Post-disaster housing value—17 to 22 months after)	Directly from tax appraisal data
	Value95	1995 Building appraisal value (Post-disaster housing value—29 to 34 months after)	Directly from tax appraisal data
	Value96	1996 Building appraisal value (Post-disaster housing value—41 to 46 months after)	Directly from tax appraisal data
Household Level Variables			
	BEDROOM	Bedroom number	Directly from tax appraisal data
	BATH	Bath number with a full bath counted as 1 and a half bath counted as 0.5	Directly from tax appraisal data
	HOME_AGE	Housing age in 1992 when the disaster happened	Directly from tax appraisal data
	OWNERSHIP	Home ownership with owner occupied coded as 1 and renter occupied as 0	Generated from tax appraisal data
	EYE	Home location relative to the path of hurricane eye: within 1, otherwise 0	Tax Appraisal Data, Damage Zone Data
	EYEWALL	Home location relative to the path of north hurricane eye wall: within 1, otherwise 0	Tax Appraisal Data, Damage Zone Data
	EDGE	Home location relative to the adjacent edge of north eye wall: within 1, otherwise 0	Tax Appraisal Data, Damage Zone Data
	SALE9294	Number of sale transactions taken place between disaster and the time when housing value is assessed in 1994	Generated from Tax Appraisal Data
	SALE9496	Number of sale transactions taken place between the time when housing value is assessed in 1994 and that time in 1996	Generated from Tax Appraisal Data
Neighborhood Level Variables			
	MED_INCOME	Median household income as of 1990 census data	1990 block group census data
	PER_WHITE	Percentage non-Hispanic White as of 1990 census data	1990 block census data
	PER_HISP	Percentage Hispanic as of 1990 census data	1990 block census data
	PER_BLACK	Percentage non-Hispanic Black as of 1990 census data	1990 block census data
	PER_N_CUBAN	Percentage non-Cuban Hispanic as of 1990 census data	1990 block group census data

Table 4.1. *Continued*

Concept	*Variable*	*Description*	*Data Source*
	PER_CUBAN	Percentage Cuban Hispanic as of 1990 census data	1990 block group census data

CHAPTER V

DATA ANALYSIS

Descriptive Statistics and Preliminary Analysis

Table 5.1 presents the descriptive statistics for each variable using 56,288 valid single family households and 3688 neighborhoods in south Miami-Dade County. Several noteworthy points come to light in the descriptive statistics. Regarding neighborhood characteristics, the average household income was $43,090, with a standard deviation of $18,210 and a range of $145,000. Clearly, neighborhoods in the study area vary to a good extent in terms of median household income. Neighborhoods in this area had an average of 54.50% of Whites, 27.44% of Hispanics, and 18.06% of Blacks. While Anglos were still majorities, Hispanics and Blacks accounted for almost half of the population. Anglo percentage had a standard deviation of 23.57, which was comparable to the standard deviation of Black percentage (23.51). On the other hand, the standard deviation of Hispanic percentage was much smaller (15.99). Clearly, Anglos and Blacks were more segregated than were Hispanics. Some neighborhoods were essentially consisted of only Blacks (max = 99.06%) or Anglos (max. = 94.83%). After dividing Hispanics into Cubans and non-Cubans, Cubans accounted for 16.38% population in the study area, with non-Cubans accounting for 11.06%. Comparing to Anglos and Blacks, these two groups were less segregated. Cuban percentage had a standard deviation of 9.98 and non-Cuban percentage had a standard deviation of 8.64. They were both considerably smaller than that of Anglos percentage and Black percentage.

Table 5.1. Descriptive Statistics of Variables

Neighborhood level variables (N=3688)

Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
MED_INCOME*	43.09	18.21	5.00	150.00
PER_WHITE	54.50	23.57	0.27	94.83
PER_HISP	27.44	15.99	0.67	68.00
PER_BLACK	18.06	23.51	0.00	99.06
PER_N_CUBAN	11.06	8.64	0.00	61.99
PER_CUBAN	16.38	9.98	0.67	36.70

Household level variables (N =56288)

Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
Value92*	59.47	53.01	5.00	1358.29
Value93*	29.51	46.10	0.00	1274.09
Value94*	59.64	52.88	0.00	1353.30
Value95*	64.00	58.38	0.00	1592.58
Value96*	68.32	59.21	0.00	1592.58
BEDROOM	3.28	0.73	1.00	10.00
BATH	1.94	0.65	1.00	9.00
HOME_AGE	22.31	11.68	0.00	91.00
OWNERSHIP	0.86	0.35	0.00	1.00
EYE	0.34	0.48	0.00	1.00
EYEWALL	0.58	0.49	0.00	1.00
EDGE	0.08	0.27	0.00	1.00
SALE9294	0.26	0.52	0.00	4.00
SALE9496	0.17	0.44	0.00	5.00

*: in thousand dollars.

Regarding household characteristics, the average age of housing in south Dade was almost 23 years at the time of the hurricane, indicating that while this was an area of prime growth, it also was an area with a considerable number of older established housing units. On the whole, 86 percent of single family homes were owner occupied. 34% of single family homes were located in the path of hurricane eye. While this area is the most damaged area, it was consisted of large proportion of rural land and natural conservation land. The human settlement mainly concentrated in two incorporated area: Florida City and Homestead. In the eye wall area, the density was considerable higher. 58% of single family homes were located in this area. The adjacent edge was a small area below Kendall drive. 8% of single family homes were located in this area. Home sales were frequent following the hurricane -- each home was sold an average of 0.26 times within two years after Hurricane Andrew (SALE9294). Some homes were sold as many as four times during this period. In the following two years (SALE9496), the average number of home sales diminished (0.17), while some homes were sold as many as 5 times. In 1992, prior to Hurricane Andrew, single family housing in South Dade County had an average home value of $59,470 and a maximum value of nearly $1.4 million. Noted that this represents only the value of the structure, not the property upon which it was located. In 1993, the average home value fell to $29,506. By the 1994 assessment, 17-22 months after the storm, the average home value had risen to $59,638. In the following two years (1995 and 1996), the average home value was $64,000 and $68,320 respectively.

In addressing the first research objective, assessing the housing recovery process, Table 5.2 provides more detailed summary statistics of changes in home values. Compared to pre-disaster (1992) assessment, the average home value declined by almost $30,000 or 50.4% in 1993. Almost all homes (more than 99%) had a value below their

1992 levels. In 1994, the average home value represented a gain of $168 over its 1992 value; however, 32% of homes had not reached their pre-disaster levels. At the time of the 1995 assessment, 29 to 34 months after the storm, the average home value was $64,004, representing a gain of $4,534 over 1992 value. Yet, nearly 21% of the homes were still below their 1992 level. And finally, by 1996, 41 to 46 months later, the average home value was $68,324 or $8,854 above its 1992 value. Still, nearly 16% of homes did not reach their 1992 values. Clearly, Hurricane Andrew was a devastating disaster and, on average, the general pattern of recovery within two years seems to have held. However, it is equally clear that the average pattern was not the case for a sizeable proportion of these properties, with 32% in 1994, nearly 21% in 1995, and nearly 16% in 1996 not reaching their pre-storm home value.

Table 5.2. Average Single Family Housing Value before and after Hurricane Andrew

	1992 (2-8 months before)	*1993 (5-10 months)*	*1994 (17-22 months)*	*1995 (29-34 months)*	*1996 (41-46 months)*
Avg. Value	$59,470	$29,506	$59,638	$64,004	$68,324
Loss/Gain		-$29,964	$168	$4,534	$8,854
% Loss/Gain		-50.4%	0.2%	7.6%	14.9%
% of Housing Units Below 92		99%	32%	21%	16%

With regard to the second research objective, identifying major factors that affected housing damage and the recovery process, Table 5.3 lists the intercorrelations among all variables. Home age had significant negative correlations with home values

Table 5.3. Intercorrelations of Variables

	Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*
1	Value92																			
2	Value93	.79*																		
3	Value94	.93*	.79*																	
4	Value95	.95*	.78*	.95*																
5	Value96	.95*	.77*	.94*	.97*															
6	HOME_AGE	-.37*	-.19*	-.36*	-.35*	-.36*														
7	BEDROOM	.49*	.35*	.47*	.47*	.48*	-.37*													
8	BATH	.69*	.53*	.65*	.66*	.66*	-.39*	.63*												
9	OWNERSHIP	.04*	.05*	.07*	.05*	.05*	-.07*	.10*	.07*											
10	SALE9294	-.00	-.05*	-.04*	-.02*	-.01*	-.05*	-.00	.00	-.17*										
11	SALE9496	-.00	-.01*	-.02*	-.01*	-.01*	-.00	-.02*	-.00	-.06*	.06*									
12	EYE	-.24*	-.26*	-.25*	-.24*	-.27*	.10*	-.23*	-.24*	-.10*	.06*	.01*								
13	EYEWALL	.12*	.07*	.12*	.12*	.15*	-.06*	.16*	.14*	.07*	-.04*	-.01*	-.84*							
14	EDGE	.19*	.34*	.21*	.21*	.21*	-.06*	.11*	.17*	.04*	-.04*	-.01*	-.20*	-.33*						
15	MED_INCOME	.56*	.49*	.55*	.56*	.57*	-.22*	.32*	.49*	.06*	.00	.01	-.36*	.30*	.08*					
16	PER_WHITE	.28*	.20*	.28*	.27*	.29*	-.12*	.15*	.33*	.04*	.03*	.02*	-.08*	.06*	.01*	.59*				
17	PER_HISP	-.04*	.03*	-.03*	-.02*	-.03*	-.14*	-.03*	-.07*	-.00	.01*	.01	.09*	-.21*	.24*	-.18*	-.34*			
18	PER_BLACK	-.25*	-.22*	-.25*	-.25*	-.26*	.22*	-.13*	-.28*	-.03*	-.04*	-.02*	.02*	.07*	-.18*	-.47*	-.76*	-.33*		
19	PER_CUBAN	.04*	.10*	.05*	.06*	.05*	-.18*	.05*	-.00	.02*	-.01*	-.01	-.10*	-.02*	.22*	-.03*	-.27*	.83*	-.29*	
20	PER_N_CUBAN	-.11*	-.03*	-.09*	-.09*	-.11*	-.07*	-.10*	-.12*	-.03*	.03*	.01*	.23*	-.32*	.19*	-.25*	-.31*	.87*	-.28*	.47*

Note: * significant at $p < 0.05$

from 1992 to 1996 (row 6, column 1 to 5). However, the magnitude of negative correlation in the year following the storm -- 1993 (- 0.19, row 6, column 2), though statistically significant, is considerably lower than the correlations in other years. This suggests that extensive housing damage reduced the variation of home values among different age groups. Moreover, the comparable correlations of 92, 94, 95, and 96 suggest that the major disaster disruption may only last two years. Home ownership maintained a significant positive correlation with home value throughout the period (row 9, column 1-5), with the positive value in 1994 (0.07, row 9 column 3) noticeably greater than the rest of the years. This stronger positive correlation supports the expectation that owner-occupied homes would recover faster than rental units. In addition, the negative correlation between homeownership and home age (-0.07, row 9 column 6) and the positive correlations with number of bedrooms (0.10 row 9 column 7) and number of bathrooms (0.07 row 9 column 8) suggest that rental units were likely to be older and smaller homes.

