The Effects of Earthquake Retrofit on the Resale Value of Single-Family Dwellings

by

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Abstract

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Thesis directed by Research Professor Keith Porter

Seismic retrofits aim to reduce future damage caused by earthquakes, which in turn reduce the cost of rebuilding. This research asks the question: does seismic retrofit affect the resale value of single-family dwellings? Using only publicly available real estate sales listings and other public databases, location, price, and market features of retrofitted and non-retrofitted homes in California were collected and tabulated. The data were then examined through multivariate linear regression analysis to quantify the effect that retrofit has on the resale value of single-family dwellings. In the analysis, the resale value acted as the dependent variable. Retrofit and other home features such as size, number of bedrooms, number of bathrooms, neighborhood household income, and others acted as the independent variables. The analysis suggests that in 2020 in California, seismic retrofit increases the resale value of home by 9.85%, significantly higher than the average cost to perform the retrofit. Equipped with this knowledge, lawmakers, engineers, and real estate professionals can entice existing and new homeowners to consider the benefits of seismically retrofitting their homes.

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Chapter 1: Introduction

1.1 Background

The United States faces risk from earthquake-induced property damage and loss of home habitability. In April of 2017, USGS and FEMA released a joint study of annualized earthquake loss (USGS, 2017). According to the FEMA P-366 report, earthquakes are expected to cost the U.S. an estimated value of $6.1 billion in building stock losses per year. The high cost of rebuilding after U.S. earthquakes is due disproportionately to older buildings. According to the 2016 American Community Survey, approximately half of homeowners live in structures that were built before 1980 (Zhao, 2018). The data also show that even though 3 million new homes were built between 2010 and 2016 across the country, they only represent 4% of home stocks nationwide.

Buildings that comply with newer building-code provisions are generally expected to experience less severe earthquake damage. Many of the features that make older buildings more vulnerable have been well known for several decades, and guidelines exist for how to identify seismically vulnerable buildings and retrofit them (see section 2.6). Governments have found the issue serious enough to offer incentives for seismic retrofit, such as the Seismic Retrofit Refund Program created by the City of Berkeley (see section 2.3).

However, since few governments require seismic retrofit of most homes, even in highly seismic regions like the State of California, it seems likely that a large future earthquake could damage a large number of single-family dwellings severely enough to render them uninhabitable. There are a variety of reasons that homeowners might not consider retrofit. They might not expect a high magnitude earthquake during their lifetime. They are unable to afford retrofit. Or they may believe that their property is not prone to severe shaking during an earthquake. Many people might only see retrofit as a system to help minimize earthquake damage rather than a financial investment for the future. But does seismic retrofit provide a positive return on investment, even if an earthquake does not occur during the owner's holding period?

1.2 Objectives

This thesis quantifies the market value of seismic retrofit for single-family dwellings in California in 2020. The value is expressed by the increase in resale price of retrofitted versus non-retrofitted homes. The value is inferred by multivariate linear regression analysis of resale price as a function of a binary independent variable for seismic retrofit and several other quantitative features of the house deemed significant for pricing purposes and reported on a publicly available listing service. Data are drawn from listing of homes for sale during the research.

1.3 Organization of this Thesis

Chapter 2 provides a summary of literature related to the thesis objective. Some of these topics are as follows: approaches to home valuation, past government expressions of the value of seismic retrofit, and past market expressions of the value of retrofit. Chapter 3 presents the analytical procedure employed: how the data of this study were collected and the mathematical method used to get the result.

Chapter 4 summarizes the data collected to conduct this study. It provides details of their geographic distribution and some statistics of their attributes. Chapter 5 presents the result and conclusion of the multivariate linear regression analysis. It presents limitations, novelties, and suggests future research needs to build upon or improve the study.

Following the References section, two appendices are presented. Appendix A offers examples of an approach to home valuation. Appendix B provides the data used in this study.

Chapter 2: Literature Review

2.1 Approaches to Home Valuation

This thesis examines whether seismic retrofit increases the resale value of homes that can be affected by earthquakes. Home valuation is an aspect of real estate appraisal. Real estate appraisers use three approaches to value real property: (1) review the price of similar recently sold real estate, (2) consider the cost to acquire the land and build improvements, and (3) estimate the income the property generates. Ling and Archer (2017) offer a standard text on the subject, summarized next.

2.1.1 The Sales Comparison Approach (SCA)

This approach is commonly used by estate agents and appraisers to find the value of a property by comparing it to similar properties that have been sold in the same area or neighborhood. This approach makes use of the economic principle of substitution, which suggests that the value of a given property can be determined by the price a buyer would pay for a different property with similar features (Ling & Archer, 2017, p.168). However, since it is difficult to find two properties that are exactly the same--from the material used on construction to the features available--one adjusts the sale price of the comparable properties to account for the features that differ from the subject property. That is, the SCA has four steps: (1) identify the characteristics of comparison and the value of adjustment of each, (2) identify comparable properties, (3) adjust their sale price based on the subject property characteristics, and (4) Find the sale price of the subject property (Ling & Archer, 2017, p.169).

When determining the value of adjustment for home characteristics, there are many methods, one of which is multivariate linear regression analysis (e.g., Maina, N.D.). This versatile pricing method does not require the subject property and comparable properties to be identical in all important characteristics. Moreover, the approach quantifies the influence of each selected comparable feature on the final result.

Appendix A presents two examples of the sale comparison approach. The first example employs a weighted approach. This approach weights the sales price of comparable properties according to how similar they are to the subject property. The more similar, the greater the weight. The second example calculates the value of the subject property by simple averaging of the present value of all comparable properties.

2.1.2 The Cost Approach

In this approach, the appraiser evaluates property by estimating the cost to build improvements (buildings, ancillary structures, landscape architecture, etc.) and adding land cost. Estimating the value of land is the simplest part in this approach compared to estimating cost of construction. There are two ways to evaluate the cost of construction: reproduction costs or replacement costs. The reproduction cost is the cost to rebuild the subject property down to the smallest detail and using the same materials, methods, and appliances. The replacement cost is the cost to rebuild using modern construction material and design, which can eliminate outdated elements. Reproduction cost may be impractical if the subject property was built using methods and materials that are unavailable or not legally allowed. Replacement cost is the more used method in the cost approach. In the case of an older property, the appraiser should account for accrued depreciation, the difference between the value of the property and cost of its new construction.

2.1.3 The Income Approach

This approach values property based on the income it generates. This method is mainly used on revenue-generating property such as apartment buildings, office buildings, and malls. The income approach has three main methods: direct capitalization, discounted cash flow analysis, and gross income multiplier (Ling & Archer, 2017, 192). By these methods, the appraiser tries to calculate the property's net operating income, which is the property revenue minus operating expenses. However, this approach focuses mainly on property income, which does not account for property conditions and future changes.

2.2 Discount Rate and Inflation

Property valuation usually involves the time value of money: the present value of currency in the past (as in past sales) or of currency in the future (such as future income). One way to account for the time value of money, and to convert past sale prices to present dollars, is to use a discount rate based on inflation.

The price that would have been paid today is estimated based on the price paid in some past year, inflated using a discount rate such as the annual change in the Consumer Price Index or the annual return on an alternative investment opportunity.

Depending on the system in question the real discount rate for the system could be on the order of 3% to 7% (Office of Management and Budget, 2003), but can be higher or lower if one uses the cost of borrowing (such as the rate on a home equity line of credit). The present value of money in the past can be estimated using a measure of inflation such as the Consumer Price Index (U.S. Bureau of Labor Statistics, 2020).

Note that home prices are only a part of the Consumer Price Index, so a better choice to account for the time value of money might be simply to use year of sale as an independent variable in a multivariate linear regression analysis of sale price in the current year.

2.3 Retrofit Construction and Cost Information

This study focuses on inferring the added market value resulting from a seismic retrofit, but what is involved in the seismic retrofit and what does it cost the owner?

