The Potential Impact of an Anthrax Attack on Real Estate Prices and Foreclosures in Seattle

Noah Dormady,1,* Thomas Szelazek,2 and Adam Rose3

This article provides a methodology for the economic analysis of the potential consequences of a simulated anthrax terrorism attack on real estate within the Seattle metropolitan area. We estimate spatially disaggregated impacts on median sales price of residential housing within the Seattle metro area following an attack on the central business district (CBD). Using a combination of longitudinal panel regression and GIS analysis, we find that the median sales price in the CBD could decline by as much as $280,000, and by nearly $100,000 in nearby communities. These results indicate that total residential property values could decrease by over $50 billion for Seattle, or a 33% overall decline. We combine these estimates with HUD’s 2009 American Housing Survey (AHS) to further predict 70,000 foreclosures in Seattle spatial zones following the terrorism event.

KEY WORDS: Housing foreclosures; real estate; regional economic consequences; terrorism

1. INTRODUCTION

An anthrax attack on a major metropolitan area in the United States would have devastating direct consequences. These would include significant death and injury, contamination of buildings, and cessation of economic activity in the affected area. The costs of health services and decontamination would be immense, and the indirect effects would likely be even greater. Ordinary resource losses stemming from ripple, or multiplier, effects would more than double the declines in economic output, employment, and income. Moreover, many people would avoid the affected area and even neighboring areas out of fear of the spread of contamination. Further property value decreases would take place not only in the directly affected area but also in the rest of the economy due to the ensuing economic downturn.4

A precipitous drop in real estate prices stemming from both direct and indirect economic declines would put many business, apartment, and homeowners “under water” in their mortgages, causing many to default.2,3 The situation could very well lead to the creation of “black holes” in the middle of a major city attacked by use of an insidious mechanism involving radiological, biological, or chemical agents. This would obviously be a great psychological, cultural, personal, and economic loss to individuals, the region, and the nation as a whole.

This article develops and applies methods to estimate the decline in property values and the number of foreclosures that would ensue from a major

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1 Assistant Professor, John Glenn School of Public Affairs, The Ohio State University, Columbus, OH, USA.
2 GIS and Economic Analyst, Point C Partners and RideAmigos Corp., Pasadena, CA, USA.
3 Research Professor, Sol Price School of Public Policy; Coordinator for Economics, CREATE, USC, Los Angeles, CA, USA.
*Address correspondence to Noah Dormady, Assistant Professor, John Glenn School of Public Affairs, The Ohio State University, Columbus, OH 43210, USA; dormady.1@osu.edu.

4 In addition to the short-term effects from the social amplification of risk and economic decline, long-run stigma effects could last for many years. A recent study comparing ordinary resource loss and behavioral effects of a radiological dispersion device (RDD) attack in a major metropolitan area, Los Angeles, estimated that the indirect effects could be more than an order of magnitude greater than direct effects, particularly if stigma effects were to last for several years.1
disaster like an anthrax attack. The results will provide key insights needed to evaluate and refine policies such as various types of mortgage subsidies to help mollify the consequences, and thus prevent Seattle from becoming a long-run disaster area. Overall, the results indicate that residential property values could decrease by over $50 billion for Seattle, or a 33% overall decline. Moreover, this increases the amount of negative equity by more than $15 billion, which could result in more than 70,000 residential units being foreclosed.

Following a review of the literature in Section 2, Section 3 provides a description of the attack scenario and background of the Seattle housing market. Section 4 presents the time series of real estate data, the regression model, and model results. The analysis breaks the Seattle metropolitan area into three zones: anthrax attack (CBD), fringe, and outlying areas. This is useful to distinguish the varied effects of the attack on real estate prices throughout the Seattle area. Key explanatory variables include area-wide personal income, median household income, employment, housing inventory, housing purchases/sales, and number of foreclosures. In Section 5, we utilize the model to perform a simulation of the effects on property values in the event of an anthrax attack scenario (AAS). Section 6 provides an overall summary, discussion of some caveats, policy implications, and suggestions for future research. The results of our analysis can serve as key ingredients in evaluating the extent of a combination of government assistance and private capital that would be needed to help large cities recover in the aftermath of an anthrax attack.

2. LITERATURE REVIEW

The effects of terrorism on housing markets have not been widely analyzed. By reviewing studies related to natural disasters, we identify approaches and findings that can be adapted to a model that captures the real estate effects of a terrorism event. Hallstrom and Smith (4) develop a model that compared how Hurricane Andrew influenced housing prices in the Florida counties in the hurricane’s direct path with those in adjacent counties. They develop two regression models that use repeat sales prices as the dependent variable. The first model regresses home prices on coastal amenities, defined in terms of distance from the coast, and increased risk to damage, due also to a home’s proximity to that coast. The second model is a hedonic equation that uses the characteristics of the property and the existence of information about a storm’s potential impact on a home. It was intended to determine whether these two parameters influence behavior and are sensitive to the treatment of property attributes. The authors found that housing prices declined by 19% in surrounding flood hazard areas, which implied that homebuyers and sellers are influenced by information or events in the areas adjacent to directly impacted areas.

Smith et al. (5) further develop this work in a study that uses basic regression models to analyze how people and housing markets respond to Hurricane Andrew in Dade County, Florida, which received the brunt of the impacts. The study found that the economic circumstances of a household appear to be the most significant factors. It examined what patterns occurred in highly damaged areas and in areas with less damage. Apropos to Hallstrom and Smith, they found that, since the rate of home value appreciation is lower in flood areas, the population grew faster after the hurricane in these areas. This behavior was driven by financial capacity, where lower-income households moved into highly damaged areas due to affordability, and middle-income households moved out of those same areas because of their financial ability to do so.

