Population and Building Factors That Impact Residential Fire Rates in Large U.S. Cities

By

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Abstract

The purpose of this explanatory research is to evaluate the impacts of population and building characteristics on the residential fire rates among large cities in the continental U.S. This study used existing aggregated data from 69 U.S cities in the continental U.S to explain the effect of population and building factors on cities' residential fire rates. Overall findings indicate that two building characteristics – vacancy rate and building age – significantly influence residential fire rates. None of the population and natural environment variables examined found to significantly impact residential fire rates. Therefore, during the economic downturn, fire prevention efforts should focus more on areas with high vacancy rates and old building structures.

Table of Contents

List of Tables

Chapter One: Introduction[1]

Residential Fire and Fire Causes in the U.S

Overview of Residential Fire in the U.S

When a fire disaster occurs, some people believe it is an "act of god". According to Munson and Oats (1983, 61), "Fire is sometimes thought to be an essentially random phenomenon: fate singles out the unfortunate to become its victims". A fatalistic attitude about fires may provide consolations for some people, but this attitude does not help people seeking solutions to prevent future fire disasters.

Fire causes huge losses in the U.S every year – typically measured by property loss, civilian death and civilian injures. According to the annual fire loss report from the National Fire Protection Association (NFPA), 1,557,500 fires were reported in the United States during 2007, which caused $14.6 billion in direct losses, three thousand deaths and 17,000 civilian injuries (Karter 2008, 7, 10, 12). Fires that occurred in residential structures accounted for the greatest losses. In 2007, there were 141,000 residential property fires. These fires represented about 78 percent of all structure fires, causing 7.5 billion in property loss, 2,865 civilian fire deaths, and 14,000 civilian injures (Karter 2008, 1, 7,10). One home structure fire was reported every 79 seconds in the U.S. in 2007.

Human behavior is the leading cause of residential fire. A high proportion of all fires that occur in residential structures are directly or indirectly attributable to human activities (Tridata and NFDC 1998, 3). Cooking, heating, and arson are the three leading causes of residential fire in the United States. Furthermore, in 2005, over 60 percent of

[1] For other Texas State Applied Research Projects dealing with fire and other disaster issues see Kevin Baum, 1997; Brian O'Neill, 2008; Donald Hall, 2000; Donna L.Rose, 1996; Heather Gatlin, 2006; Jeffrey Phillips, 1998.

home fires were caused by cooking, heating, arson, careless smoking and children playing with fire.[2,3,4] The fire losses caused by different types of fires in 2005 are summarized in table 1.1.

Table 1.1
Fire Cause for Residential Structure Fires and Fire Losses (2005)

Fire Cause	***Fire (%)***	***Losses in Dollar (2.951 Billion) (%)***	***Civilian Deaths (1,225) (%)***	***Civilian Injuries (6574) (%)***
Intentional/Arson	4.9	8.2	11.3	6.0
Playing with heat source	0.8	1.6	1.7	2.4
Smoking	2.4	4.2	19.2	7.2
Heating	12.6	3.9	3.6	2.4
Cooking	39.9	18.6	5.0	24.1
Electrical Malfunction	7.9	13.6	10.3	8.2
Appliances	2.3	4.2	1.2	3.8
Open Flame	6.4	9.8	9.1	12.2
Other Heat	5.1	7.6	8.2	7.5
Other Equipment	1.6	1.9	2.7	1.7
Natural	1.9	3.0	0.8	0.6
Exposure	2.0	3.9	0.5	0.62
Equipment Misoperation, Failure	4.4	7.4	4.4	8.7
Other Unintentional	6.6	10.1	15.0	12.2
Investigation w/Arson Module	0.8	1.6	7.1	2.4
Total (%)	100	100	100	100

United States Fire Administration(2008, 18)

[2] The causes of fires are often a complex chain of events. To make it easier to grasp the "big picture," 16 mid-level categories of fire causes such as heating, cooking, and playing with heat source are used by the USFA and National Fire Report System 5.0. See. Appendix Table 1.1
[3] United States Fire Administration. Residential structure and building fires in the U.S. Fire Administration [database online]. [Emmitsburg, Md.], 2008. Table 1.1 summarizes the fire causes and losses in 2005
[4] Arson is a legal term. For purposes of brevity "incendiary or suspicious" firs are referred to as arson fires in this paper.

Residential Fire Causes

Cooking fire is the leading cause of home structure fires and associated civilian injuries. In 2005, U.S. fire departments responded to 146, 400 home structural fires that involved cooking equipment. These fires caused about 480 civilian fire deaths, 4, 690 civilian fire injuries and $876 million in direct property damage (Hall 2008, i). However, Ahrens et al. (2007, 15) pointed out that approximately 99 percent cooking fires are never reported to fire departments. Furthermore, most of cooking equipment fires are caused by human error not equipment malfunction (Ahrens et al. 2007, 10).

Statistical data reveal two interesting gender and age patterns in cooking fire incidents. Despite the fact that females conduct most cooking activities, more than half of the people killed and almost half of those injured in reported cooking fires were male (Ahrens et al. 2007, 1). People between ages 25 and 44 accounted for the greatest risk experiencing a cooking fire, older adults and very young children accounted for the greatest risk of dying from a cooking fire (Ahrens et al. 2007, 17).

Arson fire is the leading cause of residential fire deaths. In 2005, an estimated 323, 900 intentional fires were reported to U.S. fire department resulting in 490 civilian fire deaths, 1,500 civilian fire injuries, and $1.102 billion in direct property damage. These are low estimates because “some fire investigators estimate that at least half of the fires of unknown cause are deliberately set” (Hershbarger and Miller 1978, 275).

Arson represents a bigger problem in metropolitan areas and is directly associated with human behavior. Larger cities have a larger percentage of intentional structure fires. According to a report from FEMA, the rate for arson fires in cities of 250.000 people is more than twice the rate for communities of 5,000 to 10,000 people, or 10,000 to 25,000 people (FEMA & NFDC 1997, 19).

Arson fires are caused directly by human behavior, and the motivations of arsonists vary. According to Jennings (1999, 21), "arson can result from several motivations and usually has accompanying modus operandi, it is difficult to develop predictive models that take into consideration the large number of causal scenarios that result in arson." Arson fires can result from vandalism, spite and revenge, intimidation, concealment of another crime, economic motives, civil disorder and hate related crime, gang initiation, excitement, suicide, and murder (FEMA and NFDC 1997, 26). According to the Federal Bureau of Investigation, 53 percent of arrests for arson are children under the age of 18. Approximately one-third are under the age of 15.[5]

Before 1994, children playing with fires were responsible for greater fire loss in the U.S. than any other fire cause. The number of fires caused by children playing with fire declined after 1994 for two reasons: the child-resistant lighter standard and public fire safety education. According to Hall (2005, 2), the decline in children playing with lighter fires and loss coincided with the U.S. Consumer Product Safety Commission's (CPSC) introduction of the child-resistant lighter standard in 1994.[6] Smith, et al.,(2002, 194) compared the child-playing fire rate pre and post-standard and found that in the post-standard study, 48% of cigarette lighter fires were started by children younger than age 5, compared with 71% in the pre-standard study. Smith, et al.(2002, 195) estimated that the children-resistant lighter standard prevented $566.8 million in 1998. Smith, et al. (2002,192) concluded that the CPSC standard requiring child resistant cigarette lighters has reduced fire deaths, injuries, and property loss and can be expected to prevent

[5] USFA topical fire research series, vol 1, issue 6
[6] The standard covers more than 95 percent of the 600 million lighters purchased in the United States each year.

additional fire losses in subsequent years. Public education is another factor reducing children-playing with fires. Public fire safety education programs have focused attention on child supervision and other steps that reduce the child-playing fire problem (Hall and NFPA 2005, 2). Fire education, however, has less effect in poor and rural locations (Fahy & Miller 1989, 36).

Smoking ranks second among the 16 leading causes of fire in home fire deaths. The U.S. fire department responded to an estimated 82,400 smoking-material fires in 2005. These fires caused 800 civilian deaths, 1,660 civilian injuries and $575 million in direct property damage.[7] The number of smoking-material home structure fires declined by 63 percent from 1980 to 2002, and the number of deaths declined by 60 percent in the same period. Hall, et al (2006, 4) explained that more than half of the decline may be attributed to declines in cigarette consumption.

Heating is second only to cooking as the leading cause of residential building fires. The loss due to heating equipment is considerable. In 2005, heating fires accounted for about 670 civilian deaths, 1,550 civilian injuries, and $909 million in direct property damage (Hall and NFPA 2008, 1). In the late 1970s and early 1980s, a surge in the use of space heaters and wood heating make heating equipment as the leading cause of residential fires. This surge was stimulated, in large part, by environmental concerns and energy shortages. [8]

The causes of heating equipment fires vary. Fixed and portable space heaters accounted for 32 percent of reported 2005 U.S. home heating fires, and chimneys and

[7] One out of four fatal victims of smoking-materials is not the smoker whose cigarette started the fire. Data comes from NFPA report.
[8] Stated in Homeland Security, USFA, NFDC, TFRS Volume 6, Issue 3 *Heating Fires in Residential Buildings.*

chimney connectors accounted for the largest share of fire incidents (36% in 2005). According to Hall (2007, 6), space heaters resulted in far more fires and losses than central heating devices. Hall (2007, 6) also found that space heaters have about 7 times higher risk of causing fires, 36 times higher risk of causing civilian deaths, 12 times higher risk of causing civilian injuries, and 8 times higher risk of causing direct property damage than central heating devices.

The five major residential fire causes mentioned above accounted for 60.6 percent of all residential fires in 2005. These fire causes are important because they account for the largest proportion of residential fire associated with human behavior, but also because the patterns hiding behind these causes help researchers understand the larger picture regarding residential fires.

Role of Engineering in Fire Prevention

Engineering plays a major role in the early stage of fire prevention planning. Advances in fire technology have reduced the need for firefighting services over time and the frequency of threat of fire spread (Goetz 1991, 3; Jennings 1996, 5). In particular, the use of smoke detectors and sprinklers has dramatically reduced home fire death after 1970. According to Slult et al. (1998, 165), working smoke detectors reduces the risk of death from residential fire by at least 50%. However, other researchers have identified the weaknesses of engineering in solving fire problems. For instance, Goetz (1991, 5) asserted that fire prevention technology success depends on the policies for implementing the technology. In additional, Jennings (1996, 6) maintained that “the engineering contribution to fire as a policy problem was mainly through improvement to multiple dwellings. Smaller residential structures or those predating reforms were largely avoided”.

Goetz (1991) and Jennings (1996) believe that fire can not be prevented by technology alone – people, the users of the technology must also be considered.

Ecological Perspective

The patterns of fire incidents have inspired researches to study fire problems from ecological perspectives. The ecological perspective takes into account factors such as poverty (Donner and Karter 1978, Munson and Oats 1983), abandoned buildings (Sternlieb and Burchell 1973), and rural/urban differences (Gunther 1982).

These patterns reveal that fire is not a purely random event, but an “urban ecology of risk” associated with social problems (Goetz 1991, 13, 70). “We continue to live in a society which is ‘built to burn.’ Ecological and structural factors (high density of persons, older housing, wooden structures) assure a combustible environment” (Goetz 1991, 4). Jennings (1996, 23) asserts that “fire, like other human problems, can best be considered as a product of social and structural factors within an ecological context”. Thus, fire should be considered a consequence of human engagement in household, social, and economic production activities. Buildings structures provide the locations for these activities.

Given the above sources of fire, this paper explains the underlying causes of fire rates in cities.

Research Purpose

The purpose of this explanatory research is to evaluate population and building characteristics that affect the residential fire rate among the large cities in the continental U.S. To achieve this research purpose, this study is divided into five chapters.

Chapter Two evaluates the scholarly literature that identifies population/building factors influencing a city's residential fire rates. The literature reviews helps to build the conceptual framework that guides this study. Three formal hypotheses related to the research question are developed in this chapter. Chapter 3 introduces the methodology used to test the hypotheses. This chapter includes a discussion of data collection, the dependent and independent variables, and statistics used. The sample includes the most populous 89 cities in the continental of U.S. Because of missing data, only 69 cities were finally selected in this study. Chapter 4 shows the results of statistical tests along with an analysis of the data. Chapter 5 concludes the research with a discussion of the findings and suggestions for further research concerning cities' residential fire rates.

Chapter Two: Literature Review

Chapter Purpose

Many researchers[9] had studied population, building, and environmental factors on residential fire patterns by using multiple regression analysis. Unfortunately, these researchers often lacked a theoretical foundation (Jennings 1996) before Jennings developed his fire loss and fire ignition model. The purpose of this scholarly literature review is twofold. First, it examines why population/building characteristics had been used to explain different residential fire rate in different geographic areas. Second, it identifies which kinds of building characteristics and population characteristics impact cities' residential fire rates. The first section discusses the empirical studies that examine how population/building factors impact cities residential fire rate in the U.S. This section also presents Jennings' fire ignition model. The second section presents three formal hypotheses that explain residential fire rates in U.S. cities.

Empirical Studies

Most explanatory studies relating socioeconomic characteristics to fire rates were conducted in the late 1970s using regression analysis (Jennings 1996, 39; Tridata and NFDC 1997, 2). Since that time, limited studies can be found in master thesis and unpublished doctoral dissertations. In these studies, various population/building characteristics were found to be significantly associated with the residential fire rate, see Table 2.3.

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[9] See for example, Schaenman, et al., 1977; Karter & Donner, 1978; Donnell, 1980; Gunther, 1981; Goetz, 1991

Although the purposes of these researches vary, they demonstrate that certain community characteristics not controllable by the fire department are related to the fire rate (Schaenman, et al. 1977, 63). They also show that "socioeconomic factors related to fire rates are sensitive to each city's unique conditions, and these can be traced back through the history of a city's populations and its buildings" (Tridata and NFDC 1997, 6). Unfortunately, these studies were often conducted without theoretical grounding, and often relied on suspect measurement (Jennings, 1996). Furthermore, these studies ran regression analysis on city census tracts but fail to compare one city with another.