FEMA P-1100 (Federal Emergency Management Agency, 2019) is a pre-standard that provides the information needed to identify and retrofit specific seismic vulnerabilities in one- and two-family wood frame dwellings. Older dwellings in earthquake country commonly need one or more of the following improvements: add bolts to connect the foundation to the sill plate; add structural sheathing to the short stud wall (called the cripple wall) between the sill plate and the underside of the first-floor framing; and add connections between the top plate of the cripple wall and the first-floor framing (Figure 1A). In the case of a house whose first-floor framing rests on the foundation, one adds connections from the sill plate to the foundation and from the sill plate to the first-floor framing (Figure 1B). Its purpose is to improve public safety in light wood structures in earthquake-prone areas. The retrofits aim to reduce earthquake damage, not to prevent it. Moreover, as the pre-standard is not enforced or adopted by reference in model codes, other alternative approaches to retrofit the same vulnerabilities are accepted as long as approved by building officials.

A. B.

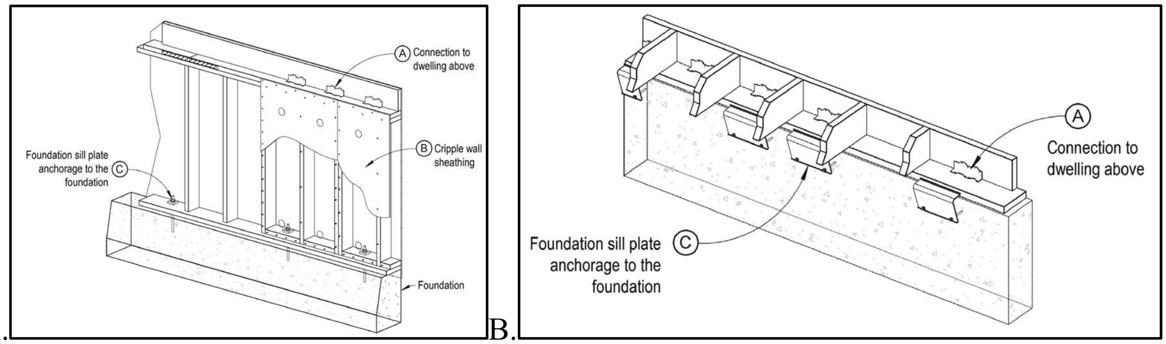

Figure 1. Elements of a seismic retrofit for a single-family dwelling according to FEMA P-1100 (Federal Emergency Management Agency, 2019, p. 4-2)

The cost depends on the property and the method of retrofit. The California Residential Mitigation Program (California Residential Mitigation Program, 2020), a joint effort of the California Earthquake Authority and the California Governor's Office of Emergency Services, estimates that the cost to retrofit a typical home can range from $3,000 to $7,000. Homes only in need of bolting the foundation would cost the owner around $3,000. Another source, fixr.com (2020), suggests a broader cost range: as low as $1,500 or as high as $10,000.

2.4 Past Government Expressions of the Value of Seismic Retrofit for Single Family Dwellings

Governments sometimes place a value on seismic retrofit. One of the first cities in California to show interest in the value of seismic retrofit was Berkeley in 1989 (Building and Safety, 2019). The City of Berkeley incentivized its residents to seismically retrofit their homes by creating the Seismic Retrofit Refund Program. This program allows homeowners to be refunded up to 1.5% of their base transfer tax rate if they voluntarily seismically retrofit their home following the proper guidelines set by the code. The 1.5% transfer tax resembles a city expression of the value of seismic retrofit similar to the cost approach of property valuation.

After the 1994 Northridge earthquake, the State of California created The California Housing Rehabilitation Program (CHRP; Federal Emergency Management Agency, 1994, 88).

Under this temporary program, the state provided low-interest loans for various types of property and focused on rental properties, helping fund their rehabilitation and retrofit effort after the Northridge earthquake. The CHRP loans had an interest rate of 3% and a minimum repayment period of 20 years, compared to the regular loans at the time that had an interest rate of around 8%. The difference can be seen as an expression of the value that retrofit provides to the state, through its willingness to pay. With this information, one can estimate how much property owners have saved by going with CHRP loans rather than regular loans. For example, if a property owner uses a CHRP loan of one million dollars, after 20 years they would have saved around four hundred thousand dollars, compared to a commercial bank loan.

Then in 1996, the California Earthquake Authority (CEA) was established as a privately funded publicly operated earthquake insurance company. The CEA provides homeowners incentives to retrofit their homes through grants and premium discounts. The CEA provided two types of programs that help homeowners who are eligible for a grant to retrofit their homes. They are the CEA Brace + Bolt and the Earthquake Brace + Bolt programs (Brace and Bolt Grants, n.d.). Under both programs, the CEA offers a grant of up to $3,000. Furthermore, if homeowners properly retrofit their homes and hold an insurance policy with the CEA, they can apply for a premium discount of up to 25%. Both the grants and the premium discount express the value that this quasi-government organization places on retrofit, the former something like the cost approach and the latter something like the income approach.

2.5 Estimates of How Retrofit Avoids Future Losses

Earthquakes in communities not only impact physical vulnerabilities but also affect the communities' social vulnerabilities. Physical vulnerabilities aggravate earthquake damage to buildings (residential and commercial buildings, schools, etc.) and other infrastructure (roads, bridges, water supply, electrical grids, etc.). As for social vulnerabilities, they include the disproportionate harm experienced by some people and groups when displaced from their households, or suffer injuries, fatalities, or posttraumatic stress disorder (PTSD) (Sutley et al., 2017). The Department of Homeland Security (DHS) in 2003 developed the HAZUS tool, a software program that estimates disaster losses, including both physical and social losses (Sutley et al., 2016). Social loss metrics include the number of displaced households and fatalities. Other similar tools include MAEViz, a program created by the Mid-America Earthquake (MAE) Center in 2008. However, neither system incorporates economic, racial, or other important social metrics (Sutley et al., 2016).

According to Natural Hazard Mitigation Saves: 2018 Interim Report presented by the National Institute of Building Sciences (NIBS), mitigation can help improve the quality of life after experiencing natural hazards. The Interim Study explored the benefit-cost-ratio (BCR) of four different mitigation strategies. The first strategy looks at the investment into exceeding select sections of the 2015 International Residential Code (IRC) and International Building Code (IBC). The authors found a BCR of 4:1, meaning this strategy saves $4 for every $1 spent. The second strategy looks into designing buildings based on the 2018 IRC and IBC. It found a BCR of 12:1. The third strategy explored mitigation for infrastructure such as utility and transportation and found a BCR of 4:1. The final strategy looks at the mitigation grants provided by federal agencies such as the Federal Emergency Management Agency (FEMA), the Economic Development Administration (EDA), and the Department of Housing and Urban Development (HUD); it found a BCR of 6:1 (National Institute of Building Sciences, 2018).

An optimization model for seismic retrofit developed by Sutley et al. (2017) looks into a two-stage multi hazard analysis that incorporates engineering and social science approaches in estimating earthquake losses. The modeled vulnerabilities in their approach account for both physical infrastructure and inequality in community-level demographics of a given geographic area of interest. The authors showed that including social inequality and vulnerability in the case of an earthquake has a significant impact on the estimated losses. As such, including a social inequality metric provides decision makers with a better understanding on how to optimize seismic retrofit in different communities. Using this approach based on data of different communities in Los Angeles County, the authors found that economically weakest communities suffer the most loss during an earthquake.