Zhang and Peacock (6) also focused on Hurricane Andrew in terms of how quickly home values recovered to their predisaster levels. They determined that housing sales increased in the wake of the storm, though the rate of appreciation for home values slowed significantly thereafter. The study focused on the rate of abandonment by homeowners and how this, along with decreased home values, influenced the high volume of sales. This study is also noteworthy because of what the authors mention in their limitations section—that studying a longer time period before and after the storm would have produced a stronger model.

Superfund sites and their impacts on property values have also been widely examined. Aydin and Smith (7) studied the effects of postremediation on property values in general, but more specifically in Houston. They sought to determine whether home prices recover after private firms or government agencies have completed efforts to remove all or most of the hazardous materials. The study’s results are compared with Kohlhase’s (8) results. Some of the key distinctions between the two studies were the geographic radius of property value diminution, direct depreciation of property values within that radius.
and the use of more widely available data. Whereas the Kohlhase study estimated the radius to be 5.3 miles, Aydin and Smith estimated the radius where property values decreased to be within 3.7 miles of the remediated areas. The direct depreciation associated with the proximity to the focused remediated site between 1985 and 1990 is also less, at 8.7% versus 14.9%. As of 2000, the direct impact on home prices declined from an 8.7% decrease in 1990 to a 2.2% decrease from the original value of the property. The direct impact is determined by whether or not a property falls within the estimated radius of diminution. Any effects outside of this area are deemed indirect, and interestingly had the greatest impact on property values and recovery in the area as a whole. This was largely attributed to changes in neighborhood characteristics, where it is common for lower-income households to move into an area that has been remediated, due to the lower property values. This in turn further depreciated property values, and the authors deduced that, postremediation, the direct effect decreased over time and shifted the focus away from the influence of proximity effects to the influence of demographics.

Most of the aforementioned studies used some type of distance measure, typically modeling it as a continuous variable in relation to some focal area. Hallstrom and Smith define it as coastal amenity. Kohlhase, and Aydin and Smith, identify it at the point from where property values first change. Redfearn, on the other hand, produces a series of models where distance variables are either continuous or discrete at three different proximities from a perceived terrorist attack. The models attempt to identify the idiosyncrasies within each zone and whether property values and perception of risk change with distance from a terrorism event. Using various prominent locations in Los Angeles as terrorist targets, he found that risk perception had no adverse effect on the housing market. In most studies, the distance variable acts as a proxy for how people assess risk, which eventually can influence property values. Nearly all of the above studies essentially conclude that some combination of demographic, economic, and distance indicators influence property values.

Finally, a decline in real estate prices would increase the number of mortgages that have negative equity. Using a panel of real estate data from Massachusetts, Foote et al. forecast the probability of foreclosure given negative equity resulting from a housing market downturn. They estimate individual equity levels from a robust data set and compare those estimates with reported foreclosures during the 1991 housing downturn. They then forecast housing prices past the term of their data set to estimate foreclosures in the current housing market three years out. Given contemporaneous drivers of foreclosure such as macroeconomic conditions and subprime lending, they estimate that the percent of homeowners with negative equity who will foreclose in the next three years will be between 7.3% and 7.9%. However, the relative share of negative equity mortgages stemming from a housing market downturn considered in their model is very much smaller than would occur following a disaster of the magnitude considered in our analysis. In fact, the lowest levels of negative equity impacts stemming from a disaster of the magnitude considered in our analysis are consistent with the highest levels of magnitude in the housing market downturn considered by Foote et al.

More recently, scholars have begun to evaluate drivers of foreclosures during the post-2008 economic downturn. This line of scholarship questions why so few homeowners have foreclosed after so many have fallen under water in their mortgages by large amounts. Given the array of economic relief programs available to homeowners, scholars suggest that many such stressed homeowners will not default until a “double trigger” of events occurs. That is, in addition to being underwater in their mortgages, a secondary shock is required to facilitate higher levels of foreclosure. They cite a liquidity shock, job loss, or adverse health conditions in a family. Bhutta et al. extend the work of Foote et al. but find significantly higher likelihood of default among homeowners who have both fallen under water in their mortgage and experienced a secondary trigger, which accounts for 80% of all mortgage defaults in their sample. Using a maximum likelihood formulation, they find that the median homeowner defaults when equity falls to minus 62% of the home’s value, and the median homeowner who experiences a secondary trigger defaults when equity falls to just minus 31% of the home’s value.

Our analysis extends this line of work by providing a short-run forecast of foreclosures beyond the levels that can be estimated from cyclical housing market downturns. Under an extreme terrorism event, the conditions for a “double trigger” are undoubtedly met, as homeowners experience a dramatic loss of equity, a significant macroeconomic shock to the local and regional economy, negative
health impacts, and in many cases forced evacuation and relocation during periods of decontamination and cleanup.

3. ATTACK SCENARIO AND CONTEXT

3.1. Background

Our Seattle anthrax attack scenario is based on a DHS interagency biological restoration demonstration (IBRD) scenario and a written script of events that could take place in its aftermath.\(^{(10-12)}\) Our simulation includes a 75% population flight from the central business district (CBD), though it should be noted that this migration is not permanent for an unspecified portion of that 75% population who are expected to begin returning after three to four months. Survey responses to the IBRD scenario\(^{(11,12)}\) indicate that the population decline would extend beyond the CBD, and be as large as 75% citywide. An out-migration of this magnitude could essentially cause the city’s economy and real estate markets to implode. Any model would have difficulty accurately predicting the decline in real estate values for this extensive of an event, and hence so great a departure from the historical statistical database. We consider such a scenario an upper bound, and prefer to simulate the impacts of a less sensational, and likely more realistic one. Therefore, we simulate a modified version of this scenario, which assumes the temporary exit of 75% of just CBD population, or only slightly over 35% of the total population of Seattle. This provides a mid-range estimate of real estate impacts, and represents a more reasonable application of our model.