Home sale has significant negative correlations with home values in the post-disaster period (row 10-11, column 2-5), especially in the years immediately following the storm (row 10, column 2, 3). The consistency of negative correlations suggests that post-disaster home sales did slow down the recovery process. In addition, home sales had significant negative correlations (row 10, 11, column 9) with homeownership, suggesting that rental properties were more likely to be in transaction following the event. Moreover, positive correlations between home sales and the percentage of the White (row 16, column 10, 11) and positive correlations between home sales and the variable Hurricane EYE (row 12, column 10, 11) suggest that post-disaster home sales were more likely to occur in Anglo-populated neighborhoods and in neighborhoods severely damaged by the storm. However, it is worthwhile to notice that although these correlations were statistically significant, their magnitudes were very small. The consistently negative correlations between EYE and home values (row 12 column 1-5), the positive correlation with home age (row 12 column 6), the negative correlations with number of bedrooms and number of bathrooms (row 12 column 7, 8), and the negative correlation with homeownership (row 12 column 9) suggest that homes in the most damaged area were older, smaller, and more likely to be rental properties.

When it comes to neighborhood race/ethnicity composition, the intercorrelations vary considerably. Percentage of White population in a neighborhood consistently had a significant positive correlation with home value throughout the period (row 16 column 1-5). The magnitude of this correlation attenuated somewhat in 1993 (0.20), which, again, reflects the fact that the extensive housing damage in the whole area reduced the variation of home values between neighborhoods. However, the magnitude of positive correlation goes up and remains at a higher level in 1994, 1995, and 1996 (row 16, column 3-5). The concentration of Hispanics in an area had a significant negative correlation with home value except for 1993 (row 17 column 2) when a significant positive correlation existed. Percentage of non-Hispanic Blacks in an area has a significant negative correlation with home value throughout the period (row 18 column 1-5). The magnitude of correlation, even with a minor reduction in 1993 (row 18 column

2), remained at a high level. Again, the attenuation of the negative correlation in 1993 suggests that the disaster caused extensive housing damage in the whole area.

When dividing Hispanics into Cuban-Hispanics and non-Cuban Hispanics, the patterns of the correlations change totally. Percentage of Cuban Hispanics consistently had a significant positive correlation with home value (row 19 column 1-5). In the post-disaster years, the magnitude of positive correlation is even stronger than that in the pre-disaster year. This pattern suggests that homes in predominantly Cuban neighborhoods recovered at a faster rate than homes in other areas. On the other hand, percentage of non-Cuban Hispanics had a significant negative correlation with home value throughout the period (row 20, column 1-5). While the value attenuated slightly in 1993, it returned to a higher level in the following years, suggesting that although Hurricane Andrew's extensive damage reduced housing inequality immediately following the event, homes in predominantly non-Cubans areas recovered at a slow pace.

In summary, the intercorrelations reveal the relationship between the independent variables and home values in the years before and after the storm. Changes of direction and magnitude of intercorrelations suggest that multiple variables affect housing damage and the recovery process. The frequently occurring attenuation of intercorrelations in 1993 reflects the reduction of pre-disaster variation in housing values. Obviously, Hurricane Andrew caused extensive damage to homes of all types. The increased positive correlation between home ownership and home value in the post-disaster era confirms the expectation that owner-occupied housing would recover faster than rental units. The negative correlation between home sales and home values suggests that post-disaster home sales did slow down the recovery process. However, many of the variables that would be expected to affect housing recovery are themselves intercorrelated. For example, there are significant positive correlation between household income and percentage of Whites (row16 column15) and significant negative correlation between household income and percentage of Blacks (row 18 column 15). The zero-order correlation of each independent variable with the dependent variable contains indirect effects as well as direct effects – making it difficult to assess the unique contribution of each predictor. Thus, further analyses are needed to determine each individual variable's effect on recovery.

Further Analysis with Hierarchical Linear Model

To review, we have appraised values for each single family home in south Miami-Dade County – one pre-disaster value (1992) and four post-disaster values for four subsequent years. While we do not have sufficient data to estimate the pre-disaster housing trajectory as indicated by Figure 3.1 in CHAPTER III, these five occasions provide enough information to estimate housing damage, the restoration rate, and the rate of long-term recovery (Figure 5.1). In this model, disaster damage (segment AB) is measured as the difference between home values of 1992 and 1993. The restoration period is defined as the time between the 1993 and 1994 assessments because the 1994 assessment represents the home value about two years after the storm (17-22 months). Mass home repairs and reconstruction are usually undertaken within two years following major disasters (Bolin, 1993; Comerio, 1998; Wu & Lindell, 2004). Our preliminary analysis also shows that, on average, home value returned to what it was in 1992 during this period (Table 5.2), even though it was not necessarily the case for every household. With this definition, the home restoration rate is measured as the difference between home values of 1994 and 1993 (segment BC). The long-term recovery trajectory (segment CD) is estimated by fitting a line using home values of 1994, 1995 and 1996. In this way, a steeper line – greater slope – represents a faster long-term recovery.

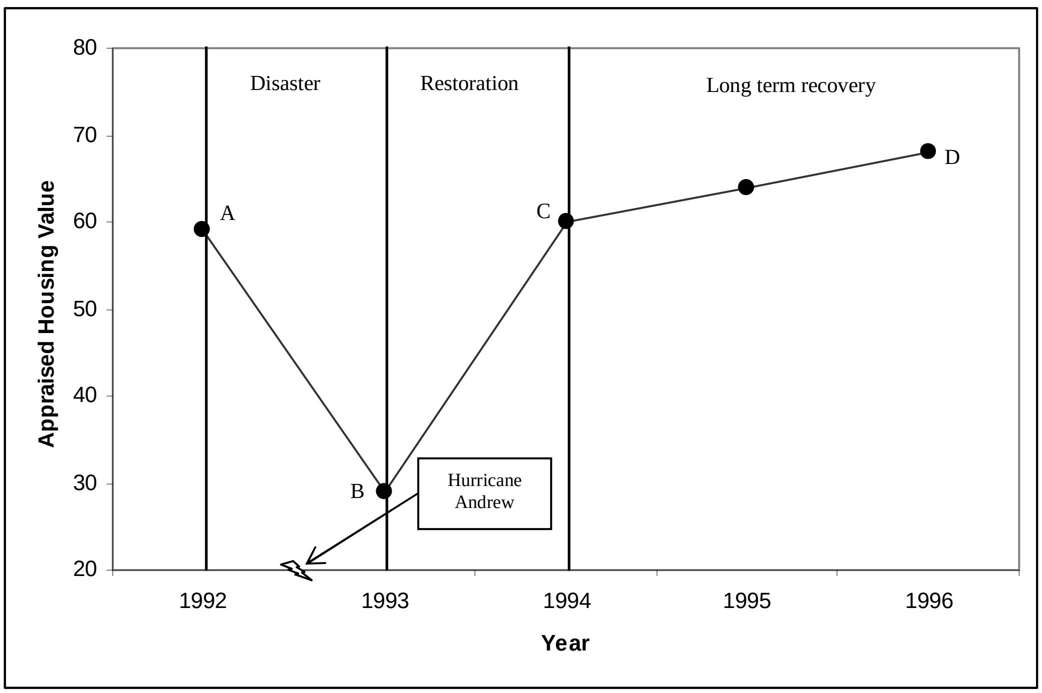

Figure 5.1. Estimating Housing Damage, Restoration and Long-term Recovery

For the convenience of discussion, we call the whole curve – A though D in Figure 5.1 – the housing damage/recovery trajectory, or simply housing trajectory, in the following sections.

The hierarchical linear model (Raudenbush & Bryk, 2002; Singer & Willet, 2003) is adopted to estimate the housing damage/recovery trajectory. In this model, appraised home values are viewed (level 1) as nested within households, and households (level 2) as nested within neighborhoods (level 3). At level 1, home values are used to estimate each household's damage, restoration rate, and the rate of long-term recovery. Levels 2 and 3 model the extent that the level 1 estimations vary across households and neighborhoods.

Model 1: Total Variation in Housing Trajectories

Specifications

This model estimated the total variation in housing damage/recovery trajectories in South Dade County. To model housing trajectory (level 1), each home value V_{thn} of household h, in neighborhood n, of year t was viewed as a linear function of the number of years this home was in the disaster period (*DISASTER*), restoration period (*RESTORATON*), and long term recovery period (*LT_RECOVERY*) at the time of *t*. For example, these variables are all coded as 0 in 1992 because the storm had not yet occurred. In 1993, DISASTER is equal to 1 and the other two variables remain as 0 indicating that this home had been in the disaster period for one year. In 1994, DISASTER remains as the same value and RESTORATION becomes 1, indicating that this home had been in both the disaster and the restoration periods for one year. In 1995, LT_RECOVERY becomes 1. At this point, this home had been in the disaster period for one year, in the restoration period for one year, and also in the long-term recovery period for one year. In 1996, LT_RECOVERY becomes 2 with other variables remaining as the same, indicating that this home had been in the long-term recover period for two years at this point. Table 5.4 provides a full list of the values of these variables in different years. The specification for housing trajectory model is:

$$V_{thn} = \alpha_{0hn} + \alpha_{1hn} DISASTER + \alpha_{2hn} RESTORATION + \alpha_{3hn} LT\_RECOVERY + e_{thn}$$

Here the interception α_{0hn} is 1992 home value (pre-disaster). Slope α_{1hn} represents the disaster damage – the absolute home value loss. Slope α_{2hn} is the home restoration rate. Slope α_{3hn} represents the increase in home value per year during the long-term recovery period. The residual term e_{thn} is the measurement error – the departure of the home value V_{thn} from the true value of household *h*. The errors of different home values are assumed as normal and independent random variables. Errors for home values of the same household are not independent, of course, but they are accounted for by including random effects for each household and neighborhood.

Each parameter in level 1 model is then broken down into variations in households (level 2) and neighborhoods (level 3). Level 2 models are:

$$\alpha_{0hn} = \beta_{00} + a_{0h},$$

$$\alpha_{1hn} = \beta_{10} + a_{1h},$$

$$\alpha_{2hn} = \beta_{20} + a_{2h}, \text{ and}$$

$$\alpha_{3hn} = \beta_{30} + a_{3h} .$$

Here, β_{00} estimates the average of pre-disaster value in neighborhood *n*. β_{10} estimates the average of housing damage, β_{20} estimating the average home restoration, and β_{30} estimating the average long term recovery rate in neighborhood *n*. a_{0h}, a_{1h}, a_{2h}, and a_{3h} are "random effects," representing the departure of household *h* from the average of neighborhood *n*. They are assumed to be independent normal variables with means of zero.

Level 3 models are:

$$\beta_{00} = \gamma_{00} + b_{0n} ,$$
$$\beta_{10} = \gamma_{10} + b_{1n} ,$$
$$\beta_{20} = \gamma_{20} + b_{2n} , \text{ and}$$
$$\beta_{30} = \gamma_{30} + b_{3n} .$$

Here, γ estimates the grand mean of each level 1 parameter: pre-disaster value, housing damage, home restoration, and the long term recovery rate. In the language of hierarchical models, the values of γ are "fixed effects." b_{0n}, b_{1n}, b_{2n}, and b_{3n} are "random effects," representing the departure of neighborhood *n* from the grand mean. They are assumed to be independent normal variables with means of zero.

Table 5.4. Coding of Independent Variables in Level I Model

Year	*DISASTER*	*RESTORATION*	*LT_RECOVERY*
1992	0	0	0
1993	1	0	0
1994	1	1	0
1995	1	1	1
1996	1	1	2

The estimated variance/covariance matrix and the correlations among the household level random effects ($a_{0h}, a_{1h}, a_{2h}, a_{3h}$) and among the neighborhood level random effects ($b_{0n}, b_{1n}, b_{2n}, b_{3n}$) reflect the extent to which level 1 parameters vary at household level or neighborhood level, and how these parameters correlate with each other at different levels. For example, if, within the same neighborhood, households with higher pre-disaster value tend to have less damage and more rapid restoration and long term recovery, then there would be a negative correlation between the household level random effects a_{0h} and a_{1h}, and positive correlations between a_{0h} and a_{2h}, a_{3h}.