2.6 Past Market Expressions of the Value of Retrofit

Outside the value of retrofitting homes for earthquakes, Awando and others (2019) at the University of Alabama describe their study of the value of designing or retrofitting homes to better resist hurricanes using the Insurance Institute for Business and Home Safety's FORTIFIED Home Hurricane standards (Insurance Institute for Business & Home Safety, 2012). Awando and colleagues collected sales information on all homes that met the FORTIFIED standard and were sold in Alabama between 2004 and the first quarter of 2016, along with sale information about similar nearby homes that did not meet the standard. To estimate the implied market value that the FORTIFIED standard seemed to provide, they used the hedonic regression model, meaning a regression analysis that attempts to estimate the extra value people were willing to pay for FORTIFIED homes. They conclude that the construction of a FORTIFIED home increased the resale value by 7% (Awando et al., 2016). The cost to comply with the FORTIFIED standard is less than 7% added to the home value, showing how the benefits of home fortification can exceed its cost.

Some surveys also looked in the public and real estate agent expressions on the value of retrofit and protection against earthquakes. Palm and Hodgson (1992) describe a survey of California communities before and after the Loma Prieta earthquake in 1989 to see if household perceptions of the danger of earthquakes changed. The survey conducted before the earthquake showed that homeowners lacked the preparedness to protect themselves and their homes from earthquakes. After the earthquake, only 10 percent of homeowners had taken measures to reduce earthquake damage. The authors briefly discuss the possibility of other factors that could have contributed to lack of homeowners taking action, such as lack of resources and powerlessness within the household.

Palm and Hodgson also surveyed real estate agents about properties within a few hundred feet of large active faults (called special studies zones) (Palm, 1981). They found that proximity to faults had no effect on home prices and offered several explanations. First, homebuyers believe that all of California is at risk of earthquake damage, therefore it does not matter whether the home is within or outside a special studies zone. Second, homebuyers do not credit environmental information given to them by the real estate agents, as at the end of the day people believe real estate agents just want to sell the property. Third, the survey found that many real estate agents do not fully understand the meaning of the special study zones and downplay their importance when selling a property.

2.7 Real Estate Data

If one wants to apply a hedonic regression model like Awando et al. (2019), what data are available? The Multiple Listing Service (mls.com) and Zillow (zillow.com) are both web-based listing sites where real estate agents can display price and other relevant information about properties for potential buyers. Both sites make their data publicly available with no fees or subscription required from buyers. The listings in the site are all filed by the real estate agent selling the property. Most or all of the listings provide common information such as home size, lot size, number of bedrooms, number of bathrooms, and so on. Neither database has a field to show whether the property has been seismically retrofitted. That information can appear in free text in the overview field of the listing. Finally, the number of listed properties in the database varies from time to time, as the database shows properties that are currently for sale in the time of search. In late November 2020, Zillow.com showed 53,393 single-family dwellings for sale in California.

2.8 Present Value of Avoided Future Earthquake Losses

The Multi-Hazard Mitigation Council (2019) values seismic retrofit another way, in terms of avoiding future losses. The authors estimate the expected value of the annual cash flow of a mitigation project over its lifespan without and with mitigation, to inform the decision of whether retrofitting makes financial sense. The cash flow identified in this approach is the average amount of money it would cost to repair a property to its previous state after being hit by earthquakes during the life of the property. It also includes the value of avoided future deaths and nonfatal injuries, the value of avoided additional living expenses, and the value of reduced indirect business interruption. One calculates the present value of the future losses, that is, how much it would cost in today's dollars to pay for the repairs, added living expenses, and so on. Two cash flows are estimated: the annual loss for a retrofitted property and annual loss for the same property without retrofit. The difference in their present values is the present value of avoided future losses. After finding both cash flows, property owners can see in terms of repair cost and other losses whether retrofitting their property is the best course of action.

2.9 Some Anecdotal Evidence of the Value of Retrofit to Avoid Future Losses

APA The Engineered Wood Association (1997, p. 7) offers a real-life example of the value of retrofit in a case study. The case study involves two nearly identical Victorian buildings located at 210 and 214 Elm Street in Santa Cruz, California (Figure 2). Both were built by the same contractor and used the same material and building techniques. The homes were built between 1890 and 1900. Local architect Michael O'Hearn bought them both in 1984. After acquiring the properties, Hearn started and finished retrofitting one of the properties (210 Elm St) with the same sort of bolts-and-braces approach discussed above. Before O'Hearn could retrofit the second property (214 Elm St), the magnitude-7.1 Loma Prieta earthquake hit in 1989, causing strong shaking in Santa Cruz. The architect stated that the retrofitted building cost him only $5,000 in repairs, whereas repairing the non-retrofitted property cost him around $260,000. The earthquake caused the non-retrofitted house to become uninhabitable. A new foundation had to be installed.

Figure 2. Two almost identical Victorian houses 210 (right) and 214 (left) Elm St, Santa Cruz, California suffered very different damage in the 1989 Loma Prieta because one had been retrofitted before the earthquake and the other had not.

Chapter 3: Proposed Procedures

3.1 Introduction

The present study looks at how earthquake retrofit affects the resale value of California single-family dwellings. It uses sales data from publicly available real estate market databases (sources), especially Zillow and Federal Financial Institutions Examination Council (FFIEC). Zillow is a free real estate website that provides information on homes and other properties. FFIEC Geocoding/Mapping System provides demographic data about the neighborhood that might matter to home resale value, especially median household income. Other demographic data that could have an effect on the resale value of homes that are not explored in this study includes racial composition, age, family structure, gender, etc., as suggested by Sutley et al. (2017). The present study estimates the effect of seismic retrofit using multivariate linear regression (MLR) of resale value. The coefficient for a binary retrofit variable measures the value that retrofit adds, if any. The method largely imitates the approach used recently by Awando et al. (2019).

3.2 Data Collection

Table 1 lists the independent and dependent variables used in the MLR analysis. Data are limited to single-family homes. Most collected information relates to the home characteristics and sale price of houses with and without retrofit, and are mainly obtained from Zillow. Data regarding the median household income of the census tract in which each house stands are also collected from the FFIEC system. These variables are selected mostly by imitating the analysis of the Awando et al. (2019) case study in Alabama.

Table 1: Description of Variables

Variables	Units	Description	Source
Address	N/A	Street address in US Postal Service format. An identifier, not an independent variable for regression analysis.	Zillow, address
Latitude	Degrees north	House location decimal degrees north latitude, a point somewhere in the interior of the house footprint, to 4 decimal places	Google Earth
Longitude	Degrees east	House location decimal degrees east longitude (negative in the U.S.), a point somewhere in the interior of the house footprint, to 4 decimal places	Google Earth
Census tract	N/A	11-digit US Census tract code: SSCCCTTTTTT, where SS = state code, CCC = county code, TTTTT = tract code. An identifier, not a variable for regression analysis.	FFIEC.gov Geocoding/Mapping System
Sale price	Dollars	For retrofitted homes, the asking price at the time the listing was observed. For comparable homes, the price of the dwelling at the time of the most recent sale in dollars of that year.	Zillow, Zestimate history, most recent value of "Sold for"
Retrofit	Binary	0 if no mention of seismic retrofit 1 if house is reported to have had seismic retrofit	Zillow Overview; see note on keywords below.
Year of construction	Year	Year built	Zillow, Facts and Features, year built
Age	Years	The age of the house at the time of the most recent sale	Calculated
Year of sale	Year	Year of the most recent sale	Zillow, Zestimate history, year of most recent sale
Lot size	Square feet	The area of the lot on which the	Zillow, Facts and

		property was built	Features, Lot
House size	Square feet	Total interior livable area	Zillow Interior details, Total interior livable area
Num. bedrooms	N/A	Number of bedrooms	Zillow, Interior details, Bedrooms area
Num. bathrooms	N/A	Number of bathrooms	Zillow, Interior details, Bathrooms
Num. fireplace	N/A	Number of fireplaces, if shown. Blank if not provided. Enter 1 if Zillow says "yes" Enter 0 if Zillow says "none"	Zillow, Interior details, Fireplace Database
Type of A/C unit	N/A	The type of air condition units installed in the property. Three categories are used, indexed by 0 to 2, as follow: 0: no air conditioner. 1: Window air condition unit 2: Central air conditioning.	Zillow, Facts and Features, Cooling
Garage	N/A	Number of garage doors that the property has.	Zillow, Property details, Parking
Num. of parking spaces	N/A	The number of parking spaces that the property provides whether that be a garage or street parking. Zillow does not categorize the type of parking space. Blank if not provided.	Zillow, Property details, Parking
Household income	Dollars	The median household income of the census tract in which the house is built	FFIEC.gov Geocoding/Mapping System, 2015 Tract Median Household Income

The Zillow database (www.zillow.com) offers most of the data listed in Table 1. One selects a region, applies the filter "Home type = houses," and "More | Keywords = seismic." Zillow indicates that some houses have been seismically strengthened. It does so in the overview free-text description of the property, rather than with a dedicated database field like the Sun Number™ score that indicates a home's potential for solar energy. Thus, one must search Zillow using the "More | Keywords" option, entering each of several likely terms a listing agent might use, most commonly "seismic," "earthquake," and "retrofit."