The condition of the housing market is largely determined by economic and demographic factors, both of which influence housing demand. Employment growth, unemployment rate, and formation of new households are all key indicators when evaluating the health of a housing market. Many of the people who work in the CBD (Zone 1) will be affected in a manner that will alter their employment. Whether it is through relocation, severance, or work-from-home situations, the housing market in the region will be impacted by CBD residents and the specific labor force that commutes to work from other zones. The impact on real estate from the attack in the CBD will be determined in part by the magnitude of business and employment disruption. Normally, in cases where natural or man-made disasters impact a region, the area at the center of the disaster suffers the brunt of the effects (as a result of both accurate information and exaggerated information associated with social amplification of risk and stigma that leads to property value depreciation).

In an area where property remediation is required, such as the experience with superfund sites, a buffer area arises out of uncertainty and fear of the spread and/or lack of thoroughness of the clean-up effort.\(^{5}\) This causes a spillover of the impact on real estate values. Depending on the radius of the buffer, the direct effects of decreasing property values will be influenced by demographic changes in the area. However, the real change could come from indirect effects such as information, stigma, job relocation, and geography. Depending on the timeliness of clean-up efforts and the recovery process, all three zones will suffer from these indirect effects, thereby increasing vacancies and slowing any rebound in real estate prices. Apartment and office space vacancies could potentially suffer the most, as the target area is very dense in employment. The potential impacts to downtown Seattle real estate could have even more lasting effects due to its concentrated population and employment cluster.\(^{6}\) Even if the cleanup is successful, residential and commercial property values could decrease more than the 12% decline that resulted from the recent recession between 2008 and 2009.\(^{(13)}\) In such an event, demand is normally not met by returning residents and employees, but by a new demographic that will be enticed by lower housing prices and work opportunities, though the timing is very uncertain.

In the case of the two outer zones, we expect that the indirect effects would play a major role. Depending on socioeconomic status and insurance policies, home abandonment could become prevalent as people leave the area in search of homes elsewhere, which would additionally exacerbate real estate sigma. Furthermore, housing recovery could

\(^{5}\)King County has published a framework for recovery in the event of a biological attack.\(^{(14)}\) Following such an attack, cleanup could take anywhere between five and ten years to complete. The recovery framework prioritizes critical infrastructure prior to residential properties and outer areas of the city prior to the central business district, due to concerns of recontamination.

\(^{6}\)For example, in Houston, layoffs during the events of the Enron scandal and 9/11 in New York impacted downtown real estate significantly, leaving many vacancies.
3.2. Current Economic and Housing Indicators

Prior to the inception of the current recession, the Seattle MSA was experiencing employment and population growth of more than twice the national rate. However, because the region entered the recession one quarter later than the nation, it began losing jobs faster than the national average due to the lag. The employment erosion was exacerbated by the failure of Washington Mutual, and layoffs conducted by Boeing and Microsoft (see Table I).

From the first quarter of 2008 to September 2010, the region experienced an employment loss of 7.1% (131,400 jobs) compared to a 5.8% loss for the rest of the nation. The construction industry, which employed over 125,000 people in 2008, has been the most affected by the recession, with employment at approximately 90,000 in 2011. These cuts have largely led to the drastic decline in housing permits issued.

In June 2011, employment was 1,706,090, and the unemployment rate was 9.2%. Personal income as of 2009 was $171.7 billion and per capita stood at $50,378. Comparatively, the Seattle MSA ranks 15th in per capita income for 365 metropolitan areas. This high ranking is a result of a strong economic influence of the region’s information technology and manufacturing industries, which is accompanied by a skilled and diverse labor pool. Because of this labor pool, Seattle’s MSA output had fully recovered in September 2010 by growing 3.4% more than the third quarter of 2008, its prerecession peak.

The strength of the regional economy prior to the start of the recession propelled activity in the housing market to unprecedented levels. Home sales and construction grew to levels higher than most parts of the country; therefore, when the housing and credit markets collapsed, the fall of the region’s economy, being a quarter behind, was delayed and more profound. Like most cities in the United States, Seattle was responding to a demand in the housing market, which eventually morphed into a recession. The region’s recessions in the late 1970s and early 2000s were engendered by a reduction of demand for regional exports, mostly stemming from Boeing’s problems.

When the speculative housing bubble burst, Seattle, like the rest of country, experienced record low rates of home building. Within a year, regional home sales fell 63%, and residential building permits were down 51%, all of which ultimately contributed to a loss of 43,500 construction jobs (33% of total job loss). Since the first quarter of 2009, average home sales prices have decreased by 8% ($365,558 to $336,284); however, the housing market appears to be on an upward trend as of the first quarter of 2011. Home sales have increased by 9% since 2009, and the rental market is performing strongly. The apartment vacancy rate has dropped from 7.1% to 4.6%
from the third quarter of 2009 and the first quarter of 2011.\textsuperscript{(15)}

4. REAL ESTATE PRICING MODEL

An overview of our methodology is presented in Fig. 1. We begin with detailed real estate market data for the Seattle metro area (discussed in detail in the Appendix). Using GIS methods, we spatially code the data by zip code to correspond to the three concentric attack zones, consistent with the AAS.\textsuperscript{(10)} We conduct a panel regression analysis, using the GIS-coded data, to determine the additive effect of each variable of interest on median sales price throughout each zone of the city (Section 4.3).

We utilize our macromodel (Section 5) to estimate macroeconomic impacts (including both direct and indirect effects), consistent with the attack scenario, and shock the panel model with those macrooutputs. That shock, discussed in detail in Section 5, allows us to predict real estate price changes resulting from the attack (Section 5.1). We then utilize HUD’s 2009 American Housing Survey (AHS)\textsuperscript{(19)} to construct a citywide distribution of homeowner equity. Finally, we utilize that distribution to predict foreclosures for each spatial zone resulting from the attack (Section 5.2).