Estimates and Interpretation

Table 5.5 lists the estimated grand mean of pre-disaster home values, disaster damage, restoration rate, and the rate of long term recovery ($\gamma_{00}, \gamma_{10}, \gamma_{20}, \gamma_{30}$), neighborhood- and household-level variations around these averages (i.e. the variance of the *a* and *b* values), and correlations among the pre-disaster value, disaster damage, restoration rate, and the rate of long-term recovery at both household and neighborhood levels (i.e. the correlation among the *a* and *b* values).

The estimates suggest several characteristics regarding housing trajectories. First, the storm caused an average of loss of $31,050 in home value, which was essentially restored in 1994 – a gain of $30,570 in average home value. In the long-term recovery period, housing values increased at a rate of $4,270 per year (This trajectory is plotted in Figure 5-1).

Second, these estimates vary across households and neighborhoods. At the household level – that is, for households in the same neighborhood – the pre-disaster home values have a variance of 828.24. Housing damage has a smaller variance of 427.02, suggesting that homes in the same neighborhood tended to experience similar losses even though their initial values could be very different. The home restoration rate in the same neighborhood has a variance of 538.83, suggesting households had differential ability to restore damage. In the long term recovery period, the variation in home growth rate is considerably smaller (39.70), suggesting home values in the same neighborhood grew at a similar rate during this period.

Table 5.5. Model 1: Housing Trajectories across Neighborhoods and Single-family Households

			Household Level		
			Correlations		
	Grand Mean	Variance	Initial Value	Housing Damage	Housing Restoration
Initial housing value (1992)	60.01***	828.24***			
Housing damage (1992-1993)	-31.05***	427.02***	-0.49***		
Housing value increase per year in the restoration period (1993-1994)	30.57***	538.83***	0.42***	-0.84***	
Housing value increase per year in long-term recovery period (1994-1996)	4.27***	39.70***	0.37***	-0.41***	0.01***

	Neighborhood Level					
		Correlations				
	Variance	Initial Value	Housing Damage	Housing Restoration	Total Variance	% of Variance Between Neighborhoods
Initial housing value (1992)	2135.29***				2963.53	72.05
Housing damage (1992-1993)	654.70***	-0.62***			1081.72	60.52
Housing value increase per year in the restoration period (1993-1994)	484.80***	0.61***	-0.96***		1023.63	47.36
Housing value increase per year in long-term recovery period (1994-1996)	28.43***	0.66***	-0.50***	0.42***	68.13	41.73

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$ (two-tailed test)

At the neighborhood level – that is, between one neighborhood and another – the variances have a pattern similar to the household level. The home restoration rate varied to a considerable extent from neighborhood to neighborhood (484.80), while the variations in home growth in the long term recovery period are significantly smaller (28.43).

Taking variances at household and neighborhood levels as a whole, 72.05% of variances of pre-disaster home values can be accounted for by neighborhood variability, suggesting home values vary more between neighborhoods than within neighborhoods. This is conceivable given the residential segregation in south Miami-Dade County. Homes with similar values tend to cluster together, while home values across neighborhoods can be very different. 60.52% of variances in home damage can be accounted for by neighborhood differences. This is plausible because some neighborhoods in the direct path of hurricane were heavily damaged, while other neighborhoods out of the direct path stayed relatively intact. So housing damage differs to a greater extent from one neighborhood to another than within a particular neighborhood. 47.36% of variances in the home restoration rate are between neighborhoods, while 52.54% are between households, suggesting both household level variables and neighborhood level variables played important roles in determining home restoration. 41.73% of variances in the rate of long term recovery are at the neighborhood level, and 58.27% are at the household level. Similarly, this suggests that both household variables and neighborhood variables are in play when determining long-term housing recovery.

Third, pre-disaster home value and disaster damage affected home restoration and long term recovery. For households within the same neighborhood, homes with higher pre-disaster values lost a larger amount of value. To see this, consider the significant negative correlation (-0.49) between pre-disaster home value and disaster damage.[*] This explains how pre-disaster housing inequality was reduced by the hurricane's impact. Please note that the damage estimation stands for the absolute home value loss for a property. Even though higher valued homes experienced larger amount of value loss, it may well be lower valued homes had a total destruction, while higher valued homes only partially damaged. The correlations between pre-disaster home value and home restoration and the rate of long term recovery are, however, significantly positive, 0.42 and 0.37 respectively. It is a normal expectation that higher income families live in homes with higher values. So, these positive correlations suggest that high income households recovered more rapidly than low income households. Unsurprisingly, housing damage has significantly negative correlations with both home restoration (-0.84) and the rate of long-term recovery (-0.41). Households with higher levels of damage fell behind in both restoration and long-term recovery periods. While home restoration has a significant positive correlation with the rate of long term recovery at the household level, the absolute magnitude of the correlation is very small (0.01). The correlations' pattern at the household level holds at the neighborhood level as well, except that the magnitude of correlations is much stronger at the neighborhood level. For example, the correlation between home restoration and the long term recovery rate is 0.42 at neighborhood level,

[*] Noted that housing damages are negative values in the model. The smaller the negative value, the larger the absolute value loss.

compared to 0.01 at household level. This strong positive correlation suggests that neighborhoods that had a higher level of home restoration continued leading the way in the long term recovery period. Housing inequality between neighborhoods kept increasing in the period following the disaster.

To sum up, estimates for Model 1 suggest the following:

1. Hurricane Andrew reduced pre-disaster housing inequality in the impact area. However, housing inequality resumed during the recovery process.
2. The home restoration rate varied substantially between households and neighborhoods. The rate of long-term recovery varied between households and neighborhoods as well.
3. Homes with higher pre-disaster values had a faster rate of restoration and long-term recovery.
4. Homes with higher levels of damage had a slower rate of restoration and long term recovery.

Model 2: The Effects of Household Characteristics

Model 1 captures the overall variation in housing trajectory following the storm, suggesting that disaster damage, home restoration, and the rate of long term recovery varied substantially across households and neighborhoods. In model 2, we relate some of this variation to households' characteristics.

Specifications

The household variables OWNERSHIP, EYE, EYEWALL, and EDGE are incorporated into level 2 models to predict pre-disaster home value α_{0hn} , disaster damage α_{1hn}, home restoration rate α_{2hn}, and the rate of long term recovery α_{3hn}. In a perfect random scenario, as noted previously, households would be equal with respect to disaster exposure. However, the reality departs from this ideal. Housing in the disaster impact area varies in terms of structural characteristics and building age. To account for this problem, variables BEDROOM, BATH, and HOME_AGE are included in the models as control variables. The models are:

$$\alpha_{0hn} = \beta_{00} + \beta_{01}HOME\_AGE_{hn} + \beta_{02}BEDROOM_{hn} + \beta_{03}BATH_{hn} + \beta_{04}OWNERSHIP_{hn} + a_{0h},$$

$$\alpha_{1hn} = \beta_{10} + \beta_{11}HOME\_AGE_{hn} + \beta_{12}BEDROOM_{hn} + \beta_{13}BATH_{hn} + \beta_{14}OWNERSHIP_{hn} + \beta_{15}EYEWALL_{hn} + \beta_{16}EDGE_{hn} + a_{1h},$$

$$\alpha_{2hn} = \beta_{20} + \beta_{21}HOME\_AGE_{hn} + \beta_{22}BEDROOM_{hn} + \beta_{23}BATH_{hn} + \beta_{24}OWNERSHIP_{hn} + \beta_{25}EYEWALL_{hn} + \beta_{26}EDGE_{hn} + a_{2h}, \text{ and}$$

$$\alpha_{3hn} = \beta_{30} + \beta_{31}HOME\_AGE_{hn} + \beta_{32}BEDROOM_{hn} + \beta_{33}BATH_{hn} + \beta_{34}OWNERSHIP_{hn} + \beta_{35}EYEWALL_{hn} + \beta_{36}EDGE_{hn} + a_{3h}.$$

Here, the β s are the effects of each variable on pre-disaster home value, or disaster damage, or home restoration, or the rate of long-term recovery. Dummy variable EYE is intentionally dropped from the model to avoid multicollinearity. Thus, the homes that were in the path of the hurricane eye are the reference group in this model.

Estimates and Interpretation

Table 5.6 gives estimates which suggest that household characteristics affected housing damage/recovery trajectories.

Before the storm, the average value of owner-occupied housing was $970 lower than rental units after controlling for other variables. Homes with higher age had lower value. Every year increase in home age, home value decreased by $1260. As expected, number of bedrooms and number of bathrooms both had significant positive effect on pre-disaster home value. One additional bedroom increased home value by $563 and one additional bathroom increased home value by $25,380.

Regarding disaster damage, homes in the hurricane eye area, on average, had the greatest value loss, followed by the eye wall area, and then the adjacent edge area. Homes in the hurricane eye wall area experienced $5,370 less value loss than those in the hurricane eye area. Homes in the adjacent edge area experienced $35,270 less damage compared to the hurricane eye area. After controlling housing damage and other factors, the value gap between owned and rental units reversed after the disaster. Owner-occupied homes had an average of $1,850 less damage than rental units. Larger homes had greater losses. One additional bedroom was associated with $3180 more damages and one additional bathroom was associated with $11,000 loss.

Table 5.6. Model 2: Explaining Pre-disaster Housing Value, Damages, Home Restoration and Long Term Housing Recovery by Household Characteristics

	Estimation
Initial housing value (1992)	
Reference Group (Rental Units)	93.17***
Home Age	-1.26***
Num. of Bedrooms	5.63***
Num. of Bathrooms	25.38***
Home Ownership	-0.97**
Housing damage (1992-1993)	
Reference Group (Rental Units & Hurricane Eye)	-54.06***
Home Age	0.65***
Num. of Bedrooms	-3.18***
Num. of Bathrooms	-11.00***
Home Ownership	1.85***
Eye Wall vs. Hurricane Eye	5.37***
Adjacent Edge vs. Hurricane Eye	35.27***
Housing value increase per year in the restoration period (1993-1994)	
Reference Group (Rental Units & Hurricane Eye)	48.25***
Home Age	-0.63***
Num. of Bedrooms	3.14***
Num. of Bathrooms	8.27***
Home Ownership	1.94***
Eye Wall vs. Hurricane Eye	-3.33***
Adjacent Edge vs. Hurricane Eye	-26.64***
Housing value increase per year in long-term recovery period (1994-1996)	
Reference Group (Rental Units & Hurricane Eye)	5.30***
Home Age	-0.04***
Num. of Bedrooms	0.33***
Num. of Bathrooms	2.18***
Home Ownership	-0.95***
Eye Wall vs. Hurricane Eye	1.53***
Adjacent Edge vs. Hurricane Eye	2.33***

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$ (two-tailed test)

The advantage of owner-occupied homes over rental units became even stronger in the restoration period with the former, on average, having a value gain of $1,940 more than the latter. On average, homes in the severely stuck area (hurricane eye) restored $3,330 more than those in moderately struck area (eye wall), and $26,640 more than those in the slightly struck area (adjacent edge). However, when taking the housing damage into account, homes in the hurricane eye area were still worse off by an average of $2,040 ($5,370 – 3,330) and $8,630 ($35,270-26,640) respectively compared to those in the eye wall area and the adjacent edge area. This suggests that the overall gap among areas with different damage levels increased during the restoration period.

In the long-term recovery period, owners' advantage was reduced. The annual value increase of owner-occupied homes was $950 less than rental homes. This may suggest that rental properties were still under reconstruction while owner-occupied units were essentially finished. Given the huge advantage owner-occupied homes had in term of less damage and faster restoration, the inequality between owner-occupied units and rental units remained at a higher level during this period compared to the pre-disaster period. Home values in the moderately damaged area (eye wall) grew $1,530/year faster than those in the severely damaged area (hurricane eye). And, home values in the slightly damaged area (adjacent edge) grew $2,330/year faster than the homes in the hurricane eye area. Clearly, the housing inequality among these three areas continued increasing during this period.

