Interstate Highways and Homeowner Wealth Distribution

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Abstract: This paper studies house-level real estate wealth distribution changes nearby a major interstate highway, pre-announcement (1940) and during the construction period (1960s). Using regression analysis, we test the hypothesis that proximity to I-84 in Hartford, CT was correlated with real estate values. We also develop Lorenz Curves to examine the distribution of housing wealth among various demographic groups of homeowners. First, we find that properties at least a half-mile away from I-84 experienced statistically significant appreciation (on average). Houses further away, in ¼ mile increments up to 1.25 miles, had smaller appreciation. Our Lorenz Curves exhibit a small inequitable distribution of wealth gains among all homeowners experiencing appreciation. But there was a large inequitable distribution of wealth losses among homeowners whose houses decreased in value in the 1960s (post-construction) compared with 1940 (pre-announcement). House price appreciation inequality in Census tracts with "high" Black populations was over 25% greater than in tracts with high White populations, for the 10th percentile of homes with wealth increases in each of these two types of tracts. Finally, we observe that approximately 0.5% of the houses in our 1940 Census sample of around 2,500 homes had a Black homeowner.

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Introduction

Many interstate highways in the U.S. were built at a time of dramatic changes in America's land use patterns. They also may have been correlated with homeowner wealth differences across various demographic groups that lived near the planned highways. Housing is the largest expenditure item for many American households, and it is one of the major mechanisms for households to accumulate wealth. The introduction of new highways can be associated with land use pattern changes and the values of real estate nearby. Geospatial analyses are crucial tools to examine highways and wealth distribution. Relatively little research has been published on the relationships between the introduction of the U.S. interstate highway system and household-level real estate values. A major focus of this research is to leverage geospatial analysis to test the hypothesis that house values have risen near a highway; and to explore the homeowner wealth distribution among various priced houses, and across demographic groups (i.e., houses in neighborhoods with "high" Black populations and "high" White populations).

The objectives of this research are to consider the above described issues for one particular interstate highway in Hartford, CT. Specifically, we (1) use regression analysis to evaluate how the implementation of Interstate 84 (I-84) in Hartford, Connecticut (the state capital) is correlated with real estate values over the 20-30 year period spanning from the planning stages (circa 1940) through the opening of the highway (in the 1960s); and (2) construct Lorenz Curves to demonstrate visually how this homeowner wealth creation varied across different groups of residents in the city of Hartford, CT.

To accomplish these objectives, several tasks have been undertaken. Data have been manually collected on nearly 2,500 home values near I-84 from the 1940 Census (before the development of the interstate highway plans) and matched with assessed values for corresponding houses that sold in the 1960's (after the opening of the I-84 in Hartford). For each property address, we then have 2 observations on that property's estimated value – one before the development of the interstate highway system (in 1940) and one after the opening of the major interstate highway that runs through Hartford (in the 1960's). These data have been geocoded, and maps developed that demonstrate how the appreciation/depreciation in property values (i.e., "wealth" changes) have varied across this part of the city of Hartford. Included among these maps is one showing percentage changes for properties that appreciated versus depreciated, and one showing dollar ranges for the home value appreciation/depreciation. While some patterns are evident from visual inspection of these maps, a more rigorous analysis using multiple regression analysis finds the following correlations.

First, we find insignificant statistical evidence of depreciation for houses that are very close to the highway (i.e., within 0.25 miles), after holding constant other factors,[1] between 1940 and the 1960's. Second, properties that are a half-mile away or more from I-84 experienced 55% appreciation, and as the distance to I-84 increases, the appreciation is less, falling to 27% appreciation for houses within 1.25 miles. But at a distance of within 1.5 miles away from I-84, property values appreciate again, rising to 45%, as those houses are closer to another interstate

[1] This seems consistent with what we observe anecdotally in Figures 4 and 5 below.

highway (I-91). Next, properties that were worth more in 1940 actually appreciated less between the period of 1940 and the 1960's, after controlling for highway proximity and drive time to I-84.

For properties that increased in value between 1940 and the 1960s, there was an inequitable distribution of wealth gains. When comparing Census tracts with more than 50% Black population and tracts with more than 50% White population (based on 1960 tract-level Census data), there are some differences. As one example, we consider the 10^{th} percentile of homes with price appreciation in these two demographic groups. The house price appreciation inequality in tracts with "high" Black populations was over 25% higher than in tracts with "high" White populations. These racial disparities in wealth accumulation, both before and after the highway construction, may have precluded many Black residents from accruing wealth in the same manner as other residents. This is underscored by our observation that approximately 0.5% of the houses in our 1940 Census sample of nearly 2,500 homes had a Black homeowner (based on 1940 Census individual-level demographics).