4.1. Data Utilized for Panel Analysis

Terrorist attacks affect real estate values both through housing market and macroeconomic variables. We begin with a discussion of a unique data set consisting of spatially differentiated macroeconomic variables. The sales price of any single property can be driven, to a large extent, by exogenous factors specific to that property: use requirements of the buyer, preferences, tastes and characteristics inherent to the specific location (e.g., square footage) or the community in which the property is located. It is community and regional drivers of real estate prices that would be most altered by a region-specific terrorism event.

We utilize zip code as our unit of analysis because it enables us to make both community-specific and region-specific assessments of the macroeconomic drivers of real estate prices, while avoiding the large quantity of property-specific and exogenous information that may otherwise provide noise in our model. Although there are 61 zip codes within the City of Seattle, our analysis focuses on the main 32 of these.\textsuperscript{8} Our unit of analysis for time scale is months, from January 1994 through December of 2010. This historical time range is important because of the region-specific history of the Seattle metro area. In 2001, the Nisqually Earthquake hit the Puget Sound region, shocking the regional economy in the short run, having a minor downward influence on real estate prices. Our historical range of time, therefore, incorporates periods before, during, and after that event.

\textsuperscript{8}The remaining zip codes were disqualified from this analysis as they represent “unique” zip codes used by a specific company or organization with a high volume of mail service (e.g., a large university), or post office boxes carrying their own zip codes. Eight zip codes were also omitted because of any one of the following: they fell within a larger zip code, they were occupied by an airport, university, or federal land, or neither residential characteristics nor data were present within that zip code.
disaster, and also encompasses events such as recessions.

Zip code 98101 is the epicenter, which means that an anthrax attack on the Seattle CBD would contaminate an area of approximately 10 square miles. We use the U.S. Census’s OnTheMap GIS tool to divide three zones: (1) Contamination Zone (includes the CBD), (2) Adjacent/Fringe Zone (a four-mile radius perimeter surrounding Zone 1), and (3) Outlying Zone (includes outlying zip codes of the City of Seattle).

4.2. Real Estate Regression Model Specification

The dependent variable of this analysis is median sales price of residential real estate. It is measured at the zip code level, and varies monthly across our 17-year panel. To adjust for constant dollars we used the Seattle-Tacoma housing Consumer Price Index as the deflator. Our method for analyzing this data is a time series cross-sectional (TSCS), or longitudinal model. This class of model provides unbiased estimates of multiple units across time that do not fall prey to the same criticisms as pooled models applied to panel data. Our analysis uses a fixed effects cross-sectional time series (FE) model. The model includes a time-stationary error term that corrects for time dependency, and enables the same style of estimates that are sought through pooled models or OLS cross-sectional, nonpanel models. This model is given by:

\[
\text{Median Sales Price}_{zt} = \beta_1 \times \text{Median Household Income}_{zt} + \beta_2 \times \text{Employment}_{zt} + \beta_3 \times \text{Personal Income}_{t} + \beta_4 \times \text{Homes Sold}_{zt} + \beta_5 \times \text{Foreclosures}_{zt} + \beta_6 \times \text{Housing Inventory}_{zt} + u_z + \varepsilon_{zt},
\]

where \(u_z\) are unit (zip code) specific fixed effects/unobservables, and \(\varepsilon_{zt}\) is the identically and independently distributed (i.i.d.) error term.

The regressors included in this equation are both the fundamentals of the local and regional macroeconomy, as well as the fundamentals of the local and regional housing market. Because the analysis is driven by the aim of estimating spatially disaggregated effects, this estimating equation is broken down into five separate regression models. First, the regression is applied to the entire City of Seattle. Second, the model is applied to each of the three zones of spatial analysis, which include the Contaminated Zone (CBD), the Fringe Zone, and the Outlying Zone. Finally, a separate regression is estimated only for those zip codes that lie outside of the Contaminated Zone, for purposes of comparison to the Contaminated Zone.

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**Table II. Real Estate Regression Analysis Results**

<table>
<thead>
<tr>
<th></th>
<th>Citywide Model</th>
<th>Zone #1 Model</th>
<th>Zone #2 Model</th>
<th>Zone #3 Model</th>
<th>Zone #2 &amp; 3 Model</th>
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<td>Median Household Income</td>
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<td>3.71***</td>
<td>3.91***</td>
<td>1.65***</td>
<td>2.14***</td>
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<td>(0.15)</td>
<td>(0.50)</td>
<td>(0.28)</td>
<td>(0.12)</td>
<td>(0.11)</td>
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<td>(0.22)</td>
<td>(0.49)</td>
<td>(0.22)</td>
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<td>(57.79)</td>
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<td>(55.16)</td>
<td>(180.11)</td>
<td>(64.50)</td>
<td>(53.13)</td>
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<td>Foreclosures</td>
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<td>−5,394.87***</td>
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<td>(477.39)</td>
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<td>(706.19)</td>
<td>(536.12)</td>
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<td>3.03*</td>
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Fixed effects panel model results generated using Stata 10. Standard errors in brackets. *p < 0.1; **p < 0.05; ***p < 0.01.