Figure 5.2 plots the average trajectories for owner-occupied homes and rental units in the hurricane eye area (EYEWALL = 0, EDGE = 0), setting other variables at their sample means (HOME_AGE = 22.31, BEDROOM = 3.28, BATHROOM = 1.94). At the beginning (1992), owner-occupied housing was somewhat lower in value than rental units. This relationship reversed after the storm (1993). In the restoration period, owner-occupied housing had a clear advantage over rental units (1993-1994) when the gap between these two groups became significantly larger. In the long-term recovery period, while rental units increased at a slightly faster rate, the gap remained large until 1996.

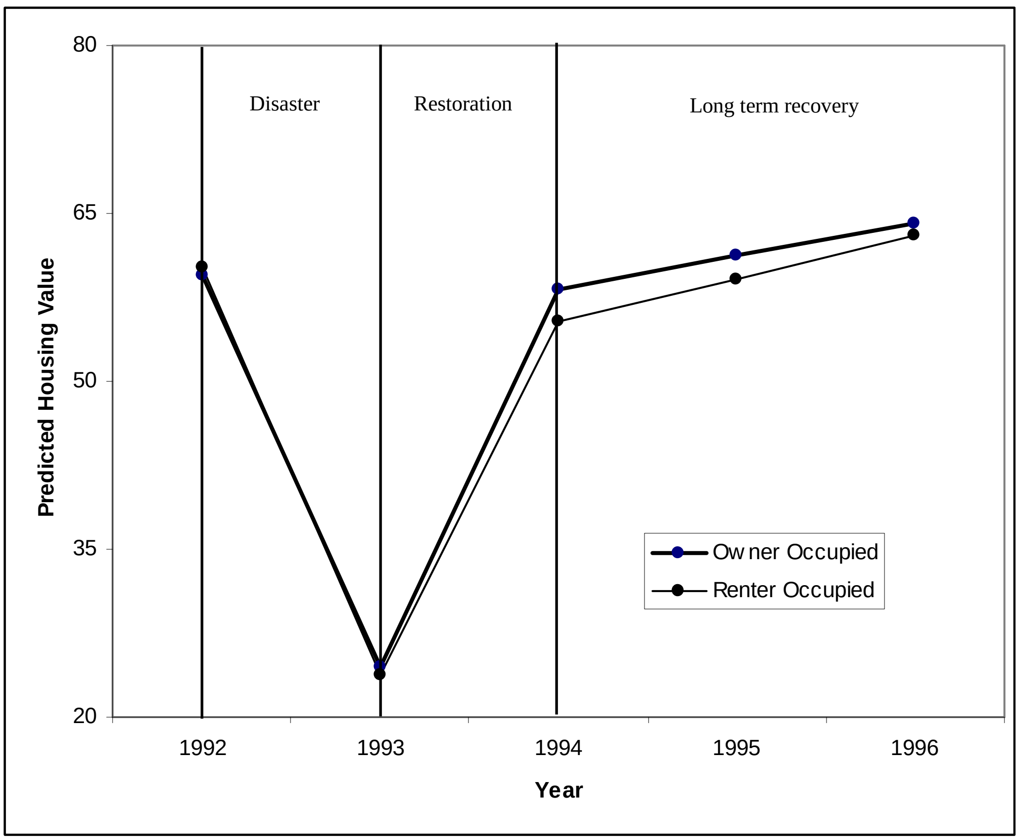

Figure 5.2. Predicted Values of Single Family Homes by Home Ownership with Other Variables Held Constant

Table 5.7 lists the variances and correlations between estimates at both the household and neighborhood levels. Compared to Model 1, the residual variances for pre-disaster housing value, disaster damage, home restoration, and the long-term recovery rate reduced by 12% to 46%. Specifically, 46% of variance within pre-disaster home value, 31% variance in disaster damage, 24% of variance within home restoration, and 12% variance within the long-term recovery rate are explained by household variables incorporated in Model 2. Clearly, the variables included in this model have the best ability to explain the variation within pre-disaster home values, followed by housing damage and home restoration. However, they only have limited ability to explain the home value increase in the long term recovery period. This is conceivable because the impact of Hurricane Andrew on housing value attainment decreased as time went along. Housing value change may well be influenced by other variables not measured in this analysis in the long run. The correlations at neighborhood level have a pattern similar to Model 1, except for a reduced magnitude. Home value shows significant positive correlations with home restoration rate and the rate of long-term recovery at both the household and neighborhood levels. Home restoration had a significant positive correlation with the long term recovery rate, suggesting that neighborhoods that restored at a higher rate kept grew faster than other neighborhoods. The housing inequality across neighborhoods were increasing following the disaster. At household level, the correlation between housing restoration and the long term recovery rate became significantly negative (-0.03) which is different from what showed in Model 1. This suggests that, in the same neighborhood, homes that lagged behind during the restoration period caught up in the long term recovery period after controlling homeownership, housing structural characteristics, home age, and damage level. In other words, homes in the same neighborhood became less variable in the long run.

In short, Model 2 suggests the following:

1. Owner-occupied housing experienced less damage and faster home restoration compared to rental units.
2. Housing inequality between owner-occupied housing and rental units increased slightly during the restoration period, but then decreased in the following long term recovery period.
3. Housing inequality among the severely damaged areas (hurricane eye), the moderately damaged area (eye wall) and the slightly damaged area (adjacent edge) increased in the recovery period as the homes in severely damaged area lagged behind during recovery.

Table 5.7. Residual Variances and Correlations Matrix for Model 2

		Household Level		
		Correlations		
	Variance	Initial Value	Housing Damage	Housing Restoration
Initial housing value (1992)	550.36***			
Housing damage (1992-1993)	369.97***	-0.37***		
Housing value increase per year in the restoration period (1993-1994)	494.58***	0.33***	-0.82***	
Housing value increas per year in long-term recovery period (1994-1996)	38.36***	0.34***	-0.38***	-0.03***

		Neighborhood Level				
		Correlations				
	Variance	Initial Value	Housing Damage	Housing Restoration	Total Variance	R Square
Initial housing value (1992)	1050.74***				1601.1	0.46
Housing damage (1992-1993)	378.49***	-0.49***			748.46	0.31
Housing value increase per year in the restoration period (1993-1994)	283.61***	0.44***	-0.94***		778.19	0.24
Housing value increase per year in long-term recovery period (1994-1996)	21.57***	0.53***	-0.41***	0.27***	59.93	0.12

Note: R square is the fraction by which total variance has decreased from model 1. This is the proportion of variance that can be explained by independent variables in model 2.
* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$ (two-tailed test)

Model 3: The Effects of Post-disaster Home Sales

This model estimates the effects of post-disaster home sales. Our expectation was that post-disaster home sales slowed down home restoration as well as long-term housing recovery. When housing was transferred repeatedly, it is conceivable that repairs and reconstruction were delayed.

Specifications

The number of home sales during the restoration period (SALE9294) is added into the model for the home restoration rate α_{2hn}; number of home sales during the long term recovery period (SALE9496) is added into the model for the long-term recovery rate α_{3hn}. These two equations then become:

$$\alpha_{2hn} = \beta_{20} + \beta_{21} HOME\_AGE_{hn} + \beta_{22} BEDROOM_{hn} + \beta_{23} BATHROOM_{hn} + \beta_{24} OWNERSHIP_{hn} + \beta_{25} EYEWALL_{hn} + \beta_{26} EDGE_{hn} + \beta_{27} SALE9294_{hn} + a_{2h},$$

and

$$\alpha_{3hn} = \beta_{30} + \beta_{31} HOME\_AGE_{hn} + \beta_{32} BEDROOM_{hn} + \beta_{33} BATHROOM_{hn} + \beta_{35} OWNERSHIP_{hn} + \beta_{36} EYEWALL_{hn} + \beta_{37} EDGE_{hn} + \beta_{38} SALE9496_{hn} + a_{3h}.$$

Estimates and Interpretation

Estimates are listed in Table 5.8. Compared to Model 2, the key estimates are substantially unchanged. The results continue to suggest that owner-occupied housing had a significantly higher restoration rate than rental units (an average of $1,570) net of other variables. In the long-term recovery period, the advantage of owner-occupied housing attenuated – with the average home value of rental units increasing $980/year faster than owner-occupied homes. However, the overall inequality still remained between owner-occupied housing and rental units at the end of 1996. Housing inequality in areas with different hurricane severity kept increasing in the recovery period. In addition, the estimates of this model show that one additional home sale in the restoration period reduced home restoration by $1,390. In the long-term recovery period, repeated home sales continued their negative effect on housing recovery, though to a much lesser extent. One additional home sale reduced home value by $210 per year in this period. Clearly, home sales significantly slowed the overall recovery process, especially during the restoration period.

Table 5.9 lists the estimated residual variances and the corresponding correlation matrix. The correlations' pattern remains the same as those in Model 2. Pre-disaster home value had significant positive correlations with both home restoration and the long term recovery at both household and neighborhood levels. Within the same neighborhood, home restoration had a significantly negative correlation with the long term recovery rate, suggesting that homes in the same neighborhoods became similar in the long run. On the other hand, home restoration and the long term recovery rate had a significantly positive correlation at the neighborhood level. Housing inequality between the leading neighborhoods and the laggard neighborhoods continued increasing during the recovery period.

Table 5.8. Model 3: Explaining Pre-disaster Housing Value, Damages, Home Restoration and Long Term Housing Recovery by Household Characteristics

	Estimation
Initial housing value (1992)	
Reference Group (Rental Units)	93.17***
Home Age	-1.25***
Num. of Bedrooms	5.63***
Num. of Bathrooms	25.38***
Home Ownership	-0.97**
Housing damage (1992-1993)	
Reference Group (Rental Units & Hurricane Eye)	-54.06***
Home Age	0.65***
Num. of Bedrooms	-3.19***
Num. of Bathrooms	-11.00***
Home Ownership	1.85***
Eye Wall vs. Hurricane Eye	5.37***
Adjacent Edge vs. Hurricane Eye	35.28***
Housing value increase per year in the restoration period (1993-1994)	
Reference Group (Rental Units & Hurricane Eye)	49.01***
Home Age	-0.64***
Num. of Bedrooms	3.15***
Num. of Bathrooms	8.30***
Home Ownership	1.57***
Eye Wall vs. Hurricane Eye	-3.36***
Adjacent Edge vs. Hurricane Eye	-26.73***
Num. of Home Sales between 1992 and 1994	-1.39***
Housing value increase per year in long-term recovery period (1994-1996)	
Reference Group (Rental Units & Hurricane Eye)	5.33***
Home Age	-0.04***
Num. of Bedrooms	0.33***
Num. of Bathrooms	2.18***
Home Ownership	-0.98***
Eye Wall vs. Hurricane Eye	1.53***

Table 5.8. *Continued*

	Estimation
Adjacent Edge vs. Hurricane Eye	2.34***
Num. of Home Sales in 1995 and 1996	-0.21***

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$ (two-tailed test)

Table 5.9. Residual Variances and Correlations Matrix for Model 3

Household Level

	Variance	Correlations: Initial Value	Correlations: Housing Damage	Correlations: Housing Restoration
Initial housing value (1992)	550.35***			
Housing damage (1992-1993)	369.98***	-0.37***		
Housing value increase per year in the restoration period (1993-1994)	494.40***	0.33***	-0.83***	
Housing value increase per year in long-term recovery period (1994-1996)	38.40***	0.34***	-0.38***	-0.03***

Neighborhood Level

	Variance	Correlations: Initial Value	Correlations: Housing Damage	Correlations: Housing Restoration	Total Variance	R Square
Initial housing value (1992)	1050.78***				1601.13	0.46
Housing damage (1992-1993)	378.36***	-0.49***			748.34	0.31
Housing value increase per year in the restoration period (1993-1994)	284.32***	0.45***	-0.94***		778.72	0.24
Housing value increase per year in long-term recovery period (1994-1996)	21.58***	0.53***	-0.41***	0.27***	59.98	0.12

Note: R square is the fraction by which total variance has decreased from model 1. This is the proportion of variance that can be explained by independent variables in model 3.
* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$ (two-tailed test)

Model 4: The Effects of Neighborhood Level Variables

As shown in previous models, pre-disaster home values, housing damage, the home restoration rate and long term recovery rate varied from one neighborhood to another. In this model, we relate the remaining unexplained variances in these variables to certain key neighborhood characteristics.