Zillow does not search for records with *any* of the keywords, only for records with *all* of them, so one must perform several searches of each region of interest, one search for each keyword. Occasionally an appurtenant structure has been retrofitted, such as a retaining wall, but not the house. Some listings mention that seismic retrofit has been planned or permitted, so the analyst must read the description to confirm that the retrofit work has been completed, not just scheduled or planned. Some retrofit work is almost certainly intended for seismic resistance, such as soft-story retrofit, but the description does not use the word "seismic" or "earthquake." Where it seems likely that most buyers would interpret the retrofit work as being done for seismic resistance, the retrofit variable is set to 1. The only situation where this seems likely is the case of soft-story retrofits, but others might arise. Furthermore, the keyword "soft story" produces a number of false-positive results, especially houses with soft-close cabinets and the term "story" appearing elsewhere in the description. False positives are removed from the data analyzed here.

Some retrofitted houses may be overlooked using these search parameters. For example, the listing could mention that work has been done to "strengthen the foundation," without using any of the three keywords. Possibly the strengthening work was done to improve seismic resilience, possibly not. It seems more prudent to assume that unless the description actually uses one of the keywords, that the buyer would not perceive the work as intended for seismic resistance. Even if seismic strengthening were the true intent, this analysis seeks to assign a market value to seismic strengthening, which means a value that buyers assign to a feature because they know or think the house offers it. A feature of which they are unaware, such as strengthening a foundation to improve seismic resistance, is assumed not to be reflected in buyers' bids.

The data are compiled as follows:

1) Select one or more cities of interest to span geographic and wealth diversity
2) In each city, search Zillow.com for single family dwellings with seismic retrofit. Tabulate their attributes according to Table 1.
3) For each house with seismic retrofit, select 10 to 15 houses geographically closest to it on Zillow.com and tabulate their attributes according to Table 1. After the retrofitted houses are selected, Zillow provides the tool to find comparable houses ("comparable" in the sense of the sales-comparison approach to property valuation) around the selected homes. Zillow automates the process of identifying comparable nearby homes near the one being examined. If the retrofitted house is near the city boundary, one collects data from nearby houses in the adjacent community by selecting "Remove boundary" in the Zillow interface, preferring closer houses in the adjacent city to more distant ones in the same city.

3.3 Multivariate Linear Regression Analysis

Multivariate linear regression (MLR) analysis is a method that correlates one dependent variable with multiple independent variables, which is a generalization of linear regression analysis. The approach can be represented by equation 1:

$$Y = b_0 + x_1 \cdot b_1 + x_2 \cdot b_2 + \dots\dots\dots\dots + x_n \cdot b_n + e$$

(1)

where Y is the dependent variable (here, representing the sale price of the home in question), x_1 through x_n represent the independent variables (or characteristics) of the home, b_0 through b_n represent the change in the dependent variable (Y) to a unit change in the independent variables (x_n), and e is an error term. Since one of the independent variables is a binary value to indicate seismic retrofit, its coefficient estimates the effect of an earthquake retrofit on the future resale value of a home. Note that census tract is not an independent variable but rather is used to find the median household income, which is an independent variable in the analysis. The independent variables in the analysis are not necessarily statistically independent, but rather represent inputs to the MLR analysis. Other results that can also be obtained from the MLR analysis includes P-value, R-squared, and R-squared (adj.). P-value is an indicative value used to validate the significance of the coefficient obtained for a given independent variable. P takes on a value between 0 and 1 that measures the chance that a given independent variable actually has no relationship to the dependent variable. R-squared shows how close the set of given data is to the regression line created by the MLR equation. As for R-squared (adj.), it is a value obtained after adjusting R-squared to account for the number of independent variables in the equation, to correct for over-fitting. In doing so, the MLR analysis model gets penalized for including independent variables that do not actually contribute to the dependent variable. Overfitting is indicated by a large gap between the values of R-squared and R-squared (adj.).

When choosing homes, the most general home characteristics were considered so as to not limit the number of homes that can be a part of the study. Other important house attributes related to the community probably also matter to sale price, attributes such as proximity to grocery stores, school ratings, etc. These are reflected by the constant (b_0). An important community variable that is explicitly considered is the median household income in the tract.

Chapter 4: Collected Data

4.1 Data

Figure 1 shows sample data for a Zillow record of a house that has been seismically retrofitted. Records just like this were used to populate Table 2 for 345 of single-family homes. The study sample includes 23 retrofitted single-family dwellings and 322 non-retrofitted homes in seven California counties, as listed in Table 2. Figure (2) below shows the location of the 23 retrofitted homes. To collect and transcribe these data took the author about 16.15 hours, or about 3 minutes per record.

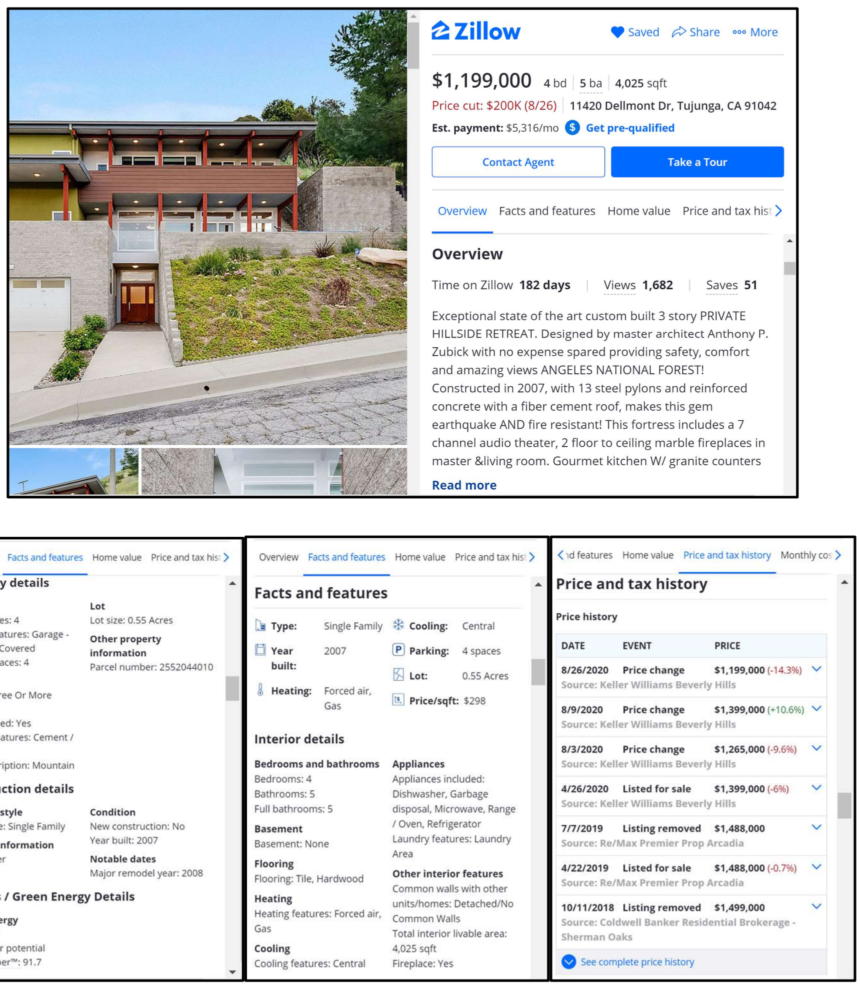

Figure 3. Sample Zillow record for a retrofitted house.