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9 The data used for this analysis come from a variety of both public and private sources. We provide a detailed explanation in the Appendix.
4.3. Real Estate Regression Results

The panel analysis results are provided in Table II. The regressions are robust overall and explain anywhere between 35% and 75% of the variance in median residential sales prices between 1994 and 2010 for the City of Seattle. The models have strong fitness measures, indicating that a proper set of both macro and real estate variables has been included. The regression model labeled “Citywide” indicates a regression that includes each of the 32 zip codes for the entire Seattle area. Spatial disaggregation at the zip-code level is important to the results because it is the ideal geographic unit for this analysis. A zip code captures significant demographic, economic, and housing data and is a good indicator of income and socioeconomic levels. Furthermore, zip codes distinguish areas of a city such as financial centers, public places, and neighborhoods mainly by these variables. The models labeled “Zone #1, Zone #2, and Zone #3” indicate individual zone-specific regression models. And, the model labeled “Zone #2 and 3” indicates a pooled model that includes the Fringe Zone and the Outlying Area, excluding the Contaminated Zone.

The citywide regression explains the average tendency of real estate prices throughout the City of Seattle, irrespective of geospatial location. Throughout the panel period, Median Household Income provides one of the strongest macro drivers of real estate prices, as it does throughout individual zones. Holding all other variables constant at their mean, a $1,000 increase in median household income would increase the median sales price of residential property in the mean zip code by more than $2,500. That effect is more than 40% higher in the area with the CBD (Zone #1) and the fringe area (Zone #2). In those districts, the median sales price of real estate is much more responsive to changes in household income. Household income is also a highly statistically significant driver of real estate prices, safely rejecting the null hypothesis that the asymptotic relationship is zero at even the most stringent levels of significance (p-value) across all geospatial parameters.

Employment (full-time equivalent persons by place of work), however, is a strong but less statistically significant driver of real estate prices through-

10We performed a number of robustness tests for the effect of multicollinearity in our models, as pair-wise correlations among some regressors are present. The robustness tests indicate that model coefficients and standard errors are highly robust to changes in model specification.
significant decreases in sales price if a “short sale” is made or if a repossession or bank ownership occurs. As with the housing market regressors, the median sales price in the CBD is less responsive to foreclosures. Similarly, the mean monthly foreclosure rate of an average Zone 1 zip code is just above one foreclosure per month, whereas that number outside of that zone is just over two foreclosures per month.

The supply side, however, provides a different effect altogether. Housing Inventory is our proxy for the supply of available residential real estate. Ceteris paribus, an increase in the supply of available real estate should lead to a decrease in the price of real estate, relative to a fixed demand for housing. We find this effect to be accurate and in the appropriate direction in each of the regressions for which the coefficient is highly statistically significant. For every additional residential property added to the housing inventory in the average Zone 1 zip code, the median sales price of housing decreases by approximately $15. That is, a single standard deviation increase (approximately 2,800) in the number of residences would decrease the average Zone 1 zip code mean sales price by over $44,000.

The supply of housing provides an interesting departure from expected disaster outcomes. That is, under a nondisaster scenario, an increase in the housing stock relative to a fixed housing demand would lead to a decline in the price of housing. However, under a disaster scenario, a decline in the housing stock stemming from property damage or condemned properties would constitute a decline in both the supply and demand for housing. There would be fewer livable homes and fewer people would prefer to reside in them. Under an anthrax attack disaster scenario, we would expect a likely sign reversal of this coefficient for housing stock, as the demand for housing in both the attack zone and neighboring communities would decline both in the short run and long run, and the supply of housing would be suppressed in the short run, with likely sticky rebound in redevelopment. It should be noted, however, for all coefficients in each of the regression-estimating equations, that the assessments were made based on a panel of data from periods that did not include terrorism events.11

5. REAL ESTATE PRICE IMPACT AND FORECLOSURE ANALYSIS

The anthrax attack affects residential property values through several channels. This includes contamination and temporary or permanent closing of buildings in the area in which the anthrax is dispersed, fear of contamination in a wider area, concern about longer-term contamination/distrust of the effectiveness of clean-up efforts, general economic decline, and factors specific to the housing market. We combine the real estate projections with data on Seattle housing stock to estimate total declines in real estate prices and the number of people whose mortgages would probabilistically be underwater. This provides useful information on potential defaults. The results can be used to evaluate government funding needs to avoid dire negative outcomes of an anthrax attack on a major urban area.

We utilize the real estate regression model to estimate the effects of a stylized AAS, based on the DHS AAS scenario, on real estate prices and foreclosures in Seattle. Our methodology employs the panel model coefficients additively to determine the net change in median residential sales price by concentric attack zone. We insert into the model independent macroeconomic and housing market variable values reflecting the current period (short-term) impacts of the attack. These variables are applied differentially across the three zones.

This simulation consists of a 75% population flight from Zone 1 and is related to employment, a major explanatory variable in our model. However, the AAS does not specify the employment loss associated with the attack. We utilize the AAS short-term population reduction for estimating employment impacts. We assume a fixed ratio of employment to population in the Seattle area, which corresponds to a constant labor force participation rate and unemployment rate. We then use population and employment data from the Impact Analysis for Planning (IMPLAN) System to convert to direct employment impacts in Zone 1.

The IMPLAN input-output table for King County is then used to estimate the indirect

11 As discussed previously, there are a number of factors that may influence the price of houses individually. These include micro-level amenities like square footage, crime rate, school district quality, etc. On an asymptotic level, that is, in large samples, the median tendency of real estate prices is unaffected by these micro-level unit-specific effects, and is driven by those factors that we include within this analysis. We acknowledge that there may in fact be alternative local and regional drivers of real estate prices; however, we suggest that including them may be problematic from both a data acquisitions standpoint and from an econometric standpoint. Overall, however, the summary and fitness measures of our estimating equations provide a concise and well-explained picture of real estate prices within Seattle.
Table IV. Macroeconomic Variable Estimated Changes

<table>
<thead>
<tr>
<th>IBRD AAS Scenario</th>
<th>Citywide</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta \text{Employment} )</td>
<td>–</td>
<td>–192,379</td>
<td>–12,341</td>
<td>–13,418</td>
</tr>
<tr>
<td>( \Delta \text{Median Household Income} ) (constant $ U.S. 2011)</td>
<td>–</td>
<td>–50,592</td>
<td>–7,065</td>
<td>–8,453</td>
</tr>
<tr>
<td>( \Delta \text{Personal Income} ) (constant $ U.S. 2011)</td>
<td>–20.69B</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

employment impacts throughout the three zones. The total (direct plus indirect) employment impacts are then entered into the predictive model equation. However, this involves one major complication, in that more people work in Zone 1 than live there due to the densely employed CBD. Thus, we deduce an employment decline of 90% of base Zone 1 employment. The macroeconomic declines due to the AAS are provided in Table IV. We use IMPLAN data to calculate the declines in the associated total personal income citywide. Median household income is determined secondarily from IMPLAN employment and personal income results.