The earliest and most frequently cited study on fire rates and community characteristics was published by Schaenman, Hall, Schainblatt, Swartz, and Karter in 1977. Their goals were to identify the (1) community characteristics that impact residential fire rates, (2) the areas that need fire prevention programs, and (3) to provide useful information to a local government (Schaenman et al. 1977, 53). They tested the relationship between population/ buildings characteristics and the residential fire rate using regression analysis.[10]

First, Schaenman et al. (1977, 56) attempted to determine why there is a variation in fire rates between different cities. Using the correlation test, they found several variables to be highly correlated and that only one variable – percentage of the population that is nonwhite – correlated with residential fire rates. When they ran a simple regression analysis on that variable, they found that only one percent of the variation for 45 cities in

[10] Population characteristics were race, poverty, affluence, unemployment rate, under-education, high-school education, transiency, family stability, and age. The housing characteristics selected were ownership, age of structure, crowdedness within the structure, vacancy, and size of the structure. Data comes from the U.S Bureau of the Census and local fire departments.

fire rates between 1960 and 1970 can be explained by this variable (Schaenman et al., 1977, 54).

Then, Schaenman et al., (1977) ran a regression analysis only in comparing census tracts within a city. They noted that the "data might be more consistent across tracts within a single city" (Schaenman et al., 1977, 56). Four cities (Seattle, Charlotte, St. Petersburg, and San Diego) and one county (Fairfax County) were selected, and a regression analysis was run again on census tracts in these cities and county. Schaenman et al. (1977, 63) found that three variables were strongly correlated with fire rates: parental presence, poverty, and under-education.

This research was the first study to use multiple regression analysis to examine how the population and building characteristics influence a city's residential fire rate. It demonstrated that this kind of study is more effective when intra-city level data is used vis-à-vis inter-city level data do less consistent. Furthermore, it showed that the population/building characteristics do not cause fires, but that certain population/building characteristics are correlated with residential fire rates (Schaenman, et al. 1977, 57). Last, "the results strongly support the common belief that certain community characteristics not controllable by the fire department are related to fire rate" (Schaenman, et al. 1977, 63).

The second year after Schaenman, et al. (1977), a similar study was conducted by Karter and Donner (1978). Karter and Donner (1978, 53) chose Syracuse, NY, Newwark, NJ, Phoenix, AZ, Toledo, OH, and Kansas City, MO as their research targets. Residential fires rate data (one or two-family dwellings, and apartments fires per 1,000 people) was collected. Nine population factors and five building factors were selected to test their impact on residential fire rates.[11]

Karter and Donner (1978) identified the population and building characteristics most correlated with each city's residential fire rate in each city. They found that two population factors – family stability (Syracuse, Kansas City) and poverty rate (Newark, Phoenix, Toledo) and three building factors – crowdedness (Syracuse, phoenix), ownership (Newark, Toledo), and vacancy rate (Kansas City) were significant in explaining residential fire rates. Their findings are summarized in Table 2.1.

The family stability of a census tract is defined as the percentage of children under 18 within the tract who live in stable families.[12] In Syrcause, a census tract with 38.7% to 70.1% of the children living with both parents is considered to be a high risk group. A census tract with 70.2% to 94.9% of the children living with both parents is considered to be a low risk group. In Syracuse, census tracts with high risk family stability experienced 6.54 residential fires per 1,000 people in 1978. Census tracts with low risk family stability experienced 1.64 residential fires per 1,000 people in 1978. In Kansas City, a census tract with 25.9% to 63.6% of the children living with both parents is considered to be in the high risk group. A census tract with 63.7% to 95.8% of the children living with both parents is considered to be in the low risk group. Kansas City experienced 4.67 residential fires per 1,000 people in the high risk group and 2.57 residential fires per

[11] The population characteristics selected were race, poverty, affluence, unemployment, race *under-education, high-school education, transiency, family stability, and age. The housing characteristics selected were ownership, age of structure, crowdedness within the structure, vacancy, and size of the structure. Data comes from the U.S Bureau of the Census and local fire departments (Karter & Donner 1978, 53)

[12] A stable family is defined as a family with at least one child under 18 living with both parents. A household which has at least one child under 18 but does not have both parents living at home is defined as an unstable family.

1,000 people in the low risk group. Therefore, family stability is negatively associated with residential fire rates in both cities.

The poverty rate of a census tract is defined as the percentage of people living below the poverty level. In Newark, a census tract with 31.1% to 51.3% of the people living below the poverty level is considered to be in the high risk group. A census tract with 5% to 31% of the people living below the poverty level is considered to be in the low risk group. Newark experienced 6.44 residential fires per 1,000 people in the high risk group and 3.22 residential fires per 1,000 people in the low risk group. In Phoenix, a census tract with 14.2% to 50.3% of the people living below the poverty level is considered to be in the high risk group. A census tract with 1.1% to 14.1% of the people living below the poverty level is considered to be in the low risk group. Phoenix experienced 8.31 residential fires per 1,000 people in the high risk group and 3.07 residential fires per 1,000 people in the low risk group. In Toledo, a census tract with 15.8% to 52.0% of the people living below the poverty level is considered to be in the high risk group. A census tract with 0.6% to 15.7% of the people living below the poverty level is considered to be in the low risk group. Toledo experienced 4.40 residential fires per 1,000 people in the high risk group and 2.04 residential fires per 1,000 people in the low risk group. Therefore, poverty rate is positively associated with residential fire rates in all three cities.

The crowdedness of a census tract is defined as the percentage of housing units which have at least 1.01 persons per room residing in the unit year-round. In Syracuse, a census tract with 5.11% to 10.07% of the housing units with at least 1.01 persons per room year-round is considered to be in the high risk group. A census tract with 0.69% to 5.10% of the housing units with at least 1.01 persons per room year-round is considered to be in the low risk group. Syracuse experienced 6.64 residential fires per 1,000 people in the high risk group and 1.79 residential fires per 1,000 people in the low risk group. In Phoenix, a census tract with 13.76% to 34.15% of the housing units with at least 1.01 persons per room year-round is considered to be in the high risk group. A census tract with 0.94% to 13.75% of the housing units with at least 1.01 persons per room year-round is considered to be in the low risk group. Phoenix experienced 7.09 residential fires per 1,000 people in the high risk group and 3.49 residential fires per 1,000 people in the low risk group. Therefore, crowdedness is positively associated with residential fire rates in all three cities.

The ownership of a census tract is defined as the percentage of year-round housing units that are owner-occupied. In Newark, a census tract with 10.28% to 54.43% of the housing units which are owner-occupied is considered to be in the high risk group. A census tract with 1.08% to 10.27% of the housing units which are owner-occupied is considered to be in the low risk group. Newark experienced 6.79 residential fires per 1,000 people in the high risk group and 3.24 residential fires per 1,000 people in the low risk group. In Toledo, a census tract with 5.56% to 49.22% of the housing units which are owner-occupied is considered to be in the high risk group. A census tract with 49.23% to 97.15% of the housing units which are owner-occupied is considered to be in the low risk group.. Toledo experienced 4.50.09 residential fires per 1,000 people in the high risk group and 2.03 residential fires per 1,000 people in the low risk group. Therefore, ownership is negatively associated with residential fire rates in both cities.

The vacancy of a census tract is defined as the percentage of year-round housing units that are vacant. In Kansas City, a census tract with 10.58% to 28.89% of the housing units which are vacant is considered to be in the high risk group. A census tract with 0.31% to 10.57% of the housing units with at least 1.01 persons per room year-round is considered to be in the low risk group. Therefore, vacancy is positively associated with residential fire rates in Kansas City.

Table 2.1
Comparison of fire cause factors and fire rates amount five cities (Karter and Donner 1978, 62-65)

City	Population Factors	Mean Fire Rate(High Risk Group)	Mean Fire Rate (Low Risk Group)	Building Factors	Mean Fire Rate(High Risk Group)	Mean Fire Rate (Low Risk Group)
Syracuse	Family Stability (-)	6.54	1.64	Crowdedness (+)	6.64	1.79
Newark	Poverty (+)	6.44	3.32	Ownership (-)	6.79	3.24
Phoenix	Poverty (+)	8.31	3.07	Crowdedness (+)	7.09	3.49
Toledo	Poverty (+)	4.40	2.04	Ownership (-)	4.50	2.03
Kansas City	Family Stability(-)	4.67	2.57	Vacancy (+)	4.79	2.57

Family Stability: Percentage of person who are under 18 living with both parents
Crowdedness: Percentage of year-round housing units that have at least 1.01 persons per room
Poverty: Percentage of persons below the poverty level
Ownership: Percentage of year-round housing units that are owner-occupied
Vacancy: Percentage of year-round housing units that are vacant
Fire rate: number of residential fires per 1,000 people

Karter and Donner (1978) demonstrated that population and building characteristics can be used to analyze a city's residential fire problem. Jennings (1999, 17) commented that Karter and Donner's (1978) study showed population and housing characteristics could explain the variation in fire rates. He (Jennings 1999, 7) also commented that this study showed these variations could be more easily explained at the census tract level than inter-city level. Fenner (1990, 17) also commented that this study demonstrated housing and population variables can be used to accurately predict differences in fire rates across tracts within a city. Tridata and NFDC (1997, 6) further pointed out “socioeconomic factors related to fire rates are sensitive to each city’s unique conditions, and that can be traced back through the history of a city’s populations and its buildings.”

Population characteristics and building characteristics were also used to examine a city’s residential fire rate by other studies. For example, Donnell (1981) explored the patterns and potential causes of structural fire incidents in Syracuse, NY. Donnell (1981, 120-122) found that two variables (abandoned structures, poverty) were statistically significantly associated with residential fire rates in Syracuse, NY. These two variables explained 60 percent of the variation in residential structural fire rates in Syracuse, NY. Donnell (1981, 122) noted that poverty and abandoned structures indicate a deteriorating neighborhood, which experience high levels of arson fires.

Muson and Oats (1983, 61) studied the relationships between fire and a wide variety of structural, climatic, and socioeconomic variables. Munson and Oats (1983) developed and tested seven hypotheses using simple regression equations.[13] They found significant relationships between income, poverty, home-ownership, unemployment rate, percentage of black people, crowdedness, housing conditions and residential fire rate in one or all of the data sets. Munson and Oats (1983, 72) concluded that “fire is clearly not a purely random phenomenon” and noted that the building and population characteristics of a city will have much to do with its fire experience.

Although Munson and Oats’ evidence supported their hypotheses both on the inter- and intra-city level, their methodology was criticized as lacking rigor. According to

[13] These hypotheses are (1) the probability of fire occurrence is inversely related to income (2) Fires are less likely in owner-occupied than in rental dwellings; (3)The likelihood of fire is greater in dwellings with children present; (4) Increased levels of social tension in a community are conducive to a higher fire-incidence rate; (5) A higher degree of crowding increases the likelihood of fire; (6) The better the condition of structures(percentage of dwelling units; lacking plumbing, the percentage of units built prior to 1940) , the less probable the occurrence of fire; (7) Colder climates increase the likelihood of fire.

Fenner (1990, 40), Munson and Oats didn't use multiple regression equations, which made the significance levels of their results suspect. Fenner (1990, 40) maintained that Munson and Oats' study would have been stronger if multiple regression analysis was used instead of seven simple regression equations. Using this approach, Munson and Oats (1983) found that each individual variable was significantly related to fire rates but accounted for relatively little variation among the census tracts.

Getz (1979) attempted to improve fire prevention effectiveness by identifying the relationship between the fire rate and the characteristics of the population/building characteristics. Unlike the studies mentioned previously, Getz (1979) divided fire rates into four categories: single-family residences, multifamily residences, commercial establishments, and industrial and warehouse occupancies.[14]

Getz (1979, 193, 195) ran multiple regression equations on several building and population characteristics in four cities. He found that variables positively associated with fire rates in some cities were either negatively associated or not associated with fire rates in other cities. None of the variables he tested were similarly associated with fire rates across four cities. He measured these variables in single-family and multi-family residences. His results were summarized in Table 2.2 (Getz, 193, 195).

As Table 2.2 displays, in single-family residences, Getz (1979, 193) tested the relationship between building characteristics and single-family residential fire rates. He found that three variables (percentage of housing in the census tract having no heat, percentage of housing in the census tract having no plumbing, and percentage of housing

[14] There were two reasons: 1) estimates of the effectiveness of the fire department activities may differ across different types of occupancy; 2) grouping fire by occupancy class instated of by causes of fire can avoid the problem of uncertain cause. The author studied Nashville, Rockford, Tacoma, and San Jose (Getz 1979, 191, 192).

in the census tract having no sewage service) were positively associated with fire rates in Nashville. One variable (percentage having no heat) was positively associated with fire rates in Rockford, no variable was associated with fire rates in Tacoma, and two variables (housing age, percentage with public water) were negatively associated with fire rates in San Jose.

When Getz (1979, 193) tested the relationship between population characteristics and single-family residential fire rates. A similar pattern still can not be found. In Nashville, one population characteristic (percentage working in central business district) was found to be strongly positively related to fire rates, but this characteristic was found negatively related to fire rates in Tacoma and did not show significant in both San Jose and Rockford. In San Jose, median family income was negatively associated with fire rate, which was opposite of the situation in Nashville result. In Tacoma, tracts with more old persons had a higher fire, which was opposite of the situation in San Jose.

Getz (1979, 195), then, tested the impact of population/building characteristics on multi-family residential structure fire rates -- no patterns were found there either (see Table 2.2). Getz (1979, 198) concluded that there were two reasons he failed to find patterns. First, all cities did not provide data for each variable. Second, the omitted variables influenced the pattern of fire rates across census tracts.

Despite failing to find a pattern across four cities, Getz's study strongly supported for the existence of intra-city variations in three different types of residences (Fenner 1990, 21). Approximately 75 percent of the variation in single-family and multifamily residence fires was explained by these variables in four cities.