Specifications

Median household income (MED_INCOME), percentage of Hispanics (PER_HISP), percentage of non-Hispanic Blacks (PER_BLACK), and percentage of White (PER_WHITE) are added into the models for pre-disaster home value α_{0hn}, housing damage α_{1hn}, the home restoration rate α_{2hn}, and the long-term recovery rate α_{3hn}. PER_WHITE is treated as a reference category in this model. It is dropped to avoid the problem of multicollinearity.

For the pre-disaster value α_{0hn}, the equation becomes[*]:

$$\alpha_{0hn} = \gamma_{00} + \gamma_{01}MED\_INCOME_n + \gamma_{02}PER\_HISP_n + \gamma_{03}PER\_BLACK_n + \beta_{01}HOME\_AGE_{hn}$$
$$+ \beta_{02}OWNERSHIP_{hn} + \beta_{03}EYEWALL_{hn} + \beta_{04}EDGE_{hn} + \beta_{05}SALE9294_{hn} + b_{2n} + a_{2h}.$$

To recall, the γ s refer to the effects of neighborhood variables, and β s stand for the effects of household level variables.

For housing damage α_{1hn}, the equation becomes:

[*] For brevity, level II model and level III model are combined here. For a full specification of models at different levels, please refer to the Appendix

$$\alpha_{1hn} = \gamma_{10} + \gamma_{11} MED\_INCOME_n + \gamma_{12} PER\_HISP_n + \gamma_{13} PER\_BLACK_n + \beta_{11} HOME\_AGE_{hn}$$
$$+ \beta_{12} OWNERSHIP_{hn} + \beta_{13} EYEWALL_{hn} + \beta_{14} EDGE_{hn} + \beta_{15} SALE9294_{hn} + b_{2n} + a_{2h} .$$

For the home restoration rate α_{2hn}, the equation becomes:

$$\alpha_{2hn} = \gamma_{20} + \gamma_{21} MED\_INCOME_n + \gamma_{22} PER\_HISP_n + \gamma_{23} PER\_BLACK_n + \beta_{21} HOME\_AGE_{hn}$$
$$+ \beta_{22} OWNERSHIP_{hn} + \beta_{23} EYEWALL_{hn} + \beta_{24} EDGE_{hn} + \beta_{25} SALE9294_{hn} + b_{2n} + a_{2h} .$$

For the rate of long-term recovery α_{3hn}, the equation becomes:

$$\alpha_{3hn} = \gamma_{30} + \gamma_{31} MED\_INCOME_n + \gamma_{32} PER\_HISP_n + \gamma_{33} PER\_BLACK_n + \beta_{31} HOME\_AGE_{hn}$$
$$+ \beta_{32} OWNERSHIP_{hn} + \beta_{33} EYEWALL_{hn} + \beta_{34} EDGE_{hn} + \beta_{35} SALE9294_{hn} + b_{3n} + a_{3h} .$$

Estimates and Interpretation

Table 5.10 lists the estimates for this model. Compared to Models 1, 2, and 3, the key findings on household variables remain substantially unchanged. Regarding neighborhood level variables, median household income had a significantly positive effect on pre-disaster home value. Every thousand dollars increase of the median household income of a neighborhood increased home value by $910. Surprisingly, neighborhood minority concentration, both non-Hispanic Blacks and Hispanics, had a significantly positive effect on pre-disaster home values. This is different from previous research that suggested high level of minority concentration has negative effect on home values (Stinchcombe, 1965; Logan & Molotch, 1987; South & Crowder, 1997). Considering the tax appraisal process in Miami-Dade, the initial property tax assessments of 1992 were completed before Hurricane Andrew hit on August 24th 1992.

It may well be that many homeowners received a property appraisal notice that was far above the value of damaged home. Despite this incredible inconsistency, Miami-Dade County kept the assessments of 1992 and promised to make appropriate adjustments in the following year to reflect home damage. However, it could not rule out the possibility of tax appraisal values being adjusted for some properties in 1992. The lower pre-disaster home value of Anglo concentrated neighborhoods shown in this model may reveal the fact that tax assessments in such neighborhoods were systematically adjusted downward in 1992.

Table 5.10. Model 4: Explaining Pre-disaster Housing Value, Damages, Home Restoration and Long Term Housing Recovery by Household and Neighborhood Characteristics

	Estimation
Initial housing value (1992)	
Reference Group (Rental Units & Percentage of White Population)	91.34***
Home Age	-1.20***
Num. of Bedrooms	5.51***
Num. of Bathrooms	24.98***
Home Ownership	-1.19***
Median Household Income	0.91***
Percentage of Hispanic Population	0.10***
Percentage of Non-Hispanic Black Population	0.12***
Housing damage (1992-1993)	
Reference Group (Rental Units & Percentage of White Population & Eye)	-52.15***
Home Age	0.65***
Num. of Bedrooms	-3.20***
Num. of Bathrooms	-10.86***
Home Ownership	1.91***
Eye Wall vs. Hurricane Eye	1.94***
Adjacent Edge vs. Hurricane Eye	32.07***
Median Household Income	-0.02

Table 5.10. *Continued*

Percentage of Hispanic Population	*0.16******
Percentage of Non-Hispanic Black Population	0.08***
Housing value increase per year in the restoration period (1993-1994)	
Reference Group (Rental Units & Percentage of White Population & Eye)	47.55***
Home Age	-0.66***
Num. of Bedrooms	3.17***
Num. of Bathrooms	7.98***
Home Ownership	1.48***
Eye Wall vs. Hurricane Eye	-1.26***
Adjacent Edge vs. Hurricane Eye	-24.27***
Num. of Home Sales between 1992 and 1994	-1.42***
Median Household Income	0.05**
Percentage of Hispanic Population	-0.14***
Percentage of Non-Hispanic Black Population	-0.08***
Housing value increase per year in long-term recovery period (1994-1996)	
Reference Group (Rental Units & Percentage of White Population & Eye)	5.09***
Home Age	-0.03***
Num. of Bedrooms	0.32***
Num. of Bathrooms	2.18***
Home Ownership	-0.99***
Eye Wall vs. Hurricane Eye	1.63***
Adjacent Edge vs. Hurricane Eye	2.13***
Num. of Home Sales in 1995 and 1996	-0.21***
Median Household Income	0.07***
Percentage of Hispanic Population	0.03***
Percentage of Non-Hispanic Black Population	-0.06***

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$ (two-tailed test)

The estimates of housing damage suggest that median household income had no effect on home value loss (-0.02 is not significant). Homes in minority populated neighborhoods experienced less dollar value loss than homes in Anglo neighborhoods.

To see this, consider the significant positive effects of non-Hispanic Blacks and Hispanics on housing damage. Every percent increase of Hispanic concentration in a neighborhood resulted in $160 less home loss. Every percent increase of Black concentration resulted in $80 less home loss. In the restoration period, median household income had a significant positive effect with every additional thousand dollars associating $50 increase in home restoration. The disadvantage of locating in minority populated neighborhoods was significant in this period. Every percent increase of Hispanics in a neighborhood slowed home restoration by an average of $140 and every percent increase of Blacks slowed down the restoration by an average of $80. These negative effects can accumulate to a considerable level for the predominantly minority neighborhoods. For example, homes in a neighborhood with 60% Hispanics restored an average of $7,000 less than those in a neighborhood that had 10% Hispanics. Homes in a neighborhood with 90% Blacks restored $6,400 slower than those in a neighborhood of 10% Blacks. Noted that the average home value in neighborhoods with 90% and more Blacks was only $27,418 before the disaster occurred, $6,400 could mean a substantial proportion of some homes in these areas. In the long term recovery period, median household income continued its positive effect. The concentration of Hispanics in a neighborhood began showing a positive effect on home growth. Every percent increase of Hispanics was associated with an additional $30/year home value increase. The positive effect of Hispanic concentration in the long term recovery period suggests that although homes in predominantly Hispanic neighborhoods were restored slower in the early recovery period, they began to pick up in the following years. The negative effect of non-Hispanic Blacks, however still remained significant during this period. Every percent increase of Blacks in a neighborhood reduced home value growth by $60/year.

In summary, median household income had a significant positive effect on housing recovery with neighborhoods with higher income neighborhoods leading the way in both restoration period and the long term recovery period. Clearly, housing inequality between neighborhoods with different income levels increased following Hurricane Andrew. While neighborhood minority composition – both Hispanics and Blacks – had significant negative effects on housing recovery in the restoration period, Hispanic concentration began having a positive effect in the long term recovery period, while the effect of Blacks concentration still remain significantly negative.

Table 5.11 presents the residual variances and the corresponding correlation matrix. Compared to Model 3, neighborhood income and race/ethnicity composition explained an additional 9% of variances in pre-disaster home values, an additional 1% of variances in housing damage, an additional 1% of variances in the home restoration rate, and an additional 2% of variances in the rate of long-term housing recovery. Overall, 55% of variances in pre-disaster home values, 32% of variance in housing damage, 25% of variance in home restoration, and 14% of variance in the long term recovery rate were explained by the independent variables included in this model. The different R squares reflect that the independent variables have the best ability to explain pre-disaster home values, followed by housing damage and home restoration. However, these variables have a relatively limited ability to explain the housing value attainment in the long run. This is probably because other unmeasured variables may also play an important role in determining housing value increase when the impact of Hurricane Andrew faded away. Again, the correlation matrix reflects the same pattern as in Models 2 and 3. Pre-disaster home value had significant positive correlations with both home restoration and the long term recovery at both household and neighborhood levels. Within the same neighborhood, home restoration had a significantly negative correlation with the long term recovery rate. It suggests that while homes in the same neighborhoods varied in terms of recovery progress with some leading the way and other falling behind, those lagging behind caught up in the long run and homes in the same neighborhood became less variable. On the other hand, home restoration and the long term recovery rate had a significantly positive correlation at the neighborhood level. Housing inequality between the leading neighborhoods and the laggard neighborhoods continued increasing during the recovery period.

Table 5.11. Residual Variances and Correlations Matrix of Model 4

		Household Level		
		Correlations		
	Variance	Initial Value	Housing Damage	Housing Restoration
Initial housing value (1992)	551.19***			
Housing damage (1992-1993)	369.90***	-0.36***		
Housing value increase per year in the restoration period (1993-1994)	494.28***	0.33***	-0.83***	
Housing value increase per year in long-term recovery period (1994-1996)	38.39***	0.34***	-0.38***	-0.03***

		Neighborhood Level				
		Correlations				
	Variance	Initial Value	Housing Damage	Housing Restoration	Total Variance	R Square
Initial housing value right before the disaster (1992)	789.98***				2963.53	0.55
Housing damage (1992-1993)	370.29***	-0.52***			1081.72	0.32
Housing value increase per year in the restoration period (1993-1994)	274.94***	0.44***	-0.94***		1023.63	0.25
Housing value increase per year in long-term recovery period (1994-1996)	20.01***	0.48***	-0.41***	0.25***	68.13	0.14

Note: R square is the fraction by which total variance has decreased from model 1. This is the proportion of variance that can be explained by independent variables in model 4.
* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$ (two-tailed test)

Model 5: Cuban-Hispanics vs. Non-Cuban Hispanics

To estimate the effects of Cuban-Hispanics and non-Cuban Hispanics, the percentages of Cuban-Hispanics (PER_CUBAN) and non-Cuban Hispanics (PER_N_CUBAN) in neighborhoods, replace the percentage of Hispanics (PER_HISP), in this model.