We also estimate similar scenario-specific real estate market impacts. As is consistent with both theory and scenario development, we assume that housing inventory will change on the basis of the quarantined and condemned residential structures (single-family dwellings), as well as multi-family dwellings that are converted into individual units. We deduce that there will be a 50% decrease in the available housing stock, which translates into approximately 5,599 homes in Zone 1. Given that there are a total of nine zip codes within this zone, we estimate that the average Zone 1 zip code will see a reduction in housing inventory of 622 units.

The effect of the AAS on housing sales is estimated for each zone by assuming a single standard deviation decline from the mean monthly quantity of property sales for the average zip code in each of the three respective zones. These single standard deviation declines are 13, 17, and 15 fewer homes sold, in Zones 1, 2, and 3, respectively.\(^\text{12}\) We maintain that this provides a conservative estimate of the potential declines in home sales that may actually occur in the event of an AAS-comparable event.

5.1. Property Value Changes

The values provided in Fig. 2 summarize the impacts from each of the variable imputations, that is, they predict a short-run change in median sales price of residential real estate in each of the three AAS concentric zones given each of our macroeconomic and real estate market parameters from the AAS scenario. These include the direct (Zone 1 only) and indirect (all three zone) effects stemming from the AAS scenario’s impact on Employment, Personal Income, and Median Household Income. These similarly include the estimated real estate market impacts stemming from a 50% decline in housing stock in each of the Zone 1 zip codes, and a single standard deviation decline in home sales for each respective zone.

The results suggest that the average zip code in the CBD (Zone 1) would see an immediate decline in the median sales price of residential real estate by over $280,000. The Zone 2 and 3 impacts are significantly smaller than those in the midst of the attack area. From the macroeconomic side, those outer zone impacts are driven by indirect effects that influence patterns of employment and economic conditions from interrelationships between zones within the regional economy. Region-wide personal income effects provide the largest share of these macroeconomic impacts. From the real estate side, these effects are driven by the decline in home sales. Home sale declines would likely stem from the demand side, through both income effects and psychological (stigma) effects that would be cross-pollinated from the central attack zone throughout the rest of the city.

It is noteworthy that increases in housing inventory have historically provided a supply-side effect that has led to declines in residential real estate prices. Simply put, as the supply of available housing increases, the price of housing relative to demand declines. In a postdisaster scenario, we estimate that there would be a proportionally small effect in the opposite direction. That is, condemned housing in the Zone 1 area would decrease the supply of housing units relative to demand for housing, and thus there would be a slight increase in the price of housing. We estimate this increase to be approximately $9,800 for Zone 1. Given the decomposition of these effects for the supply of housing units, however, the negative effects stemming from declines in home sales and macroeconomic changes overwhelm this small positive increase.

\(^{12}\)Standard deviation estimates are determined from 2008 Seattle home sales figures.
We apply these macroeconomic and real estate variables additively, as in the form of a linear model. Because our panel model is a cross-sectional time series model, with monthly variation in the data, our estimates provide predictive quantification for changes in median sales price for a short-run change in these respective markets. Residential property value losses for all three zones total $50 billion, stemming from losses of $27 billion in Zone 1, $10.3 billion in Zone 2, and $13.2 billion in Zone 3. These housing value declines from a terrorist attack represent a citywide 33% drop from baseline.13 Some perspective on the magnitude of these figures is warranted. In 2010, the median sales price of residential housing units in the CBD was $426,000. A $280,000 decline represents approximately a 65% short-run decline in housing price (or less than two standard deviations). In perspective, housing price declines in the aftermath of Hurricane Katrina in the East Bank of Orleans and St. Bernard Parish, two areas directly impacted by the storm, decreased by 20% and 40%, respectively.14 In comparison, recessionary impacts to housing prices have been even more substantial in areas hardest hit by the recent housing bubble. San Bernardino and Riverside, California, for example, suffered a nearly 60% and 47% drop in median sales prices between 2007 and 2012, respectively.

5.2. Foreclosures

Thus far, we have controlled for the impact of foreclosures on changes in real estate prices. Our predictive estimation from the previous subsection controlled for those values by holding them at their historical mean. The estimations of the panel model coefficients were ultimately taken from historical periods where markets were not constrained by effects of the terrorist hazards. We now translate our findings to provide a rough estimation of foreclosures by concentric zones, given the predictive sales price changes provided in the previous section.

Our assessment of foreclosures is based upon the assumption that changes in the sales price of real estate, which ultimately influences property values, would cause a number of housing units to retain a market value below current market values, and similarly, would increase the number of properties that are “under water” (have negative equity). We employ national survey data from the U.S. Department of Housing and Urban Development (HUD) to determine the distribution of homes that would otherwise have negative equity, given proportional changes in median sales price.