Table 2.2
Variables Associated with Residential Fire Rates in Four Cities (Getz 1979, 195)

Number of single-family residence fires per thousand single-family residences				
	Nashville	***Rockford***	***Tacoma***	***San Jose***
Building Characteristics	percent no heat (+); percent no plumbing (+); percent have sewers (+)	percent no heat (+)	N/A	housing age (-); percentage with public water(-)
Population Characteristics	percentage working in central business district (+); median family income (+)	N/A	percent of old persons (+); percentage working in central business district (-)	median family income (-); percent of old persons (-)
Number of multifamily residence fires per thousand single-family residences				
	Nashville	Rockford	Tacoma	San Jose
Building Characteristics	percentage with public water(-)	percentage with sewers (-); percentage with public water (+)	percentage with public water(+)	N/A
Population Characteristics	Income(+)	Income(+)	percentage of poverty (+); percentage of black (+)	percentage of black households (-)

Fenner's (1990) study indirectly demonstrated that population/building characteristics influence the residential fire rate. The original purpose of this study was to develop a new deployment strategic for the Austin Fire Department by analyzing the relationship between different types of calls and population/housing characteristics

(Fenner 1990, 8). In contrast to previous studies, Fenner (1990) constructed multiple regression equations by using fire calls per acre as a dependent variable.[15]

Fenner (1990, 105, 106) found that three independent variables – residential population density, poverty rate, and the square of the ratio of employees to the residential population in a tract – were significant and strongly positively associated with the total number of fire calls. His model using the number of residential fire calls per acre accounted for 77 percent of the variation in the dependent variable across tracts. After testing different fire calls separately, he found two variables -- housing density and poverty rate – to be strongly associated with residential fire calls. Fenner's (1990) finding indirectly demonstrated that population/building characteristics are associated with residential fire rates.

Goetz (1991) constructed regression equations to analyze a city's residential fires and arson fires. Arson and residential fire in Hyde (pseudonym) were examined. Goetz's (1991, 84-86) found that median income, vacancy rate, percent non-white, and median value of property were statistically associated with residential fire rates. Vacancy rates were positively correlated with arson rates, and income was negatively correlated with arson fire rates. Meanwhile, median property values and percent non-white showed weak correlations with arson fire rate.

These empirical studies demonstrate the population and building characteristics influence a city's residential fire rate. Furthermore, these studies provide information useful to the construction of a conceptual model. Jennings (1996, 40) stated that "these studies are presented with minimum commentary so that the commonalities can be

[15] Based on the literature review, Fenner (1990, 88-103) identified a series of population/building characteristic as independent variables and eight types of calls – fire calls, residential fire calls, rescue calls, service calls, good intent calls, hazard calls, false calls, and total calls – as dependent variables.

discerned and considered in the development of the conceptual model". Tridata and NFDC (1997, 2) suggested that because of population shifts and changes in specific socioeconomic characteristics, their studies should be replicated in the future. The factors explaining residential fire rates across nine studies are summarized in Table 2.3. Jennings (1996) developed a fire ignition conceptual model based on the findings of previous studies. The model developed by Jennings is used as a conceptual guide for this study.

Table 2.3
Factors Explaining Residential Fire Rates Across 9 Studies

Author	**Dependent variables**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Schaenman, et al.(1977)	Intra-city residential fire rate	+	_	+												
Karter & Donner(1978)	Intra-city residential fire rate	+			_	+	_	+								
Donnell (1980)	Intra-city residential fire rate	+						+								
Munson & Oats (1977)	Intra and inter-city residential fire rate	+				+	_		_	+	+	_	+			
Gunther (1981)	Intra-city residential fire rate								_				+			
Fenner (1990)	Intra-city residential fire rate	+				+										
Goetz (1991)	Intra-city residential fire rate							+	_		+			_		
Jennings (1996)	Intra-city residential fire rate		_					+	_							+
Tridata & NFDC	Inter-city residential fire rate												+		+	+

1= Poverty rate 2=Parental presence 3= Under- Education 4=Family stability 5= Crowdedness. 6=Percent owner occupied 7= Vacancy rate 8= Income 9=Unemployment rate 10= Percent of non-white. 11=Housing condition 12= Temperature 13= Property value 14= Age of structure 15= Population age under 5
"+"= Positively associated with dependent variables. "-" =Negatively associated with dependent variable

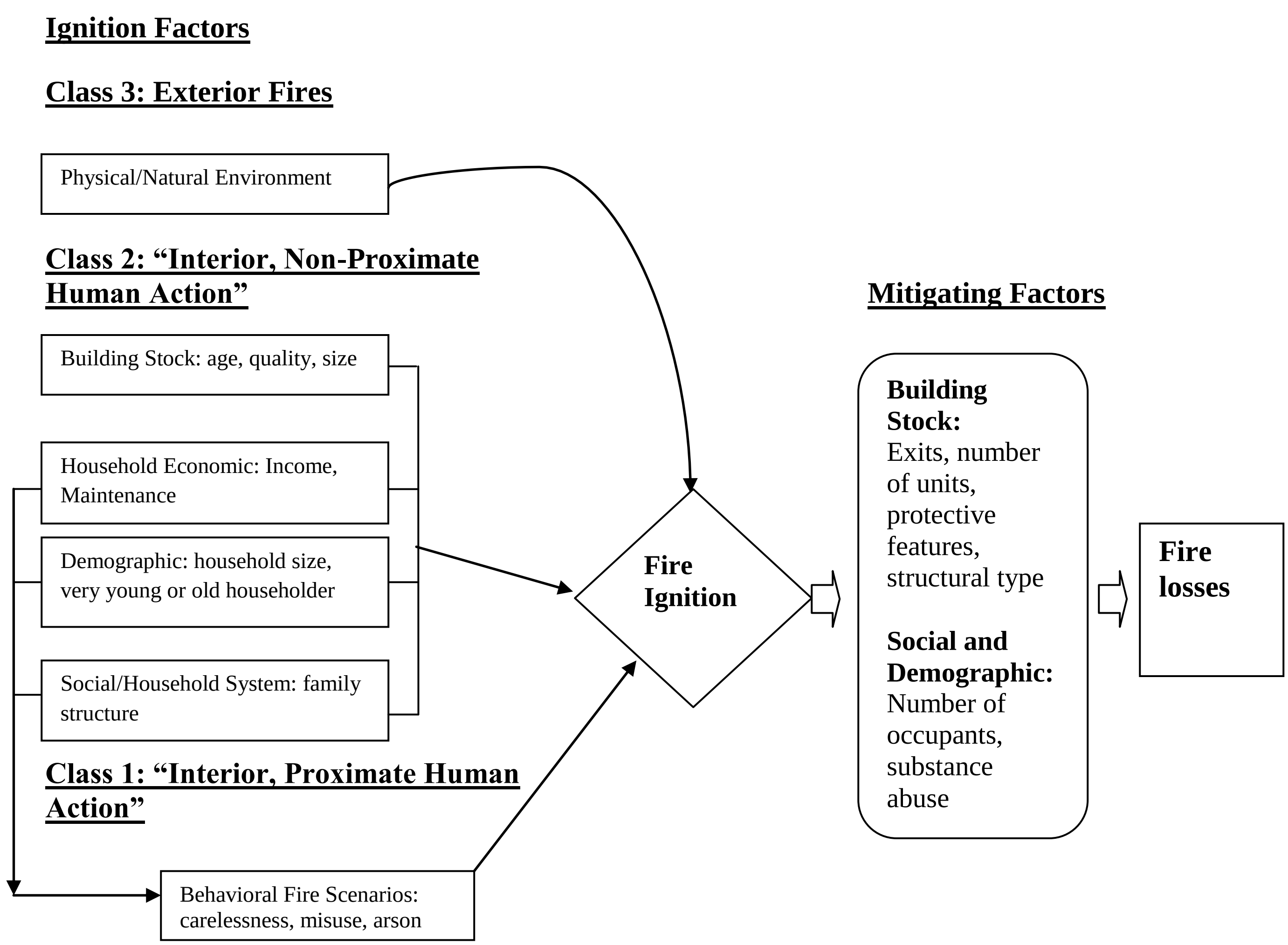
Jennings' Fire Ignition and Fire Loss Model

Jennings (1996) studied the relationship between Memphis' residential fire rate and socioeconomic and building characteristics. Before testing the relationship, Jennings (1996, 107) argued that "a major impediment to the advancement of knowledge on the fire problem is the lack of a well defined theory for differential fire risk". The purpose of his studies was "to develop a framework for directing further exploration of the residential fire problem while uniting previous work using the perspective of urban planning" (Jennings 1996, 108). Jennings (1996, 108) further pointed out that "understanding why some areas, populations or activities experience more fires relative to their number is the fundamental question in this research".

The fire ignition and fire loss model developed by Jennings (1996, 122) clearly explained how population characteristics and building characteristics impact residential fires. Exhibit 2.1 displays this model. Jennings divided residential fires into three classes. Class 3 fires originate outside the structure without human intervention. Class 2 fires originate inside the residential structure without direct human intervention (e.g. electrical short circuits). Class 1 fires originate inside the residential structure and are caused by human behaviors (e.g. arson, children playing with fires). The factors that impact class 3 fires are the physical and natural environment. The factors that impact class 2 fires causes are building condition, household economic status, household demography, and household social system. According to Jennings (1996, 123-125), class 2 fires are the most difficult to influence in the short term. Three of the factors impacting class 2 fires also impact class 1 fires. These factors are: household economic status, household demography, and household social system.

According to Jennings' model (1996, 122) and other empirical studies, the factors that impact residential fire rate are population characteristics (household economic status, household demography, and social/household system), building characteristics (such as age, ownership of structural, vacancy rate, crowdedness, average rent, etc), and the environment (climate).

EXHIBIT 2.1
Conceptual Model of Fire Initiation and Fire Loss



Jennings (1996, 122)

Conceptual Framework

This section describes the conceptual framework of the fire rate evaluation study. The goal of this research is explanatory and the conceptual framework utilized is the formal hypothesis. “Explanatory research and the formal hypothesis are the mainstay of social and policy science” (Shields 1998, 217; Shields and Tajalli 2005, 33). Explanatory research addresses the “why” question and uses the formal hypothesis as its conceptual framework, and the formal hypothesis takes the form “if X than Y” (Shields and Tajalli 2005, 33).

Although literature has confirmed that population characteristics, building characteristics, and environment influence residential fire rates, identifying the specific variables (X) that impact a city’s residential fire rate (Y) from the literature review can be difficult for two reasons. First, since the research was conducted at different geographic areas, the variables showed to be statistically significantly associated with the residential fire rate vary. The second problem is the strong correlation between variables. The biggest problem in specifying a regression equation to explain differential fire incidence or loss is the high degree of correlation between factors (Jennings 1996, 105).

In spite of these problems, Jennings’ fire ignition model provides a theoretical foundation for this research. Fenner (1990, 17) maintains that housing and population variables can be used to accurately predict differences in fire rates across tracts within a city. According to Jennings (1996, 109), building characteristics are critical to understanding the residential fire problems because building are where fires happen. Furthermore, environmental factors, especially the climate have been found to influence people’s activities in houses, which also impact the fire risk (Tridata and NFDC, 1996;

Tridata and NFDC 1998). Munson and Oats (1983, 72) also note that the building and population characteristics of a city will have much to do with its fire experience. Therefore, three variables that impact the residential fire rate are the natural environment, population characteristics, and building characteristics.

Natural Environment

Some studies have found that home fires, especially heating fires, are associated with environmental conditions.[16] The earliest research studies on the relationship between climate and the residential fire death rate was conducted by Gunther (1982). He found that the correlation between rural fire death rates in the north and heating degree-days[17] to be significant, and that the correlation between freezing days and rural fire-death rates is likewise significant. His most interesting finding was that the heating problem was greater in Southern states than Northern states.[18] Gunther (1982, 34-39) explained that fireplaces, wood stoves, and portable heaters are more widely used in the south as primary heating sources and that minimal permanent heating equipment was installed in Southern states. He also found that heating was relatively unimportant in urban areas, because many families live in apartments, which typically have professionally maintained central heating systems.

Other studies also demonstrate the relationship between climate and residential fire rates. Hall (2007,7) studied the heating fire trend from 1980 to 2005 and concluded that

[16] Gunther (1982); Munson and Oats (1983); Tridata and NFDC (1998); Hall (2007)

[17] Heating degree day is quantitative indices designed to reflect the demand for energy needed to heat a home or business. One heating degree day is accumulated for each whole degree that the mean daily temperature (max + min/2) is below 65 degrees Fahrenheit. Therefore, if the average temperature of a city in January 1st is 35 degrees Fahrenheit, that city would accumulate 30 heating degree days on January 1st.

[18] Gunther divided the Unite States into three parts by latitude; Southern states are the 13 states below 37° Latitude. Other 32 states are Northern states (Gunther, 1982, 35)

“the decline in home heating fires since 1980 has been more consistent and more dramatic than the general decline in heating demand that resulted from an historically atypical string of warmer winters”. Munson and Oats (1983, 63) pointed out that lower temperatures results in more crowding in residential structures, which negatively impacts the building conditions. Tridata and NFDC further explained that (1998, 16) lower temperatures increase the likelihood of fires because people used more heating devices stay warm. Furthermore, in colder climate, more people spend more time indoors which also increases the fire risk from social activities, such as cooking. Thus, one would expect that:

H1: There is a relationship between the residential fire rate and the natural environment.

Population Characteristics

In Jennings’ fire ignition and fire loss model, household economic status, household demography, and household social systems reflect the population characteristics that impact the likelihood of residential fires. These three population factors impact both class three (fires originating inside the structure without human intervention) and class one (fires originating inside the residential structure because of human behaviors) residential fires (Jennings 1996, 122).