Table 2. Locations of sample houses

Region	County	County FIPS	Retrofitted	Not retrofitted
Southern California	Los Angeles	06-037	12	180
	Orange	06-059	1	15
	Riverside	06-065	1	15
	San Bernardino	06-071	3	45
	Ventura	06-111	1	15
Northern California	Alameda	06-001	4	45(a)
	Humboldt	06-023	1	7

(a) Includes 6 houses in adjacent Santa Clara County.

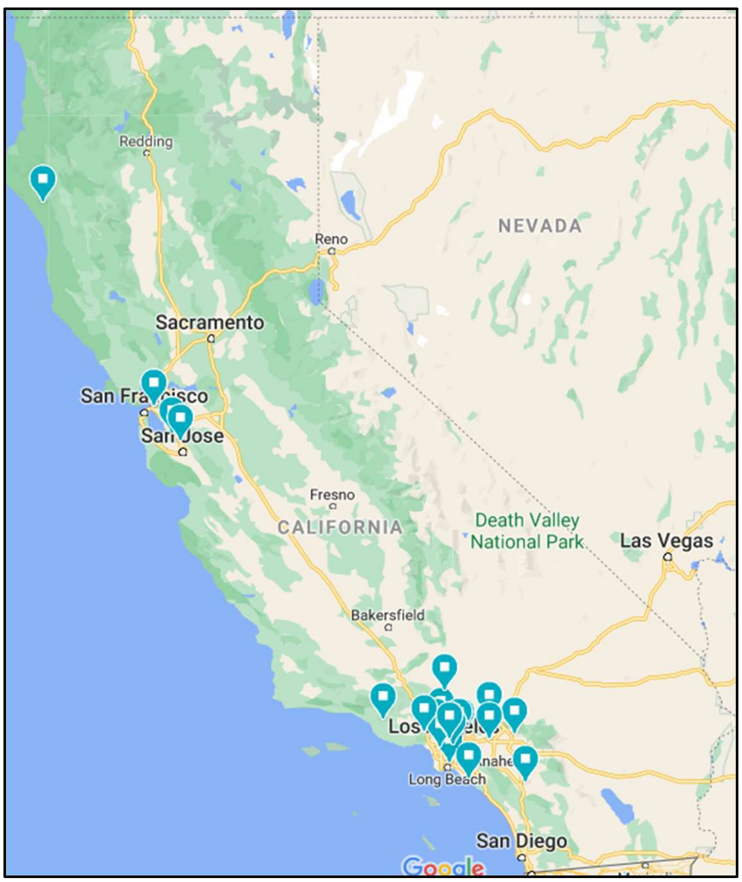

Figure 4. A Map of the State of California showing the location of retrofitted single-family dwellings (source: Google)

4.2 Selection of Subject Community

Los Angeles County and Alameda County contain most of the retrofitted homes (52% and 17%, respectively). Might the value of seismic retrofit depend on which county the house stands in? Therefore, two subset data sets were created, one representing Los Angeles County data and the other Alameda County data, shown in appendix B Tables 2 and 3. A MLR analysis is conducted on each of these county data sets to see whether the county matters or how closely it follows the trend of the full dataset. Table 3 summarizes the median value of the comparable variables of all data sets.

Table 3: The Median Value of Comparable Variables

Variables	Units	State of California	Los Angeles County	Alameda County
Sale price	Dollars	644,132.69	601,070.29	815,142.19
Year of construction	Year	1957	1955	1962
Age	Years	54	54	52
Year of sale	Year	2014	2014	2014
Lot size	Square feet	7278	7405	5998
House size	Square feet	1924	2035	1708
Num. bedrooms	Each	3	3	3
Num. bathrooms	Each	2.25	2.5	2
Fireplaces	TRUE/FALSE	TRUE	TRUE	TRUE
Type of A/C unit	N/A	2	2	1
Garage	TRUE/FALSE	TRUE	TRUE	TRUE
Num. of Parking Spaces	Each	2	2	2
Household income	Dollars	74,839	75,000	91,598
Latitude	Decimal	34.15	34.15	37.55

	degrees north			
Longitude	Decimal degrees east	-118.19	-118.18	-122.03

Chapter 5: Results and Conclusions

5.1 Results

Table 5 shows the estimated coefficient of the variables of the single-family dwelling in the State of California, Los Angeles county, and Alameda county. The natural logarithm of the sale price was used as the dependent variable, which makes the coefficient found in the MLR analysis close to a percentage term when multiplied by hundred. For example, the coefficient for retrofit is about 0.1, meaning that if retrofit is true (taking on the value of 1), the natural logarithm of sale price increases by 0.1 and the sale price in the real domain (in dollars) increases by a factor of exp (0.1) = 0.105 (equal 10.5%). A coefficient can have either positive or negative value. A positive value indicates that the variable increases the resale value. A negative coefficient indicates a reduction in expected resale value. Table 4 shows that retrofit has a noticeable positive impact on the resale value of single-family homes in the State of California in 2020. The result shows that when looking at the State of California as a whole, retrofit appears to add 9.8% to the resale value. In Los Angeles County alone, retrofit appears to add 10.4% to the resale value, whereas in Alameda County, it appears to add 8.8% to the resale value.

The analysis also showed that some variables such as number of bedrooms and fireplace have a significantly negative impact on the resale value when looking at the data as whole. Why? Perhaps conditioned on square footage, more bedrooms mean smaller rooms, less luxury, and lower value. But that is merely speculation. Furthermore, the result shows that the number of bathrooms and types of air conditioning units can significantly improve the sale value of a home in California.

Table 4: Summary of the Variables Estimated Coefficients

Variables	State of California esti. coef.	Los Angeles County esti. coef.	Alameda County esti. coef.
Constant	-106.93	-104.8	175
Retrofit	0.0985	0.104	0.088
Year of construction	-0.003158	-0.00244	0.00337
Year of sale	0.04336	0.04141	0.06118
Lot size	0.000005	0.000019	-0.000001
House size	0.000243	0.000225	0.000166
Num. bedrooms	-0.0469	-0.0473	-0.0612
Num. bathrooms	0.0974	0.0960	0.0283
Num. fireplace	-0.0102	-0.0135	0.056
Type of A/C unit	0.0738	0.0956	-0.0160
Garage	0.14	0.0701	0.393
Num. of Parking Spaces	0.0036	0.0039	0.0103
Household income	0.000005	0.000004	0.000004
Latitude	-0.4422	-0.4258	3.98
Longitude	-0.4478	-0.4462	3.62
P-Value of Retrofit	0.3	0.374	0.571
R-squared	68.34%	69.18%	85.25%
R-squared (adj)	66.99%	67.39%	79.17%

Table 4 also presents information about the explanatory power of the regression analysis. It shows P-value of retrofit, R-squared and R-squared (adj.). The P-value measures the probability that the differences between retrofitted and non-retrofitted homes occurred by a random chance. A P-value close to 1 means the retrofit variable almost certainly has no real effect on resale value.

A P-value close to 0 means that the null hypothesis is almost certainly wrong, that is, that the retrofit almost certainly affects resale value. It is large for Alameda County but less than 0.5 for the state and for Los Angeles County, suggesting that more likely than not the null hypothesis is wrong, and retrofit actually matters to the sale price. Having a smaller P-value that is less than or close to 0.05 would provide more convincing evidence of the value of retrofit. Nonetheless the results are still intriguing.