Specifications

For the pre-disaster home value α_{0hn}, the equation becomes:

$$\alpha_{0hn} = \gamma_{00} + \gamma_{01}MED\_INCOME_n + \gamma_{02}PER\_CUBAN_n + \gamma_{03}PER\_N\_CUBAN_n + \gamma_{04}PER\_BLACK_n + \beta_{01}HOME\_AGE_{hn} + \beta_{02}OWNERSHIP_{hn} + \beta_{03}EYEWALL_{hn} + \beta_{04}EDGE_{hn} + \beta_{05}SALE9294_{hn} + b_{2n} + a_{2h}.$$

For housing damage α_{1hn}, the equation becomes:

$$\alpha_{1hn} = \gamma_{10} + \gamma_{11}MED\_INCOME_n + \gamma_{12}PER\_CUBAN_n + \gamma_{13}PER\_N\_CUBAN_n + \gamma_{14}PER\_BLACK_n + \beta_{11}HOME\_AGE_{hn} + \beta_{12}OWNERSHIP_{hn} + \beta_{13}EYEWALL_{hn} + \beta_{14}EDGE_{hn} + \beta_{15}SALE9294_{hn} + b_{2n} + a_{2h}.$$

For the home restoration rate α_{2hn}, the equation becomes:

$$\alpha_{2hn} = \gamma_{20} + \gamma_{21}MED\_INCOME_n + \gamma_{22}PER\_CUBAN_n + \gamma_{23}PER\_N\_CUBAN_n + \gamma_{24}PER\_BLACK_n + \beta_{21}HOME\_AGE_{hn} + \beta_{22}OWNERSHIP_{hn} + \beta_{23}EYEWALL_{hn} + \beta_{24}EDGE_{hn} + \beta_{25}SALE9294_{hn} + b_{2n} + a_{2h}.$$

For the rate of long-term recovery α_{3hn}, the equation becomes:

$$\alpha_{3hn} = \gamma_{30} + \gamma_{31}MED\_INCOME_n + \gamma_{32}PER\_CUBAN_n + \gamma_{33}PER\_N\_CUBAN_n + \gamma_{34}PER\_BLACK_n + \beta_{31}HOME\_AGE_{hn} + \beta_{32}OWNERSHIP_{hn} + \beta_{33}EYEWALL_{hn} + \beta_{34}EDGE_{hn} + \beta_{35}SALE9294_{hn} + b_{3n} + a_{3h}.$$

Estimates and Interpretation

As listed in Table 5.12, estimates of other variables remain essentially unchanged compared to Model 4. In addition, this model shows that the concentration of Cuban-Hispanics and non-Cuban Hispanics did show different effects on pre-disaster home value, disaster damage and housing recovery. Neighborhood Blacks composition and non-Cuban Hispanics composition had significant positive effect on pre-disaster home value, while Cuban-Hispanics concentration had a negative (non-significant) effect. Again, (recall Model 4), this is different from previous research suggesting that neighborhood minority composition, especially Blacks, has a negative effect on home values. Our results in this model may reveal the fact that Cuban-Hispanics and Anglos had their property tax assessments adjusted downward in 1992 to reflect the disaster damage. However, the initial tax assessments which were completed before Hurricane Andrew were maintained for Blacks and non-Cubans.

Regarding housing damage, higher levels of Cuban, non-Cuban Hispanic and Black concentration in a neighborhood are all associated with lower damage. Note that the estimated damage stands for the absolute value loss. It may well be that some low-valued homes experienced total destruction even though their absolute value loss was small. In the restoration period, neighborhoods with higher proportion of Cuban, non-Cuban Hispanic, and Black all had negative effects. Every percent increase of Blacks slowed home restoration by $70, and it was $170 and $110, respectively, for every percent increase of Cuban Hispanics and non-Cuban Hispanics. Given the residential segregation in the study area, especially for Blacks, these negative effects could accumulate to great levels for those highly segregated neighborhoods. For example, homes in a neighborhood with 90% of Blacks restored an average of $5,600 compared to those in a neighborhood with 10% of Blacks. It is somewhat surprising that neighborhood Cuban composition had the greatest negative effect on home restoration as previous literature suggested that Cubans had advantages over non-Cuban Hispanics and non-Hispanic Blacks in reaching housing recovery (Peacock and Girard 1997). The negative effect of Cuban Hispanics, however, quickly diminished and became significantly positive during the long-term recovery period. This suggests that while homes in Cuban neighborhoods restored slower, they began to pick up as recovery process went along. The effects of Blacks, however, still remained significantly negative. Specifically, every percent increase of neighborhood Cuban composition increased home value growth by $50/year. Every percent increase of Blacks slowed down home value growth by $50/year. The effect of non-Cuban Hispanics composition was also positive, not significant, though. Every percent increase increased home value growth by $10/year.

Table 5.12. Model 5: Explaining Pre-disaster Housing Value, Damages, Home Restoration and Long Term Housing Recovery by Household and Neighborhood Characteristics

	Model 5
Initial housing value (1992)	
Reference Group (Rental Units & Percentage of White Population)	91.46***
Home Age	-1.20***
Num. of Bedrooms	5.51***
Num. of Bathrooms	24.97***
Home Ownership	-1.18***
Median Household Income	0.94***
Percentage of Non-Hispanic Black Population	0.13***
Percentage of Cuban-Hispanic Population	-0.07
Percentage of Non-Cuban Hispanic Population	0.25***
Housing damage (1992-1993)	
Reference Group (Rental Units & Percentage of White Population & Eye)	-52.35***
Home Age	0.64***
Num. of Bedrooms	-3.20***
Num. of Bathrooms	-10.87***
Home Ownership	1.91***
Eye Wall vs. Hurricane Eye	2.39***
Adjacent Edge vs. Hurricane Eye	32.45***
Median Household Income	-0.02
Percentage of Non-Hispanic Black Population	0.08***
Percentage of Cuban-Hispanic Population	0.12***
Percentage of Non-Cuban Hispanic Population	0.19***
Housing value increase per year in the restoration period (1993-1994)	
Reference Group (Rental Units & Percentage of White Population & Eye)	47.65***
Home Age	-0.63***
Num. of Bedrooms	3.19***
Num. of Bathrooms	7.96***
Home Ownership	1.48***
Eye Wall vs. Hurricane Eye	-1.29***
Adjacent Edge vs. Hurricane Eye	-24.31***

Table5.12. *Continued*

Num. of Home Sales between 1992 and 1994	*-1.43*****
Median Household Income	0.06**
Percentage of Non-Hispanic Black Population	-0.07***
Percentage of Cuban-Hispanic Population	-0.17***
Percentage of Non-Cuban Hispanic Population	-0.11***
Housing value increase per year in long-term recovery period (1994-1996)	
Reference Group (Rental Units & Percentage of White Population & Eye)	5.14***
Home Age	-0.03***
Num. of Bedrooms	0.31***
Num. of Bathrooms	2.18***
Home Ownership	-0.99***
Eye Wall vs. Hurricane Eye	1.46***
Adjacent Edge vs. Hurricane Eye	1.94***
Num. of Home Sales in 1995 and 1996	-0.21***
Median Household Income	0.07***
Percentage of Non-Hispanic Black Population	-0.05***
Percentage of Cuban-Hispanic Population	0.05***
Percentage of Non-Cuban Hispanic Population	-0.01

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$ (two-tailed test)

Table 5.13 provides the estimated variances and the correlation matrix for this model. Of course, the percentages of explained variances remain exactly same as in Model 4 because no additional explanatory information is added into the model when simply splitting PER_HISP into two variables: PER_CUBAN and PER_N_CUBAN. 46% of variances in pre-disaster home values, 68% of variances in disaster damages, 75% of variances in the home restoration rate, and 86% of variances in the rate of long term housing recovery still remain unexplained in our models. The correlation matrix had a pattern similar to that shown in Model 4. Pre-disaster home value had a significant negative correlation with disaster damage suggesting that higher valued homes experienced more absolute home value loss. On the other hand, pre-disaster home value had significant positive correlations with home restoration and the long term recovery, suggesting that higher valued homes had faster home restoration and recovery. The negative correlation between home restoration and the long term recovery rate at the household level – that is, for homes in the same neighborhood – suggested that homes within a particular neighborhood became less variable in the long run in spite of some short-term variation. On the other hand, the positive correlation between these two variables at the neighborhood level suggested that neighborhoods that led the way in the restoration period also recovery faster in the long term recovery period. Clearly, homes in different neighborhoods became more variable in the long run.

Summary

The overall single family housing recovery took two years to finish in south Miami-Dade County following Hurricane Andrew. The average home value, experiencing a 50.3% loss because of the hurricane damage, returned to its pre-disaster level in 1994. However, the average recovery process did not apply to each individual household. Two years after Hurricane Andrew (1994), 33% of households had not reached their pre-event housing status. Four years after (1996), 16% of households were still below their pre-event home values.

Table 5.13. Residual Variances and Correlations Matrix of Model 5

	Household Level			
		Correlations		
	Variance	Initial Value	Housing Damage	Housing Restoration
Initial housing value (1992)	551.16***			
Housing damage (1992-1993)	369.91***	-0.36***		
Housing value increase per year in the restoration period (1993-1994)	494.28***	0.33***	-0.83***	
Housing value increase per year in long-term recovery period (1994-1996)	38.40***	0.34***	-0.38***	-0.03***

	Neighborhood Level					
		Correlations				
	Variance	Initial Value	Housing Damage	Housing Restoration	Total Variance	R Square
Initial housing value (1992)	788.05***				2963.53	0.55
Housing damage (1992-1993)	369.61***	-0.52***			1081.72	0.32
Housing value increase per year in the restoration period (1993-1994)	274.78***	0.44***	-0.94***		1023.63	0.25
Housing value increase per year in long-term recovery period (1994-1996)	19.89***	0.48***	-0.41***	0.25***	68.13	0.14

Note: R square is the fraction by which total variance has decreased from model 1. This is the proportion of variance that can be explained by independent variables in model 5.
* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$ (two-tailed test)

The Hierarchical Linear Modeling (HLM) revealed the pattern of variations in housing recovery across households and neighborhoods. Owner occupied housing recovered faster than rental units in the early recovery period (1992-1994). Rental units began to pick up as the recovery process went along (1994-1996). Post disaster home sales, especially those occurred immediately following the event, significantly slowed housing recovery process. Neighborhood income level had a significant positive effect on housing recovery throughout the period. Neighborhood race/ethnicity composition had effect on recovery process. Homes in predominantly Hispanic neighborhood restored slower than those in predominantly White neighborhoods in the early recovery period (1992-1994). But they began to pick up as the recovery process went along (1994-1996). Neighborhood Black composition had significant negative effect on housing recovery throughout the whole period. When examining Cuban-Hispanics and non-Cuban Hispanics separately, Cubans did show a different effect on housing recovery from non-Cubans. Although neighborhood Cuban composition had a negative effect on housing recovery in the early period following the event (1992-1994), the negative effect quickly disappeared and became positive between 1994 and 1996. On the other hand, neighborhood non-Cuban composition had a negative effect on housing recovery through out the whole post-disaster period. Although not explicitly hypothesized, our data analysis also suggested that hurricane damage reduced housing inequality in the impact area right after the event. However, the pre-disaster pattern was reproduced in the recovery period. In fact, housing inequality across households and neighborhoods even went up to a higher level during the recovery process. In addition, housing inequality among the severely damaged area (Hurricane Eye), moderately damaged area (Eye Wall) and the slightly damaged area (Adjacent Edge) increased in the recovery period with homes in the heavily impact area falling further behind.