Social/Household System

The social/household system impacts residential structure fires by affecting the way that family members interact with each other. Jennings (1996, 126, 127) noted that work habits and family structure affect supervision of children in their use of household equipment, and that children playing with fires also can be attributed to a lack of parental supervision. Schaenman, et al. (1977, 57) have demonstrated that the percentage of children under 18 living with both parents is strongly negatively related to the fire rate. Tridata and NFDC (1997, 18) also found that single parent households face higher fire risk because children have less supervision.

Another social/household system factor that impacts the residential fire rate is education level. Schaenman, et al., (1977, 57) found that education level is negatively associated with the residential fire rate. Fahy and Miller (1989, 36) explained that people with less education were more likely to lack discretionary income to purchase smoke detectors and other code-compliant electrical equipments, because those people were less likely to understand the importance of fire safety equipment. Tridata and NFDC (1997, 23) further stated that low literacy levels impede people's ability to comprehend instruction manuals and warning labels for electrical devices -- this increases the fire risks.

Household Demographic

Two demographic factors influence the risk for fires – the household size and the age of the residents. Some empirical studies have found that crowdedness is positively associated with the residential fire rate.[19] According to Jennings (1996, 125), the number of residents in a household can increase the rate of the degradation of household equipment, leading to a higher chance of fire occurring. Furthermore, the increasing number of residents means more human activities and social interaction inside the buildings, which also increases the risk for certain types of fires, such as cooking fires.

The second demographic factor that influencing residential fire rates is resident's age. Some researchers have found that resident's age is associated with the residential fire rate (Jennings 1996; Tridata and NFDC 1998). Munson and Oats (1983, 67) found there is a

[19] See. Schaenman, et al. (1997); Munson and Oats (1977); Fenner (1990)

greater probability of fire in dwellings with children present. Jennings (1996, 124) noted that more children in the building increase the fire risk for two reasons: children sometimes play with fire; and there is a higher chance of cooking fires when adults leave the kitchen to take care of children. Ahrens, et al., (2007, 16) also stated that “the presence of distractions when cooking, age, time pressure, clutter, the use of alcohol or medication, and mobility or agility can increase or decrease the risk of a cooking fire or injury”. Tridata and NFDC (1997, 20) pointed out that regardless of socioeconomic background, most parents do not recognize that instances when they leave their children alone or unsupervised can increase fire risks.

The number of elderly persons also influences the fire risk. Tridata and NFDC (1997, 21) stated that elderly persons experience more fires than other age groups due to the decline of their physical or mental capabilities. Ahrens, et al. (2007, 17) found that “the twelve percent of the U.S population which is 65 years of age or older accounted for 30 percent of the cooking fire deaths, and the seven percent of the population which is under five years of age accounted for nine percent of the cooking fire death”. Ahrens, et al., (2007, 17) found that people 25 to 34 years of age face the highest risk of cooking fire injury, and they explained that people in this age group are more likely to cook and are more likely to have young children or other distractions presents when they cook, which increases the fire risk.

Household Economic

Household economic factors also affect residential fire causes. Many empirical studies have found that poverty rate is positively associated with the residential fire rate.[20]

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[20] See. Schaenman et al. (1977); Karter and Donner (1978); Donnell (1981); Munson and Oats (1977); Fenner (1990); Goetz (1991); Jennings (1996).

Jennings (1996, 9) maintains that "the poor suffered a disproportionate share of the misery inflicted by urban fire. While property alone is not sufficient to explain the incidence of fire, an examination of poverty as a risk factor for life is needed".

Gunther (1981, 54) examined the relationship between income level and residential fire rates and found a strong relationship between income and residential fire rates. In addition, different neighborhoods have different leading causes of residential fire rates (Gunther 1981, 56). For inner city and low income white groups, arson was the major cause of residential fires, followed by heating equipment and appliances; for the middle and high income white groups, the leading cause was cooking, followed by heating equipments and appliances, while for low income mixed group, cooking was the leading cause, follow by arson, smoking, and heating equipments. Gunther 1981, 56-58) concluded that if fire rates in the inner city and the other low income neighborhoods were reduced to the level experienced by middle income families, the city would experience 35 percent fewer fires.

Rural poverty poses different residential fire problems. Clark (1982, 40-41, 105-106) pointed out some unique fire problems in rural areas.

- Rural areas were more likely to fail to enforce fire codes during building design, construction, and use.
- Rural fire service usually responses to a fire more slowly than urban fire service, because they are more isolated and often rely on volunteer firefighters.
- Rural areas frequently do not have architects who thoroughly understand building codes.
- Many architects in rural areas use lightweight and combustible materials because they are cheap without considering the fire safety implications.
- Rural governments often do not have staff to administer building contracts.
- The insurance industry appears to be more interested in the protection of property than in the safety of people occupying the buildings.
- Rural home owners and property managers have limited knowledge about fire safety.

Some economic factors are associated with arson fire rate. In the economic field, some studies have demonstrated the relationship between arson fire rates and social and economic factors. Murrey, et al., used the socioeconomic factors to explain variations in fire and arson rates between states (as cited in Jennings 1999, 21). Murrey, et al., found that the general climate[21] and social structure[22] factors were significant in explaining the number of fires, while the socioeconomic and general climate factors were significant in determining the number of arson fires (as cited in Jennings 1999, 21). Hersharger and Miller also (1978, 286) found a statistically significant relationship between arson losses and selected economic indicators. A report from Tridata and NFDC (1998, 13) stated that a city's median income and percent rental housing influenced arson fire rates, and these two factors explained 70 percent of the difference in arson rates among the cities.

Household economic factors are also indirectly associated with careless smoking fire rates and children playing with fire rates. Some studies have shown that cigarette smoking is inversely related to income, which means low income households are arguably at greater risk from fires caused by careless smoking (Tridata and NFDC 1997, 22). According to Tridata and NFDC (1998, 18), there was a moderate relationship between residential careless smoking fire rates and the age of the buildings. Tridata and NFDC (1998, 18) stated that the result is not strange because the housing age was significantly related to poverty rate, unemployment rate, and other factors in this research. Tridata and NFDC (1998, 18) further found that population increases or decreases is negatively associated with the children playing with fire rate; they explained that population increase or decrease can be treated as an economic indicator.

[21] General climate includes violent and property crime rates, population density, percent nonwhite population , percent urbanized, and percent of children living with both parents
[22] Social structure includes divorce rate and percent of population under 24

Fahy and Miller (1989, 29-35) concluded that there are four reasons why poverty increases fire risk. First, in poor areas, the building conditions are worse than other areas. The buildings in these areas often lack adequate maintenance, have no indoor plumbing and running water and central heating system, and the vacancy rate is high.
Second, poor people have almost no financial resources needed to invest in fire safety equipment, such as, smoke detectors.[23] Third, many poor people do not budget to purchase code-compliant electrical equipment because they are under educated. Fourth, low income urban areas are more likely to have high crime rates, which increases the fire risk from arson.

Based on the above information, one would expect that:

H2: There is a relationship between the city residential fire rate and the population characteristics.

Building Characteristics

In Jennings' fire ignition and fire loss model, building characteristics are the major factor impacting class 2 fires. Jennings (1996, 123) stated that the condition of buildings plays a role in different kinds of fires.

Building age is the one of the variables most frequently used by researchers to measure building conditions.[24] Jennings (1996, 123) noted that older buildings with old electrical systems might be unable to handle the burden of the additional electrical devices, and older buildings may use other heating sources to provide warmth instated of a central heating system – both these factors increase the fire risk. Housing tenure as the indicator of building characteristics has been found to be associated with the residential

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[23] A 1992 national survey found that households with incomes of less than $15,000 were about 60% less likely to have a working detector than homes with higher incomes (Shults et al, 1998, 166)

[24] See. Karter and Donner (1978); Munson and Oates (1983); Tridata and NFDC (1998).

fire rate in some studies (Karter and Donner 1978; Munson and Oates, 1977). Owner occupied units seem to have lower fire risks than renter- occupied units. Owner occupied units are better maintained. Furthermore, the owner is more likely to be careful when engaged in cooking, smoking, or other activities that can cause fire if one is careless. Tridata and NFDC (1997, 23) further pointed out that an owner is more likely to invest in fire safety equipment than a renter. However, Gunther (1982, 32-39) found that urban areas with apartments experienced lower residential fire rates caused by heating devices than other residential structures in Toledo, Ohio. Gunther (1982, 39) explained that urban apartments usually have professional maintenance and central heating systems.

Many studies have linked vacant buildings structures to higher incidence of fires. Some empirical studies have demonstrated that the vacancy rate is positively associated with the residential fire rate.[25] According to Sternilieb and Burchell (1973, 26), abandoned buildings are the end product of all the urban ills of our society. Abandoned buildings suffer more fires for three reasons: high recurring fire rates, homeless invasion, and “the contagious phenomenon”. First, the recurring fire rate in this kind of structure is higher than other kinds of residential structures (Sternilieb and Burchell 1973, 26-28). Sternlieb and Burchell (1973) conducted a study of the abandoned buildings in Newark, New Jersey. They found that the frequency of severe fires in abandoned buildings is four times higher than others (Sternlieb and Burchell 1973, 28); Furthermore, they found that the recurring fires rate is high in these vacant buildings. After analyzing seven years of fire data (1964-1971), Sternlieb and Burchell (1973, 28) found that among 84 abandoned buildings, 19 experienced at least one fire, and nine suffered two to five incidents. This

[25] See. Donnell (1981); Goetz (1991); Jennings (1996); Karter and Donner (1978); Sternlieb and Burchell (1973)

result indicates that if there were 2,000 vacant buildings, about 450 would have to be serviced at least once, and half of that number (about 225) on more than occasion (Sternilieb and Burchell, 1973, 28).

Second, the homeless often use abandoned buildings as their shelter, which causes fire risk due to unsafe cooking, heating devices, careless smoking and children-playing with fire (Northon 1989, 33). The homeless population as a social bottom level group should not be excluded from research, and their fire risk is connected to poverty and abandoned buildings.[26] Norton (1989) maintains that the homeless are a diverse group, but for the most part, they are undereducated, poor, and have unstable family units, all of which are factors that have been linked to higher fire rates. Norton (1989, 29-37) suggests that the solution to the fire problems of the homeless, children, and impaired adults is supervision. He also recommended that the homeless must be prevented from entering unsafe, vacant or condemned buildings.

Third, abandoned buildings and fires cause neighborhoods to decline which causes more abandoned buildings and fires (Tridata and NFDC 1997, 11). Jennings (1996, 32) named this situation as “a contagious phenomenon”. Wallace and Wallace pointed out that when a structure is damaged by fire, it may be abandoned, which may trigger withdrawal of maintenance from others on that block by absentee landlords in preparation for abandonment. This is sufficient to cause more structural fires (Jennings, 1996, 38-39). Also, arson-for-profit problem was often localized adding to the fire risk of poverty-stricken, declining neighborhoods (Donnell, 1980, 122). The end result is usually another vacant building in the neighborhood (Tridata & NFDC, 1997).

[26] See Sternlieb & Burchell (1973); Jennings (1996); Triadata & NFDC (1998)

Based on the above information, one would expect that:

H3: There is a relationship between the city residential fire rate and building characteristics.

Testing these hypotheses will explain the different residential fire rates between cities. Table 2.4 summarizes the formal hypotheses and links them to the supporting literature.

Table 2.4
Conceptual Framework Linked to Literature

Formal Hypotheses	**Sources**
H1: There is a relationship between the residential fire rate and the natural environment.	Ahrens, et al., 2007; Clark, 1982; Gunther, 1982; Hall, 2007; Munson and Oats, 1983; TriData and NFDC 1997; TriData and NFDC 1998; Jennings 1996
H2: There is a relationship between the city residential fire rate and the population characteristics.	Clark, 1982; Donner and Karter 1978; Donnell 1981; Fahy and Miller 1989; Fenner 1990; Getz 1979; Goetz 1991; Gunther 1982; Gunther 1981; Jennings, 1996; Munson and Oates, 1983; Schaenman, et al., 1971
H3: There is a relationship between the city residential fire rate and the building characteristics.	Donnell,1981; Gunther, 1982;Goetz ,1991; Jennings, 1996; Karter & Donner, 1978; Northon, 1989, Sternlieb & Burchell, 1973; TriaData & NFDC,1997; TriData and NFDC, 1998

Chapter Summary

Chapter Two evaluates the scholarly literature that identifies population/building factors influencing a city's residential fire rates. The purpose is to develop a conceptual framework identifies the factors that contribute to cities' residential fire rates.

Most explanatory studies relating population/building characteristics to fire rates were conducted in the late 1970s without using a systematic conceptual foundation such as, Jennings' fire ignition and fire loss model. The scholarly literature review provides a theoretical foundation for this study and helps to build the conceptual framework that guilds this study. Three formal hypotheses were also presented. The next chapter introduces the methodology used to test the three hypotheses.

Chapter Three: Methodology[27]

Chapter Purpose

This chapter shows how the hypotheses that explain factors associated with the cities' residential fire rates are tested. The methodology – analysis of existing data – is described in detail.

The dependent variable is the cities' residential fire rates. Independent variables are the cities' environment, population characteristics, and building characteristics. According to Jennings' model (1996, 122) population characteristics should be measured by social/household structure, household economic statues, and household demographics. Household economic statue should be measured by median household income and the poverty rate. Social/household structure was measured by parental presence and the under-education rate. Household demographics should be measured by the number of children and old people present and crowdedness. Building characteristics were measured by the vacancy rate, building age, and housing tenure. These variables were operationalized in Table 3.1. The operationalization table outlines the variables used in the study and their relationship to the hypothesis (positive/negative). The units of measurement are also defined and the data sources identified.