R-squared measures how close the data lie to the regression line created by the regression equation. An R-squared value near 1.0 means that the regression explains virtually all of the variance in the dependent variable. An R-squared value near 0 means that the regression analysis removes none of the variance in the dependent variable. R-squared (adj.), as its name suggests, is created by adjusting the value of R-squared based on the number of independent variables in the MLR analysis. The difference between the R-squared and R-squared (adj.) also shows whether a variable is useless to the analysis or not by having a huge gap between the two values.

The author used the Pennsylvania State University-developed software Minitab to perform the MLR analysis. Table 5 presents the results as calculated by Minitab: equations for resale value for the entire State of California dataset and for the data subsets from Los Angeles and Alameda Counties.

Table 5: Summary of the Regression Equations

	Equation
State of California	Ln(Sale Price) = -106.93 + 0.0985 Retrofit - 0.0003158 Year of construction + 0.04336 Year of sale + 0.000005 Lot size + 0.000243 House size - 0.0469 Num. bedrooms + 0.0974 Num. bathrooms - 0.0102 Num. fireplace + 0.0738 Type of A/C unit + 0.14 Garage + 0.0036 Num. of Parking Spaces + 0.000005 Household Income - 0.4422 Latitude - 0.4478 Longitude
Los Angeles County	Ln(Sale Price) = -104.8 + 0.104 Retrofit - 0.00244 Year of construction + 0.04141 Year of sale + 0.000019 Lot size + 0.000225 House size - 0.0473 Num. bedrooms + 0.096 Num. bathrooms - 0.0135 Num.

	fireplace + 0.0956 Type of A/C unit + 0.0701 Garage + 0.0039 Num. of Parking Spaces + 0.000004 Household Income - 0.4258 Latitude - 0.4462 Longitude
Alameda County	Ln(Sale Price) = -175 + 0.088 Retrofit + 0.00337 Year of construction +0.06118 Year of sale - 0.000001 Lot size + 0.000166 House size - 0.0612 Num. bedrooms + 0.0283 Num. bathrooms + 0.056 Num. fireplace - 0.016 Type of A/C unit + 0.393 Garage + 0.0103 Num. of Parking Spaces + 0.000004 Household Income + 3.98 Latitude + 3.62 Longitude

Using the equations in Table 5, an estimated resale value of a subject property created by the median value of all the independent variables can be calculated. Table 6 shows the estimated sale value of the three subject properties created by the data shown in Tables 2 and 3. The table shows that the estimated sales price for properties using the State of California regression equation are much closer to that obtained from the Los Angeles county regression equation as compared to the Alameda County one. This outcome is to be expected given the fact that approximately 52% of the data is derived from Los Angeles county.

Table 6: The Sale Value of Subject Properties

Regression Equation	**Estimated Sale Price**		
	State of California Subject Property	**Los Angeles County** Subject Property	**Alameda County** Subject Property
State of California	$647,486.36	$683,822.73	$735,195.70
Los Angeles County	$611,827.71	$644,774.55	N/A
Alameda County	$1,085,929.65	N/A	$796,021.92

In an effort to compare the listing price and the actual sale price, the author revisited the 24 retrofitted properties and observed that approximately 13 of the 24 listings had been sold. See Table 7. It shows that the average ratio of sale price to asking price is 0.985, meaning that on average they sold for very close to the asking price. The standard deviation is 0.040, suggesting that the mean difference between asking and sale price is small compared with its variability. Even if the 1.5% difference were systematic, the ratio does *not* reflect a 1.5% overestimate of the value of retrofit, which is only one of several independent variables. Is the 1.5% difference somehow related to the pandemic? To other aspects of the local market? An artifact of a small sample size? The author does not know. It simply implies a slight added uncertainty in the coefficients.

Table 7: Summary of the of listed and actual sale prices of the retrofitted houses

Address	**Listed Price**	**Sale Price**	**Ratio**
2015 Orange Ave, Costa Mesa, CA 92627	$1,495,000	$1,435,000	0.960
5427 Heath Creek Dr, Wrightwood, CA 92397	$389,900	$413,400	1.060
6706 Hesperia Ave, Reseda, CA 91335	$699,950	$679,900	0.971
200 W Doncrest St, Monterey Park, CA 91754	$749,900	$745,500	0.994
207 Los Laureles St, South Pasadena, CA 91030	$1,500,000	$1,395,000	0.930
6119 W Avenue K9, Lancaster, CA 93536	$399,400	$385,000	0.964
434 Craycroft Dr, Fremont, CA 94539	$1,780,800	$1,615,000	0.907
35883 Vinewood St, Newark, CA 94560	$1,248,000	$1,220,000	0.978
139 N Ivy Ave, Monrovia, CA 91016	$978,800	$990,000	1.011
8410 Red Hill Country Club Dr, Rancho Cucamonga, CA 91730	$749,000	$752,000	1.004
631 Santa Maria Rd, Arcadia, CA 91007	$1,098,000	$1,120,000	1.020
1821 W 42nd Pl, Los Angeles, CA 90062	$769,000	$775,000	1.008
1302 E Cartagena St, Long Beach, CA 90807	$795,000	$796,000	1.001

5.2 Conclusions

The research quantified the effect of earthquake retrofit on the resale value of a home in California in 2020. The multivariate linear regression analysis showed that single family dwellings with retrofit have a higher resale value than one without by approximately 10 percent.

In the case of the state of California, retrofitting single family homes turns out to be a financially sound investment; this is given the fact that the cost to retrofit a home to better withstand earthquakes is much lower than 10% of the value of the property, meaning that the benefit outweighs the cost on the basis of resale value alone. Moreover, there are other benefits a homeowner enjoys for retrofitting their property that are not discussed here, such as insurance discounts, lower rebuilding costs in the event of an earthquake, peace of mind, and more.

Additionally, if real estate listing services such as Zillow and the Multiple Listing Service were to include a field to indicate something about seismic retrofit in their data, it might benefit sellers and buyers and make retrofit more of a market value for single family dwellings.

As noted earlier, the small difference between asking price and actual sale price adds a slight uncertainty to (all) the coefficients of linear regression. There seems to be no reason to believe that it solely reflects an error in the coefficient for seismic retrofit.

Summing up the results from these studies and previous studies carried out on the benefits of retrofit, it can be said that retrofit helps both the homeowners as well as the community alike at the local and also the state level. Hence, with increase in the number of properties across California which are retrofitted, the societal cost of repair and recovery time of homes after an earthquake will also see a decline. As such, fewer people will be dislocated from their homes, which in turn helps the communities and the state to return to their status before the earthquake.

5.3 Novelties

This study may be the first to quantify the effect on resale value from seismically retrofitting single family dwellings. A similar question was explored by Awando and others regarding property exposed to flooding and storms in the State of Alabama. The present was based entirely on publicly available databases such as Zillow and FFIEC.gov's Geocoding/Mapping System.

5.4 Limitations

Some of the limitations that faced the study were as follows:

1. Limited number of retrofitted homes. Since seismic retrofit is not a category in Zillow, the study had to rely on the information provided by the real estate agent in Zillow's overview section. Moreover, the database only shows information of recently listed homes that have not yet been sold, so information about retrofitted buildings that were sold in the past could not be obtained.
2. The result of the study was based on a limited number of commonly available independent variables. In reality, there are more variables that can be considered such as marble countertops, building layout, and property proximity to services. Possibly these other variables correlate with retrofit and buyers were actually reacting to these other variables rather than to retrofit. However, anecdotal evidence suggests that home buyers actually do care about and value retrofit (J. Maffei, California Earthquake Authority, verbal commun., September 3, 2020). Other independent variables that are solely based on the community could also have an impact on the resale value of homes such as, racial composition, age, family structure, gender, etc.