We also develop Lorenz Curves to examine the extent of housing wealth inequality among the homeowners near I-84 who experienced property value decreases. There was a relatively small number of properties that experienced declines in value, but there was a large inequitable distribution of wealth losses among homeowners whose houses decreased in value. For instance, more than 70% of the cumulative wealth losses, after vs. before construction of I-84, were experienced by roughly 20% of the homeowners.

From a policy perspective, our findings could be supportive in planning and policy for how (i.e., elevated, at grade-level, or underground) and where to reconfigure I-84 as a result of the need to revamp the highway due to age-related deterioration. It also is intended to lay the foundation for future research using similar techniques that can address these issues for other U.S. cities where interstate highways have been built. It is important as a potential methodology to place a value on the interstate highway system in the U.S. It can also be a tool for comparing real estate wealth accumulation inequality within cities due to the interstate highway construction, as well as across different cities. It could enable researchers to uncover new information about where the net benefits of highway construction have been equitable and where they have been relatively inequitable. These regional disparities could also inform future highway construction decisions that may be helpful to policy makers who are choosing how to allocate future highway construction funds across different regions of the U.S. Other transportation modes (e.g., transit or airports) could be amenable to these techniques as well.

The remainder of this paper is organized as follows. The next section presents a review of the literature on highways, wealth distribution and real estate. A detailed description of the data gathered and some GIS maps that provide visual evidence on real estate value changes are presented before the description of methodologies for achieving the objectives, which consist of regression analysis and Lorenz Curves. Finally, we conclude with a summary and some discussion of the potential directions for future research.

Literature Review

There has been extensive research done on the linkage between highway infrastructure and economic performance. Much less research has focused on analysis of how proximity to a highway correlates with real estate wealth, going back to the dates of the announcement of the original plans for interstate highways. The issue of inequality in the real estate wealth accumulation, after versus before the announcement of an original highway in the interstate system, has not been explored.

The existing studies generally agree upon the positive role of investments in transport infrastructure by producing strong economic benefits and fostering growth (the Congressional Budget Office 2015, the White House 2014). These findings have justified government funding for new and improved transportation infrastructure.

However, there is no overarching consensus on the magnitude of economic impacts of highway investment. This is because of a great deal of variance in the estimates of the impacts. A broad literature on highway infrastructure studies has focused on a variety of economic impacts, such as Gross Domestic Product (GDP), employment, productivity, production costs, and other considerations.[2]

In fact, Boarnet (1998) has found that highway infrastructure improvement in some areas (in this case counties) can draw away the most productive resources from neighboring areas (counties) which implies a negative effect of nearby infrastructure investments. Also, externalities from infrastructure investments in some locations, such as noise and air pollution, may have detrimental effects. It is also possible that the positive effects of highway infrastructure may dominate the negative effects in some locations, while at other locations the opposite may hold. Although many of the studies described above have become widely accepted benchmarks for measuring the macroeconomic impacts of public highway infrastructure on the economy as a whole or of a particular sector (such as manufacturing), relatively little research has been published on the wealth distribution associated with highway investment at the household level.

The announcement of highway improvements such as new construction can substantially change the values of properties nearby (with a net effect being either positive or negative, as described below). This change in home equity for the average household due to the potential benefits from access to highways (e.g. enhanced access to the city center and/or to other cities) is called “capitalization”. The capitalization of highways into real estate values is similar to the case for other “amenities” (such as has been found in other studies on the capitalization of parks, public safety, and public school quality into housing prices). Similarly, it is possible that proximity to highways can lead to negative impacts, such as air pollution and noise, which can also be capitalized into house prices. In other words, since the impacts of highways can be capitalized into housing prices, examining the impacts of highways on household wealth by an analysis of housing values could generate useful insights on wealth accumulation.

[2] See for instance, Aschauer (1989); Munnell and Cook (1990); and Cohen and Morrison Paul (2004).

These observations naturally lead to the research question of net benefits – either positive or negative – that households receive, and the distribution across society. Housing is the largest expenditure item for average American households, and it is one major mechanism for households to accumulate wealth. But there are disparities across demographic groups – for instance, the homeownership rate among the Black population is significantly less than for Whites (Perry and Ratcliffe, 2021). This implies a possibility of less capitalization for Black residents over time, as the house price increases from benefits of highway accessibility may not be reaped by Black