[27] This chapter is benefits from Texas State Applied Research Projects conducted by Tessa S. Doehrman 2007; Colin C. Rice, 2008

Table 3.1
Operationalization of the Hypotheses

Variables			**Direction of Hypothesis**	**Definition/Measurement**	**Data Sources**
Dependent Variable					
City residential fire rates				Number of Residential fires per 1,000 population in 2005	National Fire Incident Reporting System/Fire Department
Independent Variables					
H1: Environment	Climate		+	Heating degree days	City and County Data Book
H2: Population Characteristics	Household Economic Status	Poverty	+	Percent of population below poverty	City and County Data Book 2007
		Median household income	–	Median household income (thousands of dollars)	City and County Data Book 2007
	Household and Social Structure	Parental presence	–	Percentage of population under 18 living with both parents	City and County Data Book 2007
		Under-education Rate	+	Percent of population over 25 without high school degrees	City and County Data Book 2007
	Household Demographic	Number of Children and old people	+	Sum of percent of population under age 5yrs and percent of population over 65yrs and over	City and County Data Book 2007
		Household size	+	Percent of households with >1.01 people per room	Census Bureau
H3: Building Characteristics	Vacancy rate		+	Percent of vacant housing units	Census Bureau
	Building Age		+	Percent of housing units built in 1939 or earlier	Census Bureau
	Housing tenure		–	Percent owner-occupied housing unit	Census Bureau

Method of Data Collection

This study used existing aggregated data to explain the factors that impact cities' residential fire rates. "Residential structure fires are defined as fires that occur in structures on residential properties" (USFA 2008, 12). This study used residential fire data from 2005 which was collected by National Fire Incident Reporting System (NFIRS)[28] and local fire departments. See Appendix A to see how the residential fires were coded in NFIRS. See Appendix C to see the Foxpro program codes that used to extract residential fire numbers of 89 cities from NFIRS CD data set.

Two major problems were encountered during the collection of fire data. First, some fire data from local fire departments were found to be different from NFIRS fire data. Second, some cities' fire data are not available for the public. For consistency, when data was found to be different between NFIRS and local fire department, data from NFIRS was used in this study. Cities whose fire data are not available to the public were excluded from the study. See Table 3.2.

Population characteristics data came from the City and County Data Book 2007. This data set can be downloaded from the U.S Census Bureau, which provides comprehensive demographic and socioeconomic data of cities and counties in the U.S. Building characteristics data was also collected from the website of U.S Census Bureau.

[28] NFIRS is a State-based, voluntary data collection system administered by the USFA. 50 States, the District of Columbia, and Native American Tribal Authorities have reported to the NFIRS. The NFIRS is the world's largest fire data set, which provides a very large, robust sample. In 2005, approximately one million fire incidents and more than 13 million non-fire incidents were added to the database

Table 3.2
Cities Excluded from Statistics Tests Due to Fire Data Missing

State	*City*
AZ	Tucson
AZ	Mesa
AZ	Scottsdale
CA	San Jose
CA	Stockton
CO	Colorado Springs
FL	St. Petersburg
FL	Hialeah
GA	Atlanta
IN	Fort Wayne
MI	Detroit
NC	Jacksonville
NC	Greensboro
NJ	Jersey
NY	New York
NY	Rochester
PA	Philadelphia
PA	Pittsburgh
TX	Lubbock
VA	Norfolk

Dependent Variable

The dependent variable (cities' residential fire rate) data was obtained from the National Fire Incident Reporting System (NFIRS). The number of residential fire during 2005 in the 89 most populous cities in the U.S was extracted. The dependent was the number of residential fires per 1,000 people.

Independent Variables

…..Natural Environment

The natural environment is usually measured by temperature (Munson and Oats 1977, Gunther 1981; Tridata and NFDC 1998). This study used the number of heating degree days to reflect e a city's climate. A Heating degree day is a measure used to reflect the demand for energy needed to heat a building. One heating degree day is accumulated for each whole degree that the mean daily temperature (max + min/2) is below 65 degrees Fahrenheit. Therefore, if the average temperature of a city in January 1st is 35 degrees Fahrenheit, that city would accumulate 30 heating degree days on January 1st. A city with more heating degree days experience lower temperatures than a city with fewer heating degree days. The more heating degree days means the lower temperature a city would be (Tridata and NFDC 1998, 16).

Population Characteristics

Population characteristics were measured by three elements: household/social structure, household demographic structure, and household economic status. Many studies measured household economic status by measuring the poverty rate[29] and median income[30]. The poverty rate was defined as the percent of the population below poverty. Median household income was defined as the city's median household income in thousands of dollars.

Social/household structure was measured by parental presence and the under-education level. Parental presence was the variable most frequently used to measure the social/household system (Tridata and NFDC 1997, 18). Schaenman et al. (1977) found that the under education rate strongly affect cities' residential fire rates. Parental presence was defined as the percentage of population under 18 living with both parents. Under-education was defined as the percent of population over 25 without high school degrees.

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[29] See. Donnell (1980); Fenner (1990); Karter and Donner (1978); Munson and Oats, (1977); Schaenman, et al. (1997).
[30] . Gunther (1981); Goetz (1991); Jennings (1996); Munson and Oats (1977).

Household demographic structure was usually measured by the presence of children, the presence of elders, and household size.[31] The presence of children and old people was defined as the sum of the percent of the population younger than 6yrs old and the percent of the population 64yrs old. Household size was measured by crowdedness, which was defined as the percent of households with more than 1.01 people per room.

Building Characteristics

Housing tenure, building age, and vacancy rates were used to measure building characteristics. Building age was defined as the percent of housing units built in 1939 or earlier. Building ownership was defined as the percent of owner-occupied housing units. Vacancy rate was defined as the percent of vacant housing units. These three variables reflect a city's building conditions.

Sample Population

The study initially examined the data from most populous 89 cities[32] in continental U.S. The National Incident Reporting System (NFIRS) is a voluntary system, and larger city's fire departments were more likely to report fire incidents to NFIRS. Furthermore, large cities population/building characteristics data were more likely to be available than smaller cities. 20 cities were excluded from the final analysis because fire data missing. Table 3.2 shows the cities that were removed from analysis because of missing data. The set of cities chosen for this analysis are presented in Table 3.3 ordered by residential fire rate from highest to lowest, including the value of all variables for each city.

[31] See. Fenner (1990); Jennings (1996); Karter and Donner (1978); Munson and Oats (1977); Tridata and NFDC (1998).
[32] Population range from 8,143,197 (New York, NY) to 209, 737 (Lubbock, TX)

Table 3.3
Data Matrix from 69 U.S Cities Used to Test Hypotheses Regarding Residential Fire Rate

city	*State*	*pop*	*f.r*	*Hdd*	*pov.r*	*m.in*	*par.p*	*u.e.r*	*c&o*	*va.r*	*h.s*	*b.age*	*tenure*
St. Louis. 1	MO	344,362	6.30	4650	25.4	30,874	9.0	22.3	19.6	19.8	2.2	60.5	49.3
Boston .2	MA	559,034	3.34	5630	22.3	42,562	9.6	16.0	17.2	8.1	3.7	59.2	35.9
Birmingham.3	AL	231,483	3.02	2823	28.9	27,020	9.2	19.4	19.5	17.5	3.6	16.9	50.9
Buffalo.4	NY	279,745	2.88	6692	26.9	27,311	9.8	20.1	18.5	16.8	1.9	71.4	41.8
Baltimore.5	MD	635,815	2.61	4720	22.6	32,456	8.9	24.5	19.8	17.4	2.6	39.6	50.8
Cincinnati.6	OH	308,728	2.43	4841	25.0	29,554	9.8	19.4	19.2	18.8	2.0	45.4	42.2
Dallas.7	TX	1,213,825	2.27	2219	22.1	36,403	16.0	28.9	18.5	13.6	7.7	6.3	45.9
Toledo.8	OH	301,285	2.23	5464	23.4	33,044	12.8	18.3	19.5	14.0	2.0	34.3	60.0
Minneapolis.9	MN	372,811	2.22	7876	20.8	41,829	12.5	13.4	15.5	8.5	3.7	52.2	53.3
St. Paul.10	MN	275,150	2.21	7606	18.6	44,103	16.7	12.7	16.8	8.7	4.6	49.6	58.9
Kansas City.11	MO	444,965	2.13	4734	20.0	33,157	14.6	14.3	18.9	13.7	1.7	25.3	59.5
Cleveland.12	OH	452,208	2.12	6121	32.4	24,105	10.4	25.8	18.7	17.2	1.4	56.9	46.5
Memphis.13	TN	672,277	1.95	3041	23.6	33,244	10.6	18.0	18.0	12.5	3.2	9.9	54.2
Akron.14	OH	210,795	1.82	5752	20.1	32,937	12.1	15.4	19.0	13.3	1.5	37.3	60.6
Tampa.15	FL	325,989	1.81	591	18.3	38,568	13.5	18.2	18.4	9.6	3.1	10.3	55.7
San Francisco.16	CA	739,426	1.72	2597	12.2	57,496	10.8	15.5	20.1	9.2	5.1	52.2	38.0
Orlando.17	FL	213,223	1.70	580	15.1	36,699	13.2	16.2	18.6	7.6	3.0	3.9	39.7
Bakersfield.18	CA	295,536	1.61	2120	18.1	45,174	21.9	23.0	18.7	6.4	6.3	4.9	63.0
Tulsa.19	OK	382,457	1.56	3413	17.6	35,966	13.6	13.9	20.2	12.0	2.4	8.5	55.9
New Orleans.20	LA	454,863	1.54	1416	24.5	30,711	10.9	17.7	18.9	23.4	2.3	28.1	50.0
Wichita.21	KS	354,865	1.54	4765	14.8	40,115	17.7	13.9	19.7	11.9	2.6	12.7	60.6
Columbus.22	OH	730,657	1.31	5349	18.5	40,405	13.4	13.6	17.4	15.7	2.0	13.4	53.2
Garland.23	TX	216,346	1.31	2219	15.3	45,924	20.4	24.2	15.7	7.5	5.5	0.6	64.7
Oklahoma.24	OK	531,324	1.25	3663	18.7	37,375	14.8	16.5	18.7	10.6	2.5	8.9	60.2
Raleigh.25	NC	341,530	1.25	3514	15.5	48,131	13.8	9.3	15.2	10.7	2.1	3.0	53.8
Fort Worth.26	TX	624,067	1.23	2509	18.8	40,663	18.1	22.6	18.1	10.1	5.1	8.6	58.4

***The labels for the variables are explained in Table 3.4**

Table 3.3 (continue)
Data Matrix from 69 U.S Cities Used to Test Hypotheses Regarding Residential Fire Rate

City	*State*	*pop*	*f.r*	*Hdd*	*pov.r*	*m.in*	*par.p*	*u.e.r*	*c&o*	*va.r*	*h.s*	*b.age*	*tenure*
Omaha.27	NE	414,521	1.22	6311	15.3	40,484	15.4	12.5	18.5	8.1	2.2	24.6	57.6
Madison.28	WI	221,551	1.21	7493	17.7	45,928	12.7	7.8	14.6	7.6	2.5	15.3	48.3
Miami.29	FL	386,417	1.20	149	28.3	25,211	9.3	36.8	24.7	11.5	6.3	12.6	35.6
Louisville/Jefferson.30	KY	556,429	1.19	4352	15.3	38,664	15.0	16.4	19.3	9.5	1.7	17.0	64.8
Lexington-Fayette.31	KY	268,080	1.18	4769	14.9	42,442	15.4	12.9	17.9	10.3	0.7	10.0	60.0
Chesapeake.32	VA	218,968	1.12	3368	5.6	60,817	19.5	12.3	15.8	1.9	1.3	2.9	73.1
Denver.33	CO	557,917	1.09	5988	15.3	42,370	14.9	18.5	20.1	10.0	2.7	22.5	54.7
Charlotte.34	NC	610,949	1.06	3162	13.0	47,131	16.6	11.8	16.0	11.0	2.9	3.4	60.2
Portland.35	OR	533,427	1.05	4132	17.8	42,287	14.3	11.2	17.0	7.0	1.9	31.9	56.6
Nashville-Davidson.36	TX	549,110	1.04	3677	14.6	40,214	12.0	15.4	18.6	9.6	1.7	6.5	56.7
Las Vegas.37	NV	545,147	1.02	2239	11.7	47,863	17.1	19.6	19.4	10.3	4.1	0.5	58.9
Corpus Christi.38	TX	283,474	0.95	950	18.6	39,698	17.4	20.4	18.6	9.6	5.7	4.5	60.4
Sacramento.39	CA	456,441	0.93	2666	19.2	44,867	14.4	20.2	18.0	7.3	5.3	12.2	52.8
Oakland.40	CA	395,274	0.80	2400	18.3	44,124	14.1	21.2	18.3	9.4	6.7	43.9	42.6
Virginia Beach.41	VA	438,415	0.78	3336	7.4	58,545	18.7	7.5	16.8	5.9	0.7	1.0	66.6
Long Beach.42	CA	474,014	0.77	1211	19.2	43,746	16.6	24.1	16.8	5.5	14.1	19.0	40.5
Los Angeles.43	CA	3,844,829	0.77	928	20.1	42,667	17.0	28.0	17.0	5.3	14.7	19.6	39.9
Albuquerque.44	NM	494,236	0.76	4281	13.7	41,820	14.9	13.3	19.1	5.6	2.6	3.6	62.5
Houston.45	TX	2,016,582	0.76	1174	22.9	36,894	17.6	27.8	17.3	12.5	7.7	5.8	47.8
Austin.46	TX	690,252	0.69	1648	18.1	43,731	15.0	14.6	14.9	8.8	4.5	2.7	48.1
Washington.47	DC	550,521	0.66	4055	19.0	47,221	7.7	16.4	19.5	10.6	4.6	35.9	42.5
Plano.48	TX	250,096	0.62	2370	6.3	71,560	21.4	7.5	13.3	6.6	1.1	0.1	64.9
San Antonio.49	TX	1,256,509	0.61	1573	18.7	40,186	17.9	21.2	18.2	9.6	4.8	6.0	60.7
Milwaukee.50	WI	578,887	0.59	6886	24.9	32,666	11.6	19.5	18.0	8.7	2.6	39.3	49.4
Seattle.51	WA	573,911	0.54	4615	12.3	49,297	11.6	8.1	16.8	6.1	2.3	32.3	49.9