3. The result was only based on data gathered from the listing on Zillow, which provides little information about the opinions of new home buyers on retrofit.
4. The actual sale price of a subset of the retrofitted homes (10 out of 23) is not yet known, and the regression analysis was based on listing price for retrofitted homes rather than actual sales price, which adds some uncertainty to all of the regression coefficients. However, the actual sale price for 13 or 23 retrofitted homes was close to the listing price, within 1.5%, less than half the standard deviation of the ratio of sale price to listing price. The small difference between asking and actual sale price suggests the results of the analysis using listing price is probably close to the results if actual sale price had been used as the dependent variable.

5.5 Future Work

In future research, the effect of retrofit on the resale value of single-family dwellings can be revisited by addressing the limitations presented above. Some steps that could be taken to better answer the question explored by the presented study include:

1. Using databases that have more retrofitted properties, which might require the use of privately owned or other confidential databases such as CoreLogic and the California Earthquake Authority. The use of these types of databases might cast a wider net, bringing in data that would otherwise be difficult to obtain using only public resources. Alternatively, one could repeat the data collection in a few months using properties listed for sale and visible on Zillow at that time.
2. The inclusion of more variables in the multivariate linear regression analysis that real estate agents deem a factor in the decision making of new home buyers. Some of the variables that can be considered are marble countertops, building layout, and proximity to services.

3. Talk with California home buyers to elicit their opinions about the value of retrofit. That could be done with focus groups, surveys, or both. Focus groups could include recent buyers of retrofitted and non-retrofitted homes. One could ask them whether they considered the value of retrofit in selecting their home and why.
4. Revisit the Zillow listing for all retrofitted homes after they have either been sold or removed from the market. At that point, recalculate the coefficients of linear regression. Doing so would remove some uncertainty associated with asking versus actual sale price.

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Appendix A

Example 1: Sales Comparison Approach

To illustrate the sales comparison approach, assume transaction data from three comparable properties are used in valuing the subject property—a modest single-family residence located at 2380 Appletree Court, in the Parkway Estates neighborhood.

Jacob Jones has signed a contract to purchase the home from Blaine Strickland for $163,000. Mr. Jones has applied for a $122,250 mortgage loan from the Bank of Florida. The relevant characteristics, termed the elements of comparison, used to compare and adjust the property prices, are summarized in Exhibit 7-7, the market data grid.

We can see from the location line on the market data grid that the comparable properties are located in the subject property's neighborhood. Two sold within the last three months, while the third sold four months ago. Their prices range from $157,100 to $169,900. Note that the property rights conveyed, conditions of sale, financing terms, use, and several of the physical features of the subject are identical to the comparable properties. Thus, no adjustment will be necessary for these elements. However, adjustments are necessary for differences in several characteristics that, in the opinion of the appraiser, materially affected the comparable transaction prices. The amount of the adjustment for each item has been estimated by the appraiser and is shown in the list below:

- Market conditions: 0.3 percent per month (values have increased in neighborhood).
- Lot size: $100,000 per acre.
- Construction quality: No adjustment if all siding. $1,500 adjustment if brick front with remainder siding; $3,000 adjustment if all brick.
- Effective age: $1,250 per year.
- Living area: $48.00 per square foot.
- Porch, patio, deck area: $16.00 per square foot.
- Pool area: $7,000.
- Bath: $4,000 per bath.

The individual adjustments are shown in Exhibit 7-8. For example, Comparable Sales 2 and 3 require an upward adjustment for market conditions because they sold in earlier months and prices in the market have been increasing. The adjustment for Comparable 2 is calculated as $167,200 × 0.003 per mo. × 3 mos. = $1,504.80, and Comparable 3 as $157,100 × 0.003 per mo. × 4 mos. = $1,885.20. However, these estimates suggest a degree of precision in the estimate that is unintended and the adjustments are rounded to $1,500 and $1,900.

The individual adjustments for the various differences in physical characteristics are shown next. For example, the subject does not have a pool although Comparable Sales 2 and 3 do. Therefore, the estimated value of the pool in this market ($7,000) is subtracted from the sale price of the comparable sales 2 and 3. Adjustments are made for all items that differ, resulting in a final adjusted sale price for each of the comparable properties.

It is extremely important to emphasize that making required adjustments, such as those detailed in Exhibit 7-8, requires significant experience as well as constant attention to market transactions, trends, and conditions. Note that if the comparable properties are identical to the subject with respect to an element of comparison, that element can be deleted from the adjustment grid.

Solution:
Exhibit 7-7 Sales Comparison Approach: Market Data Grid for 2380 Appletree Court

Elements of Comparison	**Subject**	**Comp Sale 1**	**Comp Sale 2**	**Comp Sale 3**
Sale price of comparable		$169,900	$167,200	$157,100
Transaction characteristics				
Property rights conveyed	Fee Simple	Same	Same	Same
Financing terms	Conventional	Same	Same	Same
Conditions of sale	Arm's length	Same	Same	Same
Expenditures immed. after purchase		None	None	None
Market conditions	Today	This month	3 mos. ago	4 mos. ago
Property characteristics				
Location	Parkway Estates	Same	Same	Same
Physical characteristics:				
Site/lot size	0.50 acres	0.50 acres	0.45 acres	0.48 acres
Construction quality	Siding	Siding/brick	Siding	Brick
Effective age	3 years	6 years	10 years	15 years
Living area	1,960 sq. ft.	2,060 sq. ft.	2,077 sq .ft.	1,818 sq. ft.
Number of baths	2.5 baths	2.5 baths	2.5 baths	3.0 baths
Garage spaces	2-car	2-car	2-car	2-car
Porch, patio, deck	None	None	None	200 sq. ft.
Fence, pool, etc.	None	None	Pool	Pool

Exhibit 7-7 Continued

Elements of Comparison	Subject	Comp Sale 1	Comp Sale 2	Comp Sale 3
Economics characteristics	N.A	N.A	N.A	N.A
Use	Single- family	Same	Same	Same
Non Realty components	None	None	None	None

Exhibit 7-8 Sales Comparison Approach: Adjustment Grid for 2380 Appletree Court

Elements of Comparison	Subject	Comp Sale 1	Comp Sale 2	Comp Sale 3
Sale price of comparable		$169,900	$167,200	$157,100
Transaction adjustments				
Adj. for property rights conveyed	Fee simple	0	0	0
Adjusted price		$169,900	$167,200	$157,100
Adjustment for financing terms	Conventional	0	0	0
Adjusted price		$169,900	$167,200	$157,100
Adjustment for conditions of sale	Arm's length	0	0	0
Adjusted price		$169,900	$167,200	$157,100
Adj. for expend. immed. after purchase		0		0
Adjusted price				
Adjustment for market conditions	Today	0	1,500	1,900
Adjusted price		$169,900	$168,700	$159,000
Property Adjustments for				
Location	Suburban	0	0	0

Exhibit 7-8 Continued

Elements of Comparison	**Subject**	**Comp Sale 1**	**Comp Sale 2**	**Comp Sale 3**
Physical characteristics:				
Site/lot size	0.50 acres	0	$5,000	$2,000
Construction quality	Siding/good	-$1,500	0	-$3,000
Effective age	3 years	$3,750	$8,750	$15,000
Living area	1,960 sq. ft.	-$4,800	-$5,600	$6,800
Number of baths	2.5 baths	0	0	-$2,000
Porch, patio, deck	None	0	0	-$3,200
Fence, pool, etc.	None	0	-$7,000	-$7,000
Total adj. for physical characteristic		-$2,550	$1,150	$8,600
Economics characteristic		0	0	0
Use		0	0	0
Nonrealty components		0	0	0
Final adjusted sale price		$167,350	$169,850	$167,600

Exhibit 7-9 Reconciliation of Final Adjusted Sale Prices

Source	**Final Adjusted Sale Price**	**Weight (%)**	**Weight Price**
Comparable Sale 1	$167,350	60	$100,410
Comparable Sale 2	$169,850	20	$33,970
Comparable Sale 3	$167,600	20	$33,520
Indicated Opinion of Value (using the sales comparison approach)			$167,900

Example 2: Sales Comparison Approach

You are using the sales comparison approach to value, to determine the true tax value of a single-family residence.