Every two years, HUD conducts a comprehensive regional AHS. Fortuitously, the 2009 survey was conducted in the Seattle area and included nearly 1,000 respondents. We use two key variables from the survey: the level of mortgage/home loans (in dollars) and outstanding loan balances. From these key variables, we were able to determine a citywide distribution of homeowner equity (money already
paid toward a home loan via monthly payment or monthly mortgage payment). Our foreclosure analysis assumes that the sample survey is asymptotically equivalent to the true distribution of the Seattle region. Similarly, we utilize this distribution of equity values to determine the probability that a housing unit within a concentric zone will have negative equity following a proportional reduction in median sales price, consistent with our estimates for each zone.

The likelihood of a housing unit foreclosing depends upon the degree to which it maintains negative equity. For example, a homeowner who owes $500,000 on a home that has a postdisaster market value of $200,000 would have a high probability of foreclosing, relative to a homeowner who has a higher proportion of equity in the home. As such, we decompose this negative equity distribution into five quintile ranges. Those housing units in the largest quintile (lowest quintile) have the largest negative equity, and thus would have the largest probability of foreclosing. We apply these quintile ranges to a fixed scale of foreclosure likelihood, as provided in Table V.

Table V. Negative Equity and Foreclosure Rate
Scaling Parameters

<table>
<thead>
<tr>
<th>Negative Equity Quintile</th>
<th>Foreclosure Rate ($\phi$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10%</td>
<td>0%</td>
</tr>
<tr>
<td>10–25%</td>
<td>10%</td>
</tr>
<tr>
<td>25–50%</td>
<td>25%</td>
</tr>
<tr>
<td>50–75%</td>
<td>50%</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>75%</td>
</tr>
</tbody>
</table>

Each scenario-specific median price change is applied to the quintile range of negative equity for each zone, as given by:

$$\sum U_q \times \sum U_z \times \phi,$$

where

- $\sum u_q$ = the number of housing units within a negative equity quintile from the U.S. HUD’s AHS,
- $\sum u_T$ = the total number of housing units (completed responses) from the U.S. HUD’s Seattle AHS,
- $\sum u_z$ = the total number of housing units by concentric disaster zone,

$\phi$ = a scaling parameter equal to $\text{Pr}(F|Q(u))$ the conditional probability that a housing unit will foreclose given its percentage of negative postshock equity.

There is also recent precedent for this method of foreclosure estimation. A recent analysis\(^2\) utilized a forecasting model to estimate foreclosures stemming from a housing market downturn in the State of Massachusetts. Our method of negative equity estimation and the variables we include in our panel models are consistent with that analysis for the lowest level of negative equity in Table V.\(^5\) However, given the difference between an ordinary housing market downturn and an anthrax terrorism attack, our analysis includes several additional levels of negative equity, more closely resembling foreclosure probabilities that would occur under a “double-trigger” of events that would undoubtedly ensue (see Section 2).

Our foreclosure estimates are as follows: 42,211 housing units in foreclosure in Zone 1, 14,101 foreclosures in Zone 2, and 15,931 foreclosures in Zone 3, following an impact consistent with our AAS.\(^6\) The average zip-code-wide estimates can be derived from these numbers, by dividing each zone-wide total by the number of zip codes within that zone: nine zip codes in Zones 1 and 2, respectively, and 14 in Zone 3. This accounts for the greater total number of foreclosures in Zone 3 because that zone has a proportionately larger number of zip codes, encompasses a larger geospatial area, and has more housing units. Overall, we project nearly 72,000 foreclosures.

Given disasters of the magnitude simulated in our scenario, a large number of housing units would lose a significant amount of equity due to the declines in sales price. Our analysis also estimates the

\(^5\) An additional contribution that our analysis provides is data reliability. That is, whereas Foote et al\(^2\) are forced to estimate equity values from reported purchase prices and current housing prices (or forecasts for future years), our use of HUD’s AHS data provides a robust baseline estimate of homeowner equity. The AHS data provide the current outstanding balance as a survey response. Foote et al. acknowledge that their estimates could be biased based on terms and conditions inherent to the loan (e.g., interest rate) that are outside of their estimates. The AHS survey data are not subject to the same potential bias.

\(^6\) These estimations are indicative of how many housing units will be impacted by a foreclosed property. Our definition of a housing unit includes single family (1 living unit), multi-family (2–3 living units), individual condominium units, and individual apartment units. Therefore, when we say that 42,211 units will be foreclosed, we assume that several foreclosed condominium and/or apartment complexes capture a significant amount of those units.
total sum of negative equity from all housing units, whether they foreclose or not. For example, a homeowner who has an original mortgage of $400,000 and has currently paid $50,000 toward that home loan, and is hit by a sales price decline of $75,000, will wind up holding $25,000 in negative equity. In other words, that homeowner owes $350,000 on a home he/she can currently sell for only $325,000.

This accounts for extant negative equity. We utilize the U.S. HUD AHS results for the City of Seattle and assume that the zone-wide distribution of amortization is asymptotically equivalent to that of each of our three concentric zones. Given the original mortgage value of each housing unit and current equity in that unit, we calculate the postdisaster equity following the disaster scenario for each zone. We then separate those housing units into quintiles of negative equity, and determine the quintile-specific mean dollar value of negative equity. We then multiply that total by the quantity of housing units that we estimate would be within that quintile of negative equity following each disaster scenario (based on the assumption that the distribution of equity in each zone is equivalent to the equity distribution of respondents from the 2009 AHS). Next we aggregate these subtotals into a zone-wide total of negative equity for each zone. Finally, we deduct from these totals the estimated totals of predisaster negative equity. In each zone, that amounted to approximately 3% of the total quantity of housing units, with each of those housing units holding a mean predisaster negative equity of just over $33,000.

Total negative equity increases for all three zones by $15.2 billion, with nearly 80% of the total in Zone 1. Negative equity increases nearly 25-fold, and represents about 30% of total real estate value losses.