***The labels for the variables are explained in Table 3.4**

Table 3.3 (continue)

Data Matrix from 69 U.S Cities Used to Test Hypotheses Regarding Residential Fire Rate

City	***State***	***pop***	***f.r***	***Hdd***	***pov.r***	***m.in***	***par.p***	***u.e.r***	***c&o***	***va.r***	***h.s***	***b.age***	***tenure***
Chicago.52	IL	2,842,518	0.53	5787	21.3	41,015	13.4	22.4	18.2	12.8	5.0	44.1	48.5
Phoenix.53	AZ	1,461,575	0.51	1125	16.4	42,353	18.3	21.4	16.3	9.4	7.3	2.0	59.3
Santa Ana.54	CA	340,368	0.50	1153	17.3	47,438	24.8	49.9	16.6	2.8	28.8	6.6	52.2
Newark.55	NJ	280,666	0.48	4843	24.8	30,665	10.6	35.3	18.1	9.0	7.6	31.3	23.2
Riverside.56	CA	290,086	0.46	1475	14.1	50,416	19.8	23.3	16.4	4.7	9.6	8.3	56.1
El Paso.57	TX	598,590	0.42	2543	27.2	32,205	18.6	29.9	20.5	7.0	5.9	4.9	62.9
Indianapolis.58	IN	784,118	0.42	5521	15.1	41,578	15.9	16.4	19.1	13.0	1.6	18.4	61.6
Aurora.59	CO	297,235	0.40	6128	13.1	48,309	17.2	16.9	16.8	10.1	5.6	0.7	65.7
Baton Rouge.60	LA	222,064	0.40	1689	29.6	31,049	10.9	17.8	19.0	12.2	2.4	5.8	52.8
Chula Vista.61	CA	210,497	0.37	1321	9.1	55,610	21.6	21.5	18.5	5.7	6.9	1.6	58.8
San Diego.62	CA	1,255,540	0.37	1063	13.5	55,637	17.3	13.3	18.0	7.0	5.9	7.6	51.3
Arlington.63	TX	362,805	0.34	2370	13.3	48,992	20.7	14.3	15.6	10.4	4.2	0.4	57.8
Fresno.64	CA	461,116	0.33	2447	24.3	37,800	19.9	29.0	17.1	5.7	9.8	6.9	50.2
Lincoln.65	NE	239,213	0.29	6242	12.2	45,790	17.3	7.1	17.7	6.1	1.5	15.7	60.1
Glendale.66	AZ	239,435	0.27	1535	15.4	46,713	20.1	16.7	16.6	7.4	7.0	0.8	64.2
Henderson.67	NV	232,146	0.25	2239	6.5	61,483	16.7	9.4	17.1	9.7	1.0	0.1	68.2
Anaheim.68	CA	331,804	0.23	1286	11.7	52,158	21.1	29.4	17.7	4.6	14.6	1.9	50.3
Chandler.69	AZ	234,939	0.21	1271	7.5	62,010	22.1	11.0	13.7	6.4	1.6	0.3	70.6

***The labels for the variables are explained in Table 3.4**

In table 3.3, “f.r” is the only dependent variable – it refers to the number of residential fire that occurred during 2005. The other ten variables are independent variables. “hdd” refers to the number of heating degree days; “pov.r” refers to the poverty rate, which is measured by the percentage of the population below the poverty line; “m.in” refers to the median household income; “par.p” refers to parental presence, which is measured by the percentage of the population under 18 year’s old living with both parents; “u.e.r” refers to the under-education rates, which is measured by the percentage of population over 25 without high school degrees; “c&o” refers to the number of children and old people, which is measured by sum of the percentage population under age five and the percentage of population age 65 and over; “h.s” refers to the household size, which is measured by the percentage of households with more than 1.01 person per room; “va.r” refers to the vacancy rate, which is measured as the percent of vacant housing units; “b.age” refers to building age, which is measured as the percentage of vacant housing units built in 1939 or earlier; “tenure” refers to housing tenure, which is measured as the percentage of owner-occupied housing units. Table 3.4 displays the variables (and their labels) used in this study.

Table 3.4
Variables and Labels Used in Statistical Test

Dependent Variable (1)	***Measurement***	***Variable Label***
Residential fire rate, 2005	Number of residential fire per 1,000 population, 2005	f.r
Independent Variables (10)	***Measurement***	***Variable Label***
Climate (H_1)	Number of Heating degree days, 2005	hdd
Poverty (H_2)	Percentage of population below the poverty line, 2005	pov.r
Median household income (H_2)	Median household income (thousands of dollars), 2005	m.in
Parental presence (H_2)	Percentage of the population under 18 living with both parents, 2005	par.p
Under-education Rate (H_2)	Percent of the population over 25 without high school degrees, 2005	u.e.r
Number of Children and old people (H_2)	Sum of the percentage population under age 5yrs and the percent of population over 65yrs and over, 2005	c&o
Household size (H_2)	Percentage of households with >1 person per room, 2005	h.s
Vacancy rate (H_3)	Percent of vacant housing units	va.r
Building Age (H_3)	Percent of housing units built in 1939 or earlier	b.age
Housing tenure (H_3)	Percent owner-occupied housing units	tenure

Statistics Analysis

Existing data was used to test the three formal hypotheses. The correlation coefficient test was used to test the inter-correlation between variables. Some independent variables must be excluded from the multiple regression analysis if a strong correlationship is found. A multiple regression analysis was conducted to determine the impact of each independent variable on residential fire rates among sample cities. This statistical method was used to analyze the data, determined whether the hypotheses were supported or rejected. A Multiple regression analysis was also used to identify the factors that explained the greatest amount of difference in residential fire rates between cities (Traidata and NFDC, 1998, 12). The Statistical Package for Social Sciences (SPSS) was used to run the correlation test and multiple regression analysis.

Correlation Test

The first procedure was a correlation coefficient test. A Person's product-moment correlation is an appropriate measure of the correlation between interval variables (for example, age, income, and grade point average) (Babbie 2007, 455). The correlation is always between -1 and +1. As the correlation coefficient moves from zero in either direction, the strength of the association between the two variables increases (FEMA 2004, 59).

There are two uses for this test. First, using the correlation coefficient method to examine the association between dependent variables and independent variables helps to identify which independent variables can be predictors of the dependent variable. Second, if two or more independent variables are found to be highly correlated with each other – this is call multicollinearity – they must be excluded from the multiple regression analysis.[33] According to Johnson(1972, 160), multicollinearity would cause 1) difficulty to disentangle the relative influences of the various, because different variables measure the same thing 2) the coefficients to become very sensitive to particular sets of sample data; which implies that the addition of a few more observations would produce dramatic changes in the values of some of the coefficients.

Multiple Regression Analysis

The second procedure was a multiple regression analysis. This analysis was conducted to determine the impact of each independent variable on cities' residential fire rates. Multiple regression analysis is used to analyze how a given dependent variable is simultaneously affected by multiple independent variables (Babbie 2007, 455).

The F-test was used to test whether the regression model is statistical significantly or not. Adjusted R^2 value shows how much of the variance in the residential fire rate is explained by the regression model. The T-test was used to determine the value of the coefficient for each independent variable and the significance of each independent variable.

Chapter Summary

This chapter presented the methodology for testing the three hypotheses by using a multiple regression analysis to determine if a city's natural environments, population characteristics, and building characteristics influence residential fire rates. The next chapter discusses the results of the multiple regression analysis.

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[33] The reason is that when some or all of the explanatory variables are perfectly collinear, no linear dependence exists between the explanatory variables; and when some or all of the explanatory variables are highly but not perfectly collinear, assumption is only just satisfied   (Johnston1972, 160).

Chapter Four: Results

Chapter Purpose

This chapter presents the results of the multiple regression analysis used to examine how the natural environment, population, and building factors influence residential fire rates in 69 U.S cities. Table 4.1 shows the correlation between ten variables, and table 4.2 shows descriptive statistics.

Correlation Coefficient Test

The correlations between the dependent variable and independent variables

Running a correlation determines whether a multiple regression analysis is an appropriate statistical technique for the research. The correlation coefficient test quantifies the relationship between two independent variables. As Table 4.1 illustrates, three independent variables parental presence (-.543), vacancy rate (593), and building age (.599) show a strong correlation with the dependent variable residential fire rates. Three independent variables –heating degree days (.320), poverty rate (.442), and median income, (-.465) show a moderate correlation with the dependent variable residential fire rates. Two independent variables – percentage of number of children and old people, (.281) and household size (-.259), show a weak correlation with the dependent variable residential fire rates. One variable – under education rate – was not found to be associated with residential fire rates. Another independent variable – tenure housing tenure shows a week correlation with residential fire rates but is not statistically significant at either the on .05 or .01 level. Therefore, a multiple regression analysis is an appropriate method of statistical analysis for the next step.

Table 4.1
Correlation Matrix

	Fire Rate	*Heating degree days*	*Poverty rate*	*Median Income*	*Parental presence*	*Under-education rate*	*% of children & old*	*Vacancy rate*	*Household size*	*Building age*	*Tenure*
Fire rate	1	.320**	.442**	-.465**	-.543**	.001	.281*	.593**	-.259*	.599**	-.237
Heating degree days		1	.158	-.224	-.412**	-.351**	.002	.246*	-.437**	.607**	-.002
Poverty rate			1	-.895**	-.591**	.485**	.464**	.580**	.056	.493**	-.548**
Median Income				1	.612**	-.388**	-.604**	-.642**	.087	-.411**	.424**
Parental presence					1	.112	-.472**	-.634**	.439**	-.659**	.571**
Under-education rate						1	.336**	.001	.759**	.021	-.424**
% of children & old							1	.418**	-.090	.247*	-.278*
Vacancy rate								1	-.402**	.443**	-.220
Household size									1	-.173	-.279*
Building age										1	-.510**
Tenure											1

* Significant at alpha = .05
** Significant at alpha = .01
The labels for the variables are explained in Table 3.4

The correlations between independent variables

The results of the previous analysis indicated that some of the independent variables are high correlated. For example, as Table 4.1 displays, median income strongly correlated with poverty rate (-.895), parental presence, (.612), percentage of number of children and old people, (-.604), and vacancy rate, (-.642). The under education rate shows a strong correlation with household size, (759). Furthermore, other independent variables are also moderately or weakly correlated with each other.

Independent variables excluded from multiple regression analysis

Two principles were used to judge which independent variable should be excluded from the multiple regression analysis. The first principle used was that the independent variable was strongly correlated with other independent variables. The second principle used was that the independent variable could also not be correlated with the dependent variable after applying first principle.

After applying these two principles, two independent variables were excluded from the multiple regression analysis median income and under education rate. Although the other variable – tenure – could not found significantly different from zero, it should be still included the multiple regression because that "the true situation may be not that a variable has no effect but simply that the set of sample data has not enabled us to pick it up." (Jonson, 1972, 160)

Table 4.2
Residential Fire Rates: Descriptive Statistics

Variables	Range	Mean	Median	Standard Deviation
Fire rate (DV)	0.21 – 6.3	1.23	1.05	.972
Heating degree days (H_1)	149 – 7876	3459.1	3162.00	2.0
Poverty rate (H_2)	5.6 – 32.4	18.0	18.1	5.8
Median income (H_2)	24105 – 71560	42137.4	41829.0	9361.9
Parental presence (H_2)	7.7 – 24.8	15.2	15.0	3.9
Under education rate(H_2)	7.1 – 49.9	18.6	17.7	7.5
% children & old (H_2)	13.3 – 24.7	17.9	18.1	1.8
Household size (H_2)	0.7 – 28.8	4.6	3.1	4.3
Vacancy rate (H_3)	1.9 – 23.4	10.0	9.6	4.1
Building age (H_3)	0.06 – 71.35	18.1	10.0	18.4
Tenure (H_3)	23.2 – 73.1	54.1	55.7	9.3

Multiple Regression Analysis

Table 4.3 displays the multiple regression analysis results that test the impact of eight independent variables on cites' residential fire rates. The results of the adjusted R squared analysis demonstrate that 51.5% of the variance in the dependent variable – residential fire rate is explained by the eight independent variables. The significance ($p=.000$, <0.01) of the F ($f=7.97$) statistic indicates that there is a linear relationship between the residential fire rate and the eight independent variables.

Table 4.3
Residential Fire Rate: Multiple Regression Results

Independent Variables	Coefficient	Significance*
heating degree days	-.155	.265
poverty rate	.040	.780
parental presence	-.198	.336
% children and old people	-.027	.810
household size	.053	.739
vacancy rate	.330	.020*
building age	.543	.001**
housing tenure	.255	.140
Adjusted R Square	.515	________
F Statistic	7.96	.000**

* Significant at alpha = .05
** Significant at alpha = .01
The labels for the variables are explained in Table 3.4

Table 4.3 reveals that two building factors (H_3) –vacancy rate (*.020) and building age (**001) significantly influenced cities' residential fire rates. The building age (534) had more impact on residential fire rates than vacancy rate (330). No population (H_2) and natural environment (H_1) factors were found to significantly influence cities' residential fire rates.

The natural environment (H_1) was postulated to have an effect on cities' residential fire rates. The results did not support this hypothesis. Population characteristics (H_2) were predicted to have an effect on residential fire rates. The results did not support this hypothesis – none of the population factors selected in this study were found to significantly impact cities' residential fire rates. Building characteristics (H_3) were postulated to have an effect on residential fire rates. Two building factors – vacancy rate and building age – were found to significantly impact cities' residential fire rates. Another building factor – housing tenure – cannot be found to be significantly associated with residential fire rates.

Chapter Summary

This chapter discussed the results of the correlation test and multiple regression analysis. The correlation test results showed high correlation between some independent variables. The multiple regression analysis results showed that only two building variables significantly affected the cities' residential fire rates, and that population and natural environment variables did not significantly impact the cities' residential fire rates. Chapter five summarizes the findings of this study, suggests possible future research in this field, and describes weaknesses of this study.

Chapter Five: Conclusion

The purpose of this explanatory research is to evaluate the population and building characteristics that influence the residential fire rate in the large cities in the continental U.S. The first chapter introduced the research subject and discussed five fire causes of residential fire associated with human behaviors. Chapter two reviewed the scholarly literature that used the multiple regression approach to analyze how population/building characteristics influence cities' residential fire rates. Based on these empirical studies and Jennings' fire ignition and fire loss model, a conceptual framework was developed to test the following research hypotheses.

H_1: There is a relationship between the city residential fire rate and the natural environment.

H_2: There is a relationship between the city residential fire rate and the population characteristics.

H_3: There is a relationship between the city residential fire rate and the building characteristics.

Chapter three discussed the methodology used in this research to test these three formal hypotheses. The conceptual framework was operationalized. The correlation analysis tested the correlation between ten variables. The multiple regression analysis evaluated the existing data to determine whether independent variables impacted cities' residential fire rates.

Chapter four discussed the results of the statistical analysis. Two building characteristics – vacancy rate and building age – were found to significantly influence residential fire rates. The relationship between vacancy rate and residential fire rates was positive. The positive relationship between vacancy rate and residential fire rates indicated that cities with higher building vacancy experienced higher residential fire rates.

The relationship between building age and residential fire rates was also positive. The positive relationship between building age and residential fire rates indicated that the cities with more old residential buildings experienced higher residential fire rates. None of the population and natural environment variables were found to significantly impact residential fire rates. Table 5.1 shows whether each hypothesis was supported or rejected by the analysis.

Table 5.1
Hypotheses Tests Summary

Variables/Hypotheses			**Expected Direction (+/-)**	**Evidence (Support/Failed to Support)**
<u>Dependent Variable</u>				
City residential fire rates				
<u>Independent Variables</u>				
H1:Environment	Climate		–	Failed to Support
H2: Population Characteristics	Household Economic Status	Poverty	+	Failed to Support
		Median household income	(Excluded)	
	Household and Social Structure	Parental presence	–	
		Under-education rate	(Excluded)	
	Household Demographic	Number of children and old people	–	
		Household size	+	
H3: Building Characteristics	Vacancy rate		+	Partial Support
	Building Age		+	
	Housing tenure		+	

Cities' Fire Rate Comparison

Table 5.2 displays the 69 cities' residential fire rates, vacancy rates, and the percentage of structures built before 1939 with residential fire rates ranked from highest to lowest. To demonstrate the how building/population characteristics impact residential fire rates, Karter and Donner (1978, 62-65) divided the census tracts into high risk and low groups. Similarly, to demonstrate the impact of vacancy rates and building age on cities residential fire rates, the study divided the cities into two groups – the high risk group and the low risk group – according to the mean value of the vacancy rate and building age. See Table 5.3.

The vacancy rate was defined as the percentage of vacant buildings. A city with 1.9% to 10.0% vacant buildings was placed in the low risk group. A city with 10.1% to 23.4% of vacant buildings was placed in the high risk group. The cities in the high risk group experienced 1.6 residential fires per 1,000 people. The cities in the low risk group experience 0.9 residential fires per 1,000 people. The mean fire rate in the high risk group was 1.8 times higher than the mean fire rate in the low risk group.

Building age was defined as the percentage of building structures built before 1939. A city which had 0.06% to 18.1% of the building constructed before 1939 was placed in the low risk group. A city which had 18.2% to 71.35% of building constructed before 1939 was placed in the high risk group. The cities in the high risk group experienced 1.7 residential fires per 1,000 people. The cities in the low risk group experience 1.0 residential fire per 1,000 people. The mean fire rate in the high risk group was 1.7 times higher than the mean fire rate in the low risk group.

Table 5.2
Residential Fire Rate, Vacancy Rate, and Building Age Data Matrix

City	***State***	***Residential fire rate***	***Vacancy rate***	***Building age***
St. Louis.1	MO	6.30	19.8	60.5
Boston.2	MA	3.34	8.1	59.2
Birmingham.3	AL	3.02	17.5	16.9
Buffalo.4	NY	2.88	16.8	71.4
Baltimore.5	MD	2.61	17.4	39.6
Cincinnati.6	OH	2.43	18.8	45.4
Dallas.7	TX	2.27	13.6	6.3
Toledo.8	OH	2.23	14.0	34.3
Minneapolis.9	MN	2.22	8.5	52.2
St. Paul.10	MN	2.21	8.7	49.6
Kansas City.11	MO	2.13	13.7	25.3
Cleveland.12	OH	2.12	17.2	56.9
Memphis.13	TN	1.95	12.5	9.9
Akron.14	OH	1.82	13.3	37.3
Tampa.15	FL	1.81	9.6	10.3
San Francisco.16	CA	1.72	9.2	52.2
Orlando.17	FL	1.70	7.6	3.9
Bakersfield.18	CA	1.61	6.4	4.9
Tulsa.19	OK	1.56	12.0	8.5
New Orleans.20	LA	1.54	23.4	28.1
Wichita.21	KS	1.54	11.9	12.7
Columbus.22	OH	1.31	15.7	13.4
Garland.23	TX	1.31	7.5	0.6
Oklahoma.24	OK	1.25	10.6	8.9
Raleigh.25	NC	1.25	10.7	3.0
Fort Worth.26	TX	1.23	10.1	8.6
Omaha.27	NE	1.22	8.1	24.6
Madison.28	WI	1.21	7.6	15.3
Miami.29	FL	1.20	11.5	12.6
Louisville/Jefferson.30	KY	1.19	9.5	17.0
Lexington-Fayette.31	KY	1.18	10.3	10.0
Chesapeake.32	VA	1.12	1.9	2.9
Denver.33	CO	1.09	10.0	22.5
Charlotte.34	NC	1.06	11.0	3.4
Portland.35	OR	1.05	7.0	31.9
Nashville-Davidson.36	TX	1.04	9.6	6.5
Las Vegas.37	NV	1.02	10.3	0.5
Corpus Christi.38	TX	0.95	9.6	4.5
Sacramento.39	CA	0.93	7.3	12.2
Oakland.40	CA	0.80	9.4	43.9
Virginia Beach.41	VA	0.78	5.9	1.0
Long Beach.42	CA	0.77	5.5	19.0
Los Angeles.43	CA	0.77	5.3	19.6

Table 5.2(continued)
Residential Fire Rate, Vacancy Rate, and Building Age Data Matrix

City	***State***	***Residential fire rate***	***Vacancy rate***	***Building age***
Albuquerque.44	NM	0.76	5.6	3.6
Houston.45	TX	0.76	12.5	5.8
Austin.46	TX	0.69	8.8	2.7
Washington.47	DC	0.66	10.6	35.9
Plano.48	TX	0.62	6.6	0.1
San Antonio.49	TX	0.61	9.6	6.0
Milwaukee.50	WI	0.59	8.7	39.3
Seattle.51	WA	0.54	6.1	32.3
Chicago.52	IL	0.53	12.8	44.1
Phoenix.53	AZ	0.51	9.4	2.0
Santa Ana.54	CA	0.50	2.8	6.6
Newark.55	NJ	0.48	9.0	31.3
Riverside.56	CA	0.46	4.7	8.3
El Paso.57	TX	0.42	7.0	4.9
Indianapolis.58	IN	0.42	13.0	18.4
Aurora.59	CO	0.40	10.1	0.7
Baton Rouge.60	LA	0.40	12.2	5.8
Chula Vista.61	CA	0.37	5.7	1.6
San Diego.62	CA	0.37	7.0	7.6
Arlington.63	TX	0.34	10.4	0.4
Fresno.64	CA	0.33	5.7	6.9
Lincoln.65	NE	0.29	6.1	15.7
Glendale.66	AZ	0.27	7.4	0.8
Henderson.67	NV	0.25	9.7	0.1
Anaheim.68	CA	0.23	4.6	1.9
Chandler.68	AZ	0.21	6.4	0.3

Table 5.3
Comparison of Fire Cause Factors and Fire Rate

	Vacancy Rates	**Building age**
	Mean fire rates	***Mean fire rates***
High risk group	**1.6**	**1.7**
Low risk group	**0.9**	**1**

Top 20 Cities with Highest Residential Fire Rates and Their Coordination

Table 5.4 displays the top 20 cities with the highest residential fire rates and their geographic coordination. Exhibit 5.1 shows all 69 cities' positions on the U.S map – the top 20 cities with the highest residential fire rates are marked with "fire" icons. In Exhibit 5.1, the 18 cities which were marked "fire" icons are located east of -97 degree longitude, and only two cities are located west of -97 degree longitude.

Table 5.4
The Top 20 Cities with Highest Residential Fire Rates and Their Geographic Coordination

City	State	Latitude	Longitude	Fire Rate
1. St. Louis	MO	38.46	-92.30	6.30
2. Boston	MA	42.35	-71.05	3.34
3. Birmingham	AL	33.51	-86.81	3.02
4. Buffalo	NY	42.88	-78.87	2.88
5. Baltimore	MD	39.29	-76.61	2.61
6. Cincinnati	OH	39.09	-84.51	2.43
7. Dallas	TX	32.78	-96.79	2.27
8. Toledo	OH	41.65	-83.57	2.23
9. Minneapolis	MN	44.977	-93.26	2.22
10. St. Paul	MN	44.94	-93.10	2.21
11. Kansas City	MO	39.09	-94.58	2.13
12. Cleveland	OH	41.49	-81.69	2.12
13. Memphis	TN	35.14	-90.05	1.95
14. Akron	OH	41.08	-81.51	1.82
15. Tampa	FL	27.98	-82.45	1.81
16. San Francisco	CA	37.77	-122.41	1.72
17. Orlando	FL	28.55	-81.36	1.7
18. Bakersfield	CA	35.37	-119.01	1.61
19. Tulsa	OK	36.13	-95.97	1.56
20. New Orleans	LA	29.95	-90.06	1.54

Exhibit 5.1
69 Cities in Study

*  are the top 20 cities with the highest residential fire rates

*  are the cities that selected in this study

Residuals and Outliers

The residual is the difference between the dependent variable's observed value and the predicted value (Residual=observed value – predicted value). According to Cook and Weisberg (1982, 1, 2), a scatter plot of residuals versus fitted values helps identify the outliers that can narrow the gap between theory and practice. Outliers indicate "conditions under which a process works differently, possibly worse or better" (Cook and Weisberg 1982, 2), which helps researchers identify important unnoticed phenomena.

Outlying cases have greater scientific importance than the bulk of the data (Cook and Weisberg 1982, 2). In this study, the outliers are those cities' observed residential fire rates that are significantly higher or lower than the predicted values. Those cities with observed residential fire rates value lower than predicted value are worth studying because that management practices may have affect risk factors. Hence, others can learn from their fire prevention efforts. Likewise, those cities with observed residential fire rates value higher than their predicted value need to be examined to see why they are at risk of fire in spite of low vacancy rate and a relatively young residential building structures. The predicted value for the 69 cities' residential fire rate were obtained by running SPSS 16.0 on one dependent variable (residential fire rates) and eight independent variables (same variables used in multiple regression analysis).

Table 5.5 presents the residential fire rate's observed value, predicted value, and residual value in 69 cities ordered by residual values from the largest to the smallest. Cities with positive residual values have observed residential fire rates higher than the predicted value, which indicated that those cities were worse in fire prevention efforts than expected. Cities with negative residual values have observed residential fire rates lower than the predicted value, which indicated that those cities were better in fire prevention effort than expected. Table 5.5 shows that St. Louis, Boston, Dallas, Orlando, and Bakersfield are the five cities with the highest residuals value. Chicago, New Orleans, Washington, Baton Rouge, and Indianapolis are the five cities with the lowest residuals value.

Table 5.5
The residential fire rates' observed value, predicted value, and residuals value in 69 cities

City	*State*	*Observed Value*	*Predicted Value*	*Residuals*
St. Louis	MO	6.30	3.30	3.00
Boston	MA	3.34	1.91	1.43
Dallas	TX	2.27	1.07	1.20
Orlando	FL	1.70	0.52	1.18
Bakersfield	CA	1.61	0.59	1.02
Birmingham	AL	3.02	2.08	0.94
Chesapeake	VA	1.12	0.37	0.75
Garland	TX	1.31	0.68	0.63
Madison	WI	1.21	0.65	0.56
Tampa	FL	1.81	1.30	0.51
Memphis	TN	1.95	1.47	0.48
Wichita	KS	1.54	1.11	0.43
St. Paul	MN	2.21	1.80	0.41
Tulsa	OK	1.56	1.18	0.38
Kansas City	MO	2.13	1.77	0.36
Raleigh	NC	1.25	0.91	0.34
Minneapolis	MN	2.22	1.91	0.31
Virginia Beach	VA	0.78	0.49	0.29
Fort Worth	TX	1.23	1.02	0.21
Las Vegas	NV	1.02	0.81	0.21
Santa Ana	CA	0.50	0.29	0.21
Albuquerque	NM	0.76	0.58	0.18
Lexington-Fayette	KY	1.18	1.01	0.17
Plano	TX	0.62	0.46	0.16
Omaha	NE	1.22	1.08	0.14

Table 5.5 (continue)
The residential fire rates' observed value, predicted value, and residuals value in 69 cities

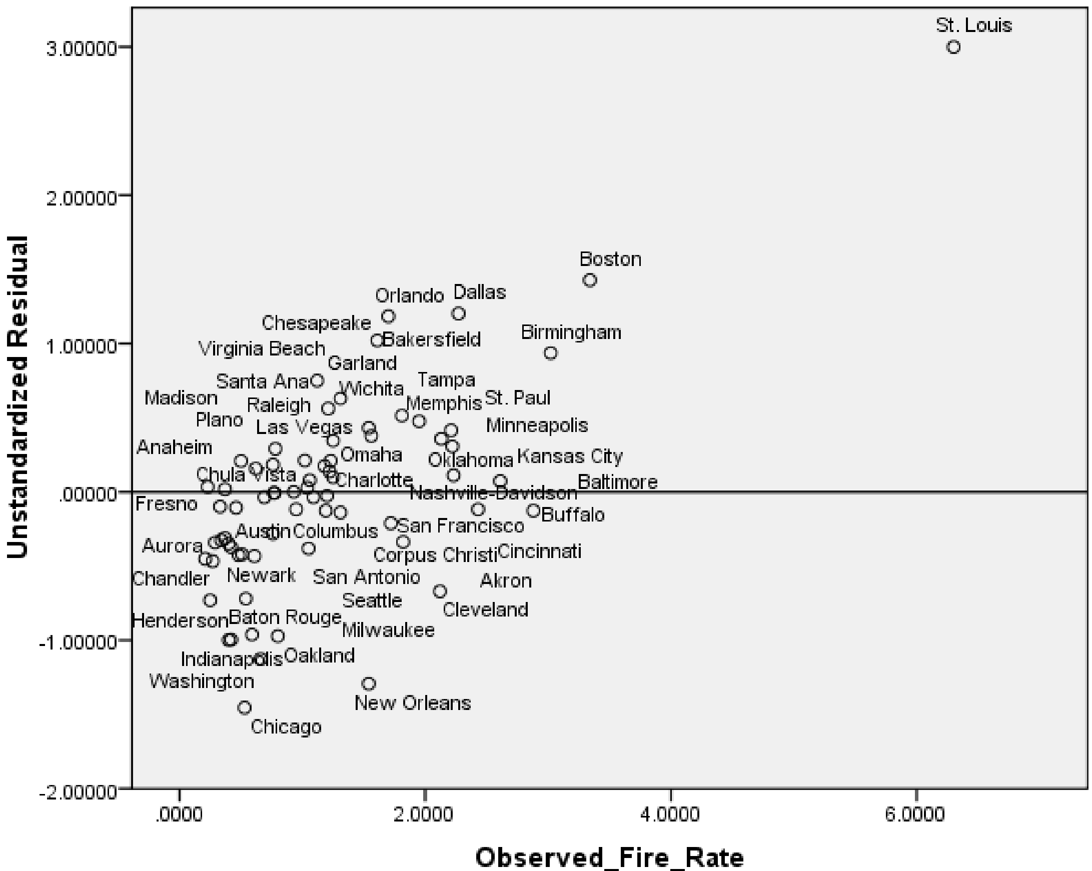
Toledo	OH	2.23	2.12	0.11
Oklahoma	OK	1.25	1.15	0.10
Charlotte	NC	1.06	0.98	0.08
Baltimore	MD	2.61	2.54	0.07
Anaheim	CA	0.23	0.20	0.03
Nashville-Davidson	TX	1.04	1.01	0.03
Chula Vista	CA	0.37	0.35	0.02
Sacramento	CA	0.93	0.93	0.00
Los Angeles	CA	0.77	0.77	0.00
Long Beach	CA	0.77	0.78	-0.01
Miami	FL	1.20	1.23	-0.03
Denver	CO	1.09	1.12	-0.03
Austin	TX	0.69	0.73	-0.04
Fresno	CA	0.33	0.43	-0.10
Riverside	CA	0.46	0.57	-0.11
Corpus Christi	TX	0.95	1.07	-0.12
Cincinnati	OH	2.43	2.55	-0.12
Buffalo	NY	2.88	3.01	-0.13
Louisville/Jefferson	KY	1.19	1.32	-0.13
Columbus	OH	1.31	1.45	-0.14
San Francisco	CA	1.72	1.93	-0.21
Houston	TX	0.76	1.04	-0.28
San Diego	CA	0.37	0.68	-0.31
Arlington	TX	0.34	0.66	-0.32
Akron	OH	1.82	2.16	-0.34
Lincoln	NE	0.29	0.63	-0.34
Aurora	CO	0.40	0.75	-0.35
El Paso	TX	0.42	0.79	-0.37
Portland	OR	1.05	1.43	-0.38
Phoenix	AZ	0.51	0.93	-0.42
Newark	NJ	0.48	0.91	-0.43
San Antonio	TX	0.61	1.04	-0.43
Chandler	AZ	0.21	0.66	-0.45
Glendale	AZ	0.27	0.73	-0.46
Cleveland	OH	2.12	2.79	-0.67
Seattle	WA	0.54	1.26	-0.72
Henderson	NV	0.25	0.98	-0.73
Milwaukee	WI	0.59	1.55	-0.96

Table 5.5 (continue)
The residential fire rates' observed value, predicted value, and residuals value in 69 cities

Oakland	CA	0.80	1.77	-0.97
Indianapolis	IN	0.42	1.42	-1.00
Baton Rouge	LA	0.40	1.40	-1.00
Washington	DC	0.66	1.79	-1.13
New Orleans	LA	1.54	2.83	-1.29
Chicago	IL	0.53	1.98	-1.45

Figure 5.1 displays the scatter plot of the 69 cities in the study used to identify the outliers. The Y-Axis represents the predicted value of the residential fire rate. The X-Axis represents the unstandardized residual. A reference line was drawn at y=0. In Figure 5.1, those cities with the higher positions above the reference line and with the higher x values are the cities doing worse in residential fire prevention – for instance, St. Louis, Boston, Dallas, and Birmingham. St. Louis seems to have bigger residential fire problems than other cities. These cities should be examined to see what problems existing in the fire prevention effort, and what other factors might impact their residential fire rate in the future. The cities with the lower position below the reference line and with smaller x values are the cities doing better in residential fire prevention, such as, Chicago, Baton Rouge, and Indianapolis. These cities should be examined to see what fire prevention efforts have been used, which can benefit those cities with more server residential fire problems.

Figure 5.1
The scatter plot of the 69 cities in the study used to identify the outliers



Economic Downturn and Fire Prevention

The United States housing bubble and the high default rates on “subprime” and adjustable rate mortgages triggered the subprime mortgage crisis in 2007. During 2007, nearly 1.3 million U.S housing properties were subject to foreclosure activity, up 79% from 2006. This crisis finally grew into a global financial crisis. Millions of people lost their homes, the unemployment rates rose to their highest since 1983, and the Dow fell to its lowest level since 1997.

During the economic downturn, this research has three messages for local governments. First, fire prevention efforts should focus more on areas with high vacancy rates and old building structures. Second, although population characteristics were not found to impact residential fire rates in this study, areas with high unemployment rates and poverty rates still have high fire risk according to previous empirical studies. Third, fire education can not be restricted to schools. People who live in areas with higher poverty rate, more young people, and low education rates should be targeted for fire education.

Strengths and Weaknesses

This study has three strengths.

1. It is the first study to use Jennings' fire ignition and fire loss model to examine the factors impacting cities residential fire rats.
2. It is the first study to compare factors impacting residential rates in more than ten cities. Previous empirical studies restrict their sample to few cities or census tracts within a city.
3. It shows that two building characteristics (vacancy rate and building age) significantly impact residential fire rates. The result demonstrates that "certain community characteristics not controllable by the fire department are related to the fire rate" (Schaenman, et al. 1977, 63).

This study has two major weaknesses.

1. It only examined 69 cities. This is a small percentage of U.S cities and does not include any median or small cities.
2. The hypotheses did not fully address the sheer scope of the research question.

This study only examined how six population factors and three building factors impact cities residential fire rates. Many other population/building characteristics were not examined in the study.

Suggestions for Future Research

Future research on population/building factors that influence residential fire rates should study more cities. Follow-up studies should also select mid-size and small U.S cities. Southern and northern cities' residential fire rates should be compared to assess the impact of climate.

Future studies should include more dependent variables and independent variables. The only dependent variable tested in this study was the residential fire rate. Future studies should also examine fire causes that have been found to be associated with human behaviors. For example, children playing with fire rates, arson fire rates, cooking fire rates, and heating fires rates, should be tested as dependent variables. Also, other population and building characteristics such as, unemployment rate, race, poverty value, rental price, should be examined. Studying these additional dependent and independent variables will help local governments design more effective fire prevention policies. Future studies should also examine the "outliers" founded in this study. Those cities with observed residential fire rates value lower than predicted value are worth studying because that management practices may have affect risk factors. Hence, others can learn from their fire prevention efforts. Likewise, those cities with observed residential fire rates value higher than their predicted value need to be examined to see why they are at risk of fire in spite of low vacancy rate and a relatively young residential building structures.

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Appendix A
NFIRS Residential Structure Fires Codes

Residential Structures
Residential structure fires are defined as fires that occur in structures on residential properties. In terms of NFIRS data, these fires are defined as:

Incident types 111 to 123:
111–Building fire;
112–Fires in structure other than in a building;
113–Cooking fire, confined to container;
114–Chimney or flue fire, confined to chimney or flue;
115–Incinerator overload or malfunction, fire confined;
116–Fuel burner/boiler malfunction, fire confined;
117–Commercial compactor fire, confined to rubbish;
118–Trash or rubbish fire, contained;
120–Fire in mobile property used as a fixed structure, other;
121–Fire in mobile home used as fixed residence;
122–Fire in motor home, camper, recreational vehicle; and
123–Fire in portable building, fixed location.
(Note that incident types 113 to 118 do not specify if the structure is a building.)

Property use 400 to 499:
400–Residential, other;
419–1 or 2 family dwelling;
429–Multifamily dwelling;
439–Boarding/Rooming house, residential hotels;
449–Hotel/Motel, commercial;
459–Residential board and care;
460–Dormitory-type residence, other;
462–Sorority house, fraternity house; and
464–Barracks, dormitory.

Appendix B

Carter, Kathleen <kathleen.carter@dhs.gov> **Thu, Jan 15, 2009 at 8:01 AM**

To: kaihuang@txstate.edu

Cc: "Pabody, Brad" <brad.pabody@dhs.gov>

Mr. Huang:

Thank you for your email to the United States Fire Administration. I would be more than happy to send you the 2005 NFIRS data CD. Below is a bit more information regarding NFIRS and the database. Please send me your mailing address and I can get the CD out to you today.

Thanks!

Kate

NFIRS is a voluntary system, and it includes only those fire incidents reported to the system by fire departments that report to NFIRS. Also, not all States participate in NFIRS, and all fire departments that report to NFIRS within a State do not necessarily report all of their fire incidents. Additionally, some fire departments that report fire incidents do not report associated casualties. States and/or fire departments that report in one particular year may not report to NFIRS the following year. Therefore, NFIRS is not representative of all fire incidents in the United States and is not a census of fire incidents or casualties.

Each fire department in the database has a unique id referred to as the FDID. The FDIDs are unique within a State. You will need to use the following fields as the unique incident key to link the basic incident file to the fire incident file: STATE, FDID, INC_DATE, INC_NO, and EXP_NO.

The U.S. Fire Administration (USFA) defines all fires using the following fields and codes from the basic incident file: incident type(INC_TYPE) codes 100-173. You will probably want to exclude mutual aid incidents (AID not equal to '3' AND AID not equal to '4') to avoid double counting fires.

For more information about NFIRS, please visit the following web page:

http://www.nfirs.fema.gov/index.shtm. For information regarding the NFIRS codes, you may download the NFIRS 5.0 Complete Reference Guide from the following USFA web page:

http://www.nfirs.fema.gov/documentation/reference/ . The reference guide is also included on the cds. The NFIRS cause category matrix

can be found
at: http://www.usfa.dhs.gov/fireservice/nfirs/tools/index.shtm

USFA is currently revising this matrix, but it is not yet available for release.

For information about the methodologies used in analyzing NFIRS data, please refer to Chapter 1 of Fire in the United States 1995-2004 14th

Edition: http://www.usfa.dhs.gov/statistics/reports/fius.shtm

If you wish to use NFIRS to compute national estimates in your analyses, you may want to review the article "The National Estimates Approach to U.S. Fire Statistics" by Hall and Harwood. A free copy of this article may be downloaded from the following National Fire Protection Association's (NFPA) Web page:

http://www.nfpa.org/assets/files/PDF/Research/Nationalestimates.pdf

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kai huang <hhkkhhkk@gmail.com> **Fri, Jan 16, 2009 at 4:04 AM**

To: "Carter, Kathleen" <kathleen.carter@dhs.gov>

Mr. Carter,

Thanks for your helping. The information and comments you give are valuable for this research. The major data I need is the number of residential fire in the 89 cities of the U.S in 2005. I have check several state martial offices; however, as you mentioned that many cites' fire department did not report to the system. What make me interested is that the data directly obtained from some fire departments are not consistence with the data comes from system. That is not a surprise because it is a voluntarily participated system. However, for a research, I would like my data all come from same source, so the CD you provide are extremely important and valuable for me.

I really appreciate you taking time. Have a great day.

--
Texas State University-San Marcos
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Kai Huang

Appendix C[34]

Foxpro Program Code Used to Extract Residential Fire Numbers of 89 U.S Cities from NFIRS CD Data Set

```
Use c:\temp\basicincident
set safety off
create table c:\temp\fd2 free (fdid c(5) )
select fd2
*c:\temp\fd1.xls is excel 95 spreadsheet with one column which lists all of the 69 fdid codes use
in this study
append from c:\temp\fd1 type xls
select inc_type, prop_use,state,fdid from basicincident into table c:\temp\basic
select basic
select * from  basic ;
where inc_type in ('111','112','113','114','115','116','117','118','120','121','122','123') ;
into table c:\temp\c1
select * from c1 where prop_use in ('400','419','429','439','449','459','460','462','464') ;
into table c:\temp\basic2
select * from basic2 ;
where fdid in (select fdid from fd2) ;
into table c:\temp\basic3
select state,fdid, count(fdid) as count1 from basic3 ;
group by state,fdid ;
into table c:\temp\basicg
select basicg
copy to c:\temp\basicg2 type xls
browse
```

[34] This Foxpro code was written under the assistants of Don Castiglioni, who is working at Texas Travis County Attorney's Office