CHAPTER VI

DISCUSSIONS AND CONCLUSIONS

Discussions

This research addresses a critical gap in disaster recovery literature by systematically examining housing recovery processes following a major natural disaster. With a longitudinal dataset, descriptive statistics, intercorrelations, and the hierarchical linear modeling (HLM) were applied to answer two research questions: (1) what is the housing recovery process after Hurricane Andrew in Miami-Dade County, and (2) how does housing recovery vary across households and neighborhoods? Regarding the first question, our findings suggest that Hurricane Andrew caused extensive housing damage in the impact area, rendering an average of 50.4% loss of pre-disaster home values. Two years after the storm (1994), the average home value returned to its pre-disaster level. In the subsequent two years –1995 and 1996-- the average home value continued growing, representing a 7.6% and 14.9% gain, respectively, over the pre-disaster averages. This "average" recovery process, however, was clearly not representative of all affected households. Two years after the disaster (1994), 32% of 56,288 households (18,013) had not reached their pre-disaster levels. Three years later (1995), the percentage of un-recovered households had dropped to 21% and four years later (1996), it had dropped to 16%.

These analyses reveal that the recovery process varied significantly from one household to another. Our analysis also indicates that housing recovery varied significantly across neighborhoods with some areas leading and others falling behind.

Although Hurricane Andrew's extensive damage initially reduced pre-disaster housing inequality in south Miami-Dade County, this inequality resumed during the recovery period, and returned to a higher level four years after the storm. Previous studies suggested that the community impact of natural disasters disappears within a decade (Friesma et al., 1979; Wright et al., 1979). Our results showed that the impact of hurricane damage on housing recovery lasted at least more than four years.

With regard to the second research question, our analysis found that household characteristics and neighborhood characteristics are important factors in determining the recovery process. Hypothesis 1 is supported. Owner-occupied single family housing did show more rapid recovery than rental units, especially in the early recovery period (before 1994). This is consistent with the observations of previous research which concluded that rental properties often take significantly longer to rebuild (Bolin, 1986, 1993; Comerio et al., 1994).

Hypothesis 2 is supported by finding that home sales were very active after Hurricane Andrew in Miami-Dade County. Home sales, especially those occurring in the years immediately following the disaster, significantly slowed the housing recovery process. One plausible explanation is that Hurricane Andrew reinforced the ongoing out-migration of Anglos in south Miami-Dade County as suggested by Morrow and Peacock (1997). The positive correlations between number of home sales and the percentage of White population in a neighborhood are consistent with this hypothetical explanation. With such an intensive disaster, some home owners may have just sold their damaged houses, taken their insurance settlements and immigrated to other areas they may have been contemplating before the disaster. In addition, we cannot rule out the possibility that some property owners were forced to sell their homes because they did not have the ability to repair the damaged homes. The strong negative correlations between number of home sales and home ownership provide evidence for this argument. Research by Bolin (1986, 1993) and Comerio et al. (1994) documented that landlords of rental units often did not have sufficient resources and incentives to repair damaged rental properties.

Hypothesis 3 is supported. Our findings suggest neighborhood racial/ethnic composition matters during the housing recovery process. Considering all Hispanics as a group, the concentration of minorities in a neighborhood (both Blacks and Hispanics), had a significant negative effect on housing recovery. In addition, this negative effect was especially strong in the early recovery period (before 1994). Clearly, homes located in neighborhoods with a high minority representation recovered at a much slower rate than areas with a high level of White concentration.

Hypothesis 4 is also supported. Neighborhood median household income had a positive effect on housing recovery. Homes in higher income neighborhoods not only led the way in the restoration period, their advantages were further strengthened in the long term recovery period. As a result, housing inequality between neighborhoods at different income levels increased during the recovery period. This finding is consistent with previous research on household recovery which suggested that income is an important determinant of household recovery (Bolin, 1986, 1993; Bolin & Bolton, 1983; Bolin & Stanford, 1991, 1997; Phillips, 1993).

The evidence for Hypothesis 5 is mixed. When considering Cubans and non-Cubans as two separate groups, the neighborhoods with a high a percentage of Cubans experienced a negative effect on housing recovery in the early recovery period (prior to 1994). This is somewhat surprising given previous research that suggested the advantages of Cubans over non-Cuban Hispanics and Blacks (Peacock & Girard, 1997). However, this negative effect of neighborhood Cubans composition quickly disappeared as the recovery went along. Ultimately, it had a significantly positive effect on housing recovery in the long-term recovery period.

Hypothesis 6 is supported. Neighborhoods with a high percentage of non-Hispanic Blacks experienced negative effects on housing recovery throughout the whole period. Homes in neighborhoods with high concentrations of non-Hispanic Blacks lagged further behind as the recovery went along. Consequently, housing inequality between Blacks populated areas and other neighborhoods was exacerbated in the period following the disaster. Hypothesis 7 is partially supported. While the concentration of non-Cuban Hispanics had a significant negative effect on housing recovery in the early recovery period, it showed no difference from the effect of the neighborhood White concentration in the long-term recovery period.

Limitations and Future Research

Every research has its limitations. This study is no exception. First, we did not have data on housing reconstruction financing. The amount of insurance settlements, governmental reconstruction loans or grants that an affected household received is an important factor determining housing recovery progress. However, previous studies suggested that owner occupancy (Bolin, 1986, 1993; Comerio et al., 1994), income level (Bolin, 1986; Bolin & Bolton, 1983; Tierney, 1997), and household race/ethnicity (Peacock & Girard, 1997) are significantly correlated with the ability to acquire sufficient repair/reconstruction financing to repair damage. Taking these findings into account, our conclusions about homeownership, income, and race/ethnicity are likely robust when considering the lack of data on reconstruction financing.

Second, the direct measurement of individual household characteristics such as income, race/ethnicity, education, and occupation is needed to fully discern each variable's effect on housing recovery. Although our findings about the effect of neighborhood racial/ethnic composition on housing recovery may reflect the aggregated effect of race/ethnicity of each individual household within a neighborhood, one should be cautious when applying these results to any particular household.

Third, more data needs to be gathered to separate the effects of independent variables due to the disaster impact from those that would have taken place if there had not been a disaster. One may argue that housing values had been appreciating between 1992 and 1996 in Miami-Dade County. According to the Consumer Price Indexes (CPI) published by the Department of Labor, the average annual appreciation of housing values was 4.5% in Miami-Dade County during this period[2]. This means that the *real* housing recovery – reflected through housing values – following Hurricane Andrew was actually slower than that shown by the tax appraisal. CPI, however, does not threaten our

[2] The CPI index is for the Miami-Fort Lauderdale area in Florida, which covers Miami-Dade County. Data was retrieved from the Department of Labor website: http://www.bls.gov/cpi/homt.htm on Jan. 10th 2006.

findings because all home values in our dataset will simply change by a constant proportion when being adjusted by CPI. The differences in the housing recovery process across households and neighborhoods still remain the same.

Others may draw conclusions from previous studies which showed that neighborhood minority composition, especially Black representation, exerts a significantly negative effect on housing value appreciation (Conley, 1999; Flippen, 2004; Massey & Denton, 1995; Oliver & Shapiro, 1995). Thus, the findings on race/ethnicity effects may simply reflect the prevailing differences in housing value appreciation. However, a series of studies found that property values of low-income households and minority households are systematically over-assessed in the United States (Black, 1977; Brich et al., 1990, 1992; Birch et al., 2004; Engle, 1975; Ihlanfeldt, 1982). Thus, the real difference in home values across households and neighborhoods should have been bigger than that shown in our analysis. Clearly, more data is needed to separate the *recovery process* from the *"normal" process*. A dataset with multiple time points before the disaster or a quasi-experimental design could fulfill this purpose.

Fourth, although single family dwellings constitute the major proportion of the housing stock in Miami-Dade County (54 %), multi-family housing (46%), is a very important element in housing recovery as well. This type of housing actually includes a number of variations such as duplex, multi-family housing with three or more units, cluster homes, condominiums, and townhouses. Comerio (1998) and Wu and Lindell (2004) suggested that the recovery problem for multi-family housings is very different from single family because of the complexity of property ownership: a combination of individual ownership of each dwelling unit and group ownership of the common space. Thus, more empirical research on this topic is also needed.

Finally, in-depth research on post-disaster home sales is needed to fully understand how housing transactions affect recovery. Clearly, research on post-disaster home sales represents a gap in the literature. The following questions should be addressed in future research: (1) who is selling? (2) who is buying? (3) what are the reasons for buying and/or selling? (4) how do these factors correlate with housing repair/reconstruction of the properties in the transaction?

Theoretical Contribution and Practical Implications

Notwithstanding the limitations, this study has theoretical contributions to social vulnerability literature. There has been a general consensus in the literature on the major socioeconomic and sociodemographic variables that influence social vulnerability to disasters (Blaikie et al., 1994; Cutter et al., 2003). The most widely accepted variables include age, gender, race/ethnicity, and income. However, there has been little research attempting to measure how the social vulnerability realizes itself in the housing recovery process. This research addresses this critical gap by revealing the significant variations of housing recovery across households and neighborhoods. Rental properties, homes in minority neighborhoods experienced slower housing recovery.

In addition, this study improves the current state of knowledge about disaster impact. Although previous research concluded that the residual impact of disasters on housing over a decade is minimal at the community level (Friesma et al., 1979; Wright et al., 1979), it did not attempt to document at which point the disaster impact disappears. Our data suggest that the housing impact was still significant four years after Hurricane Andrew when a considerable proportion of households (16%) had not reached their pre-disaster housing status. In addition, the housing recovery process varied considerably across households and neighborhoods with some leading the way and others falling behind. Indeed, housing inequality in the impact area increased during the recovery process.

This research also has important practical implications. Our findings suggest that market-based housing recovery fails to achieve a balanced housing recovery. Rental properties and homes in predominantly minority neighborhoods, especially areas with a high percentage of Black, were left behind during the reconstruction process. Government should improve its role in assisting private housing recovery. This is not suggesting that government should expand its already very expensive recovery bill (Mileti, 1999; Cemerio, 1998), but rather make current programs more effective. Recent major disasters have repeatedly taught us that government aid for housing reconstruction is not particularly effective in reaching low income, minority victims (Bolin, 1986; Comerio, 1998; Kamel & Loukaitou-Sideris, 2004). Current recovery assistance programs (i.e., FEMA’s MHR and IFG, SBA loan) should consider the special needs victims may have when accessing these programs. For example, low income and minority people often have limited mobility, language barriers, and limited ability to navigate the application process. These special needs should be taken into consideration when administrating recovery assistance programs following a major disaster.

In addition, government housing recovery programs should have a collaboration strategy to avoid any duplication or confusion that can create considerable time delays for victims, especially low-income and minority populations. Comerio (1998), for example, documented that victims of Loma Prieta Earthquake had to work with FEMA and SBA separately in order to become eligible for grants or loans. As a result, many applicants had to have their damaged properties inspected many times by various agencies. Moreover, the slow recovery of rental properties and frequent turnover of such units following Hurricane Andrew call for government recovery programs specially designed for this portion of housing stock. Current federal programs, both FEMA's IFG/MHR and SBA loan are mainly targeted to homeowners (Comerio, 1998).