6. CONCLUSION

We intend that our analysis serve as a template for future research on the effects of natural disasters and terrorism on real estate markets in general and foreclosures in particular. While the former has long been a subject of the literature, the latter has been addressed for the first time in the disaster context in this study. Our work and the recent concerns over foreclosures prompted by the bursting of the 2008 housing bubble(2,3) indicate how important foreclosures are to the housing market, family well-being, and regional economies. Our methodology is applicable not only to an anthrax attack but to any event that is likely to have a major effect on a combination of real estate prices and the surrounding macroeconomy. This would include terrorist attacks using other insidious means such as chemicals or radiological devices. It would also include natural disasters that cause widespread toxic spills or nuclear reactor accidents generating widespread contamination. All of these would be characterized by fear and stigma effects, forced or voluntary evacuation, and massive and costly cleanup taking years to complete.

This article has illustrated the usefulness of a statistical analysis analyzing some of the more important impacts of a terrorist anthrax attack on the Seattle real estate market. The model’s ability to predict a decrease in housing prices following such an attack can serve as the basis for estimating the vulnerability of the real estate market. The model is used to help predict the extent to which Seattle residents will find their mortgages underwater, and offers an indication of the amount of government assistance that might be needed to prevent defaults/foreclosures in the city and hence a large population exodus. The results for our scenario indicate that residential property values could decrease by over $50 billion, or a 33% overall drop. This increases the amount of negative equity by more than $15 billion, and could result in more than 70,000 residential unit foreclosures.

Specifically, we have provided an example of how the model can calculate changes in real estate values when economic variables, such as employment and median household income, are shocked. Such a stark employment reduction has significant implications for real estate market conditions, and further emphasizes the need for businesses in contaminated areas to implement long-term resilience measures that attract employment and investment. Furthermore, federal, state, and local government agencies can use an analysis such as this to gauge incentives to stimulate this return, so as to expedite the recovery process for homeowners and businesses.

We emphasize the caveat that our results are intended to be illustrative rather than precise figures for policy formulation at this time. While the predictive model is statistically sound, its application could still be improved. This would entail obtaining additional data on the distribution of original mortgage levels and pre-attack equity levels in each of the three geographic zones in Seattle. The analysis could be further bolstered by finding ways to differentiate the prediction of median home values by impact zone. The final step would be to improve the
supplementary analysis of the likelihood of default/foreclosure in the event that home values drop significantly below mortgage balance levels.

This situation poses a serious public policy dilemma. Does government enter the picture in order to provide incentives to reestablish the population economic base of Seattle? Although recovery may fail the market test, broader societal objectives might warrant an infusion of various forms of subsidies. These objectives could include national pride, concerns for disaster victims (who have joined the ranks of severely economically disadvantaged), and even concerns about the drag on the national economy stemming from an empty Seattle, a large displaced population, and large induced migration. The latter implies it may be less expensive nationally to subsidize Seattle residents and businesses than to pay private out-of-pocket or government-financed relocation costs and unemployment insurance, or incur potential costs of severe disruption of families and strains on other regions to absorb the migration. A large number of incentives could be applied, including mortgage payment subsidies, low-interest loans, decontamination and testing subsidies, and safe building guarantees/buyouts. Broader measures would include investor subsidies, wage subsidies, personal and business income tax credits, and job retraining.

ACKNOWLEDGMENTS

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APPENDIX: DATA ACQUISITION

Our dependent variable (Median Sales Price) and two other key variables (Quantity of Homes Sold and Quantity of Foreclosures) were acquired from the real estate and database firm, Data Quick. It acquires its raw data directly from records available through the King County Department of Assessments, in Washington State. Each of those variables is provided at the zip-code level by month.

The remaining data were available only on an annualized basis. Housing Inventory and Population were acquired through Seattle’s Office of Financial Management and the Puget Sound Regional Council (PSRC) respectively. PSRC data were acquired only at the census-tract level. We adjusted these data into zip code levels using the University of Missouri Census Data Center’s Geographic Correspondence Engine.

Employment and Median Household Income were gathered from The Sourcebook of Zip Code Demographics which has been published annually (excluding the year 2002) by CACI International Inc., and as of 2003, by Environmental Systems Research Institute (ESRI). We capture employment by place of work to assess conditions inherent to a location’s economic climate. Median Household Income provides for a robust assessment of

<table>
<thead>
<tr>
<th>Table A1. Citywide Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>Median Sales Price</td>
</tr>
<tr>
<td>Median Household Income</td>
</tr>
<tr>
<td>Employment</td>
</tr>
<tr>
<td>Personal Income ($B U.S.)</td>
</tr>
<tr>
<td>Homes Sold</td>
</tr>
<tr>
<td>Foreclosures</td>
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<tr>
<td>Housing Inventory</td>
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</table>

<table>
<thead>
<tr>
<th>Table A2. Central Business District (Zone 1) Descriptive Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>Median Sales Price</td>
</tr>
<tr>
<td>Median Household Income</td>
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<tr>
<td>Employment</td>
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<tr>
<td>Personal Income ($B U.S.)</td>
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<td>Homes Sold</td>
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<td>Foreclosures</td>
</tr>
<tr>
<td>Housing Inventory</td>
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</tbody>
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Potential Impact of an Anthrax Attack on Real Estate Prices

of missing data, we used a smoothing technique known as double exponential smoothing to generate an interperiod forecast from the available data, and utilized those “smoothed” observations to replace missing observations in the original data.

Finally, we use Personal Income as a control variable that is measured at the regional level for the entirety of the City of Seattle. The data, acquired from the U.S. Bureau of Economic Analysis, provide us with a highly robust assessment of the general overall macroeconomic climate of the region. Median Household Income and Personal Income are measured in constant 2011 dollars, based on Consumer Price Indices.

REFERENCES