You have determined the following elements of comparison contribute significantly to value and have estimated their values.

The amount of the adjustment for each item has been estimated by the appraiser and is shown in the list below:

- Basement: $10,000.
- Garage Space: $3,000.
- Time: +1.5% per month
- Living area: $40.00 per square foot.
- Fireplace: $3,000.
- Location: 10% more for waterfront.
- Brick Exterior: $15,000.

The subject property: is a 2,400 square foot cedar sided ranch home located on a lot with water frontage. It has a full basement, 2 car garage, 1 fireplace, and 2 full bathrooms.

Comparable Sale 1: Sold for $210,000 five months ago. It is identical to the subject in all aspects except it does not have a basement.

Comparable Sale 2: Sold last week for $240,000. It is a brick home with 2,250 square feet. It has a full basement, 2 full bathrooms, 2 fireplaces and a 2 car garage. It is located on the water.

Comparable Sale 3: It is a 2,600 square foot cedar sided ranch home on a slab foundation. It has a 3 car garage, 2 fireplaces, and 2 full bathrooms. It is not located on the water. It sold 11 months ago for $195,000.

Comparable Sale 4: It is a brick ranch home with a full basement. It has 2,520 square feet. It has 2 full bathrooms, a 1 car garage, and 1 fireplace. It is not located on the water. It sold 20 months ago for $172,500.

Solution:

Elements of Comparison	**Subject**	**Comp Sale 1**	**Comp Sale 2**	**Comp Sale 3**	**Comp Sale 3**
Sale Price	Current	$210,000	$240,000	$195,000	$172,500
Date of Sale	Current	5 months	Current	11 months	20 months
Time Adjustment	None	$15,750	$0	$32,175	$51,750
Time Adj Sale Price	None	$225,750	$240,000	$227,175	$224,250
Other Adjustment					

Continue

Elements of Comparison	Subject	Comp Sale 1	Comp Sale 2	Comp Sale 3	Comp Sale 3
Basement	Full	$10,000	$0	$10,000	$0
Garage	2 car	$0	$0	-$3,000	$3,000
Size Sq Feet	2400	$0	$6,000	-$8,000	-$4,800
Fireplace	1	$0	-$3,000	-$3,000	$0
Location	water	$0	$0	$22,718	$22,425
Exterior	Cedar	$0	-$15,000	$0	-$15,000
Bathrooms	2	$0	$0	$0	$0
Net Adjustments		$10,000	-$12,000	$18,718	$5,625
Adjusted Price		$235,750	$228,000	$245,893	$229,875
Median	$232,813				

Appendix B

Table 1: Sample of the Collected Data

Address	Sale Price	Sale Price 2020	Ln(Sale Price)	Retrofite	Year of construction	Year of Sale	Age	Lot Size (sqft)	House Size (sqft)	Num. Bedroom	Num. Bathroom	Garage	Num. of Parking Spaces	Household Income	Type of A/C unit	Num. Fireplace	Latitude	Longitude	Census tract
6119 W Avenue K9, Lancaster, CA 93536	$399,400	$399,400	12.8977187	1	2005	2020	15	9,147.00	2,568.00	4	3	1	2	$79,816	2	1	34.67	-118.24	06-037-9012.05
43453 62nd St W, Lancaster, CA 93536	$290,000	$320,171	12.5776362	0	2006	2013	7	7,230.00	3,206.00	5	3	1	0	$85,610	2	0	34.67	-118.24	06-037-9012.05
6021 Ryans Pl, Lancaster, CA 93536	$499,500	$618,039	13.12136288	0	2006	2007	1	6,690.00	3,142.00	5	4	2	0	$85,610	2	0	34.67	-118.24	06-037-9012.05
6137 Ryans Pl, Lancaster, CA 93536	$300,000	$300,000	12.61153775	0	2006	2020	14	6,594.00	2,734.00	4	3	2	3	$85,610	2	1	34.67	-118.24	06-037-9012.05
43406 62nd St W, Lancaster, CA 93536	$398,900	$408,094	12.89646604	0	2006	2018	12	6,621.00	3,242.00	5	3	2	0	$85,610	2	1	34.67	-118.24	06-037-9012.05
43421 Hampton St, Lancaster, CA 93536	$430,500	$532,664	12.9727026	0	2006	2007	1	6,098.00	2,554.00	4	3	2	3	$85,610	2	0	34.67	-118.24	06-037-9012.05
43271 62nd St W, Lancaster, CA 93536	$473,500	$601,611	13.06790719	0	2005	2006	1	8,712.00	3,610.00	5	4	2	3	$85,610	2	1	34.67	-118.24	06-037-9012.05
43713 Brandon Thomas Way, Lancaster, CA 93536	$376,500	$478,367	12.83867333	0	2006	2006	0	6,969.00	2,200.00	4	3	2	3	$85,610	2	0	34.68	-118.24	06-037-9012.05
43718 Elena St, Lancaster, CA 93536	$370,000	$389,398	12.82125828	0	2005	2017	12	6,969.00	2,825.00	4	3	1	2	$79,911	2	1	34.68	-118.23	06-037-9010.04
5751 W Avenue K4, Lancaster, CA 93536	$462,500	$587,635	13.04440184	0	2006	2006	0	6,534.00	3,767.00	6	4	2	3	$54,183	2	0	34.67	-118.23	06-037-9011.01
44310 Apache Plume St, Lancaster, CA 93536	$270,000	$319,341	12.50617724	0	2006	2010	4	7,405.00	3,573.00	5	3	2	3	$79,911	2	0	34.69	-118.24	06-037-9010.04
5759 Golding Dr, Lancaster, CA 93536	$537,000	$682,292	13.19375337	0	2006	2006	0	8,276.00	3,564.00	4	3	2	2	$79,911	2	1	34.69	-118.23	06-037-9010.04
5750 Balmont St, Lancaster, CA 93536	$372,500	$402,406	12.82799232	0	2006	2015	9	9,953.00	3,707.00	5	5	1	0	$54,183	2	1	34.66	-118.23	06-037-9011.01
7028 Lyric Ave, Lancaster, CA 93536	$442,500	$547,512	13.00019574	0	2007	2007	0	9,743.00	3,650.00	5	4	1	0	$85,610	2	0	34.66	-118.26	06-037-9012.05
5352 W Avenue L, Lancaster, CA 93536	$117,000	$208,880	11.66992921	0	1992	1993	1	9,152.00	1,372.00	3	2	1	0	$54,183	2	0	34.66	-118.23	06-037-9011.01
5618 W Avenue L1, Lancaster, CA 93536	$430,000	$569,937	12.97154049	0	1999	2005	6	10,018.00	2,382.00	4	2	1	0	$54,183	2	1	34.66	-118.23	06-037-9011.01
505 Fairmont Dr, San Bernardino, CA 92404	$395,000	$395,000	12.88664104	1	1955	2020	65	8,001.00	1,831.00	3	2	1	2	$50,653	2	1	34.16	-117.28	06-071-0051.00
567 Fairmont Dr, San Bernardino, CA 92404	$385,000	$393,874	12.86099861	0	1950	2018	68	8,550.00	2,502.00	3	2.75	1	3	$50,653	2	1	34.16	-117.27	06-071-0051.00
3876 Valencia Ave, San Bernardino, CA 92404	$315,000	$336,929	12.66032792	0	1957	2016	59	10,001.00	2,184.00	3	2	1	2	$50,653	0	1	34.16	-117.27	06-071-0051.00
154 E 39th St, San Bernardino, CA 92404	$244,000	$263,916	12.4049235	0	1957	2014	57	8,058.00	1,570.00	3	2	1	2	$50,653	2	1	34.16	-117.28	06-071-0051.00

To see the full set of data used in this study visit the following link:
https://www.designsafe-ci.org/data/browser/public/designsafe.storage.published/PRJ-2971