Local governments should incorporate housing recovery into their disaster recovery agenda. Particularly, housing recovery for those socially vulnerable groups and areas should be prioritized in local policies. First of all, local governments should keep updated information on 1) characteristics of the hazards and the areas likely to be affected; 2) population characteristics, composition and distribution; and 3) existing building stock location and characteristics. Based on this information, local governments should pinpoint the groups and areas that are likely to have the most difficulty in achieving housing recovery. Second, local governments should maintain communication with external recovery programs in order to direct the reconstruction resources to the most needy victims and areas following a disaster. Pre-event housing reconstruction planning should be practiced to achieve these purposes. However, in addition to emphasizing fast post-disaster administrative decision making for housing reconstruction

(Comerio, 1998; Schwab et al., 1998; Wu & Lindell, 2004), the planning process should also focuses on 1) identifying households with the most obstacles to overcoming for housing recovery, and 2) connecting these households with potential external recovery resources.

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APPENDIX

Model Specifications for Model 1 through Model 5

Model 1: Total Variation in Housing Trajectories

Level I: Housing damage, restoration and long term recovery

$$V_{thn} = \alpha_{0hn} + \alpha_{1hn} DISASTER + \alpha_{2hn} RESTORATION + \alpha_{3hn} LT\_RECOVERY + e_{thn}$$

Here:

α_{0hn} Initial value of housing 1992

α_{1hn} Housing damage

α_{2hn} Housing restoration rate

α_{3hn} Long term housing recovery rate

e_{thn} Error item; it is assumed to be independent and normally distributed with a mean of 0 and constant variance σ^2.

Level II: Household Level Variation

$$\alpha_{0hn} = \beta_{00} + a_{0h}$$

$$\alpha_{1hn} = \beta_{10} + a_{1h}$$

$$\alpha_{2hn} = \beta_{20} + a_{2h}$$

$$\alpha_{3hn} = \beta_{30} + a_{3h}$$

Level III: Neighborhood Level Variation

$$\beta_{00} = \gamma_{00} + b_{0n}$$

$$\beta_{10} = \gamma_{10} + b_{1n}$$

$$\beta_{20} = \gamma_{20} + b_{2n}$$

$$\beta_{30} = \gamma_{30} + b_{3n}$$

Model 2: The Effects of Household Characteristics

<u>Level I:</u> Housing damage, restoration and long term recovery

$$V_{thn} = \alpha_{0hn} + \alpha_{1hn} DISASTER + \alpha_{2hn} RESTORATION + \alpha_{3hn} LT\_RECOVERY + e_{thn}$$

<u>Level II:</u> Household Level Variation

$$\alpha_{0hn} = \beta_{00} + \beta_{01} HOME\_AGE_{hn} + \beta_{02} BEDROOM_{hn} + \beta_{03} BATH_{hn} + \beta_{04} OWNERSHIP_{hn} + a_{0h}$$

$$\alpha_{1hn} = \beta_{10} + \beta_{11} HOME\_AGE_{hn} + \beta_{12} BEDROOM_{hn} + \beta_{13} BATH_{hn} + \beta_{14} OWNERSHIP_{hn} + \beta_{15} EYEWALL_{hn} + \beta_{16} EDGE_{hn} + a_{1h}$$

$$\alpha_{2hn} = \beta_{20} + \beta_{21} HOME\_AGE_{hn} + \beta_{22} BEDROOM_{hn} + \beta_{23} BATH_{hn} + \beta_{24} OWNERSHIP_{hn} + \beta_{25} EYEWALL_{hn} + \beta_{26} EDGE_{hn} + a_{2h}$$

$$\alpha_{3hn} = \beta_{30} + \beta_{31} HOME\_AGE_{hn} + \beta_{32} BEDROOM_{hn} + \beta_{33} BATH_{hn} + \beta_{34} OWNERSHIP_{hn} + \beta_{35} EYEWALL_{hn} + \beta_{36} EDGE_{hn} + a_{3h}$$

<u>Level III:</u> Neighborhood Level Variation

$$\beta_{00} = \gamma_{00} + b_{0n}$$

$$\beta_{10} = \gamma_{10} + b_{1n}$$

$$\beta_{20} = \gamma_{20} + b_{2n}$$

$$\beta_{30} = \gamma_{30} + b_{3n}$$

Model 3: The Effects of Post-disaster Home Sales

Level I: Housing damage, restoration and long term recovery

$$V_{thn} = \alpha_{0hn} + \alpha_{1hn} DISASTER + \alpha_{2hn} RESTORATION + \alpha_{3hn} LT\_RECOVERY + e_{thn}$$

Level II model: Household Level Variation

$$\alpha_{0hn} = \beta_{00} + \beta_{01} HOME\_AGE_{hn} + \beta_{02} BEDROOM_{hn} + \beta_{03} BATH_{hn} + \beta_{04} OWNERSHIP_{hn} + a_{0h}$$

$$\alpha_{1hn} = \beta_{10} + \beta_{11} HOME\_AGE_{hn} + \beta_{12} BEDROOM_{hn} + \beta_{13} BATH_{hn} + \beta_{14} OWNERSHIP_{hn} + \beta_{15} EYEWALL_{hn} + \beta_{16} EDGE_{hn} + a_{1h}$$

$$\alpha_{2hn} = \beta_{20} + \beta_{21} HOME\_AGE_{hn} + \beta_{22} BEDROOM_{hn} + \beta_{23} BATHROOM_{hn} + \beta_{24} OWNERSHIP_{hn} + \beta_{25} EYEWALL_{hn} + \beta_{26} EDGE_{hn} + \beta_{27} SALE9294_{hn} + a_{2h}$$

$$\alpha_{3hn} = \beta_{30} + \beta_{31} HOME\_AGE_{hn} + \beta_{32} BEDROOM_{hn} + \beta_{33} BATHROOM_{hn} + \beta_{35} OWNERSHIP_{hn} + \beta_{36} EYEWALL_{hn} + \beta_{37} EDGE_{hn} + \beta_{38} SALE9496_{hn} + a_{3h}$$

Level III model Neighborhood Level Variation

$$\beta_{00} = \gamma_{00} + b_{0n}$$

$$\beta_{10} = \gamma_{10} + b_{1n}$$

$$\beta_{20} = \gamma_{20} + b_{2n}$$

$$\beta_{30} = \gamma_{30} + b_{3n}$$

Model 4: The Effects of Neighborhood Level Variables

Level I: Housing damage, restoration and long term recovery

$$V_{thn} = \alpha_{0hn} + \alpha_{1hn} DISASTER + \alpha_{2hn} RESTORATION + \alpha_{3hn} LT\_RECOVERY + e_{thn}$$

Level II: Household Level Variation

$$\alpha_{0hn} = \beta_{00} + \beta_{01} HOME\_AGE_{hn} + \beta_{02} BEDROOM_{hn} + \beta_{03} BATH_{hn} + \beta_{04} OWNERSHIP_{hn} + a_{0h}$$

$$\alpha_{1hn} = \beta_{10} + \beta_{11} HOME\_AGE_{hn} + \beta_{12} BEDROOM_{hn} + \beta_{13} BATH_{hn} + \beta_{14} OWNERSHIP_{hn} + \beta_{15} EYEWALL_{hn} + \beta_{16} EDGE_{hn} + a_{1h}$$

$$\alpha_{2hn} = \beta_{20} + \beta_{21} HOME\_AGE_{hn} + \beta_{22} BEDROOM_{hn} + \beta_{23} BATHROOM_{hn} + \beta_{24} OWNERSHIP_{hn} + \beta_{25} EYEWALL_{hn} + \beta_{26} EDGE_{hn} + \beta_{27} SALE9294_{hn} + a_{2h}$$

$$\alpha_{3hn} = \beta_{30} + \beta_{31} HOME\_AGE_{hn} + \beta_{32} BEDROOM_{hn} + \beta_{33} BATHROOM_{hn} + \beta_{35} OWNERSHIP_{hn} + \beta_{36} EYEWALL_{hn} + \beta_{37} EDGE_{hn} + \beta_{38} SALE9496_{hn} + a_{3h}$$

Level III: Neighborhood Level Variation

$$\beta_{00} = \gamma_{00} + \gamma_{01} MED\_INCOME_{n} + \gamma_{02} PER\_HISP_{n} + \gamma_{03} PER\_BLACK_{n} + b_{0n}$$

$$\beta_{10} = \gamma_{10} + \gamma_{11} MED\_INCOME_{n} + \gamma_{12} PER\_HISP_{n} + \gamma_{13} PER\_BLACK_{n} + b_{1n}$$

$$\beta_{20} = \gamma_{20} + \gamma_{21} MED\_INCOME_{n} + \gamma_{22} PER\_HISP_{n} + \gamma_{23} PER\_BLACK_{n} + b_{2n}$$

$$\beta_{30} = \gamma_{30} + \gamma_{31} MED\_INCOME_{n} + \gamma_{32} PER\_HISP_{n} + \gamma_{33} PER\_BLACK_{n} + b_{3n}$$

Model 5: Cuban-Hispanics vs. Non-Cuban Hispanics

Level I: Housing damage, restoration and long term recovery

$$V_{thn} = \alpha_{0hn} + \alpha_{1hn} DISASTER + \alpha_{2hn} RESTORATION + \alpha_{3hn} LT\_RECOVERY + e_{thn}$$

Level II: Household Level Variation

$$\alpha_{0hn} = \beta_{00} + \beta_{01} HOME\_AGE_{hn} + \beta_{02} BEDROOM_{hn} + \beta_{03} BATH_{hn} + \beta_{04} OWNERSHIP_{hn} + a_{0h}$$

$$\alpha_{1hn} = \beta_{10} + \beta_{11} HOME\_AGE_{hn} + \beta_{12} BEDROOM_{hn} + \beta_{13} BATH_{hn} + \beta_{14} OWNERSHIP_{hn} + \beta_{15} EYEWALL_{hn} + \beta_{16} EDGE_{hn} + a_{1h}$$

$$\alpha_{2hn} = \beta_{20} + \beta_{21} HOME\_AGE_{hn} + \beta_{22} BEDROOM_{hn} + \beta_{23} BATHROOM_{hn} + \beta_{24} OWNERSHIP_{hn} + \beta_{25} EYEWALL_{hn} + \beta_{26} EDGE_{hn} + \beta_{27} SALE9294_{hn} + a_{2h}$$

$$\alpha_{3hn} = \beta_{30} + \beta_{31} HOME\_AGE_{hn} + \beta_{32} BEDROOM_{hn} + \beta_{33} BATHROOM_{hn} + \beta_{35} OWNERSHIP_{hn} + \beta_{36} EYEWALL_{hn} + \beta_{37} EDGE_{hn} + \beta_{38} SALE9496_{hn} + a_{3h}$$

Level III: Neighborhood Level Variation

$$\beta_{00} = \gamma_{00} + \gamma_{01} MED\_INCOME_{n} + \gamma_{02} PER\_BLACK_{n} + \gamma_{03} PER\_CUBAN_{n} + \gamma_{04} PER\_N\_CUBAN_{n} + b_{0n}$$

$$\beta_{10} = \gamma_{10} + \gamma_{11} MED\_INCOME_{n} + \gamma_{12} PER\_BLACK_{n} + \gamma_{13} PER\_CUBAN_{n} + \gamma_{14} PER\_N\_CUBAN_{n} + b_{1n}$$

$$\beta_{20} = \gamma_{20} + \gamma_{21} MED\_INCOME_{n} + \gamma_{22} PER\_BLACK_{n} + \gamma_{23} PER\_CUBAN_{n} + \gamma_{24} PER\_N\_CUBAN_{n} + b_{2n}$$

$$\beta_{30} = \gamma_{30} + \gamma_{31} MED\_INCOME_{n} + \gamma_{32} PER\_BLACK_{n} + \gamma_{33} PER\_CUBAN_{n} + \gamma_{34} PER\_N\_CUBAN_{n} + b_{3n}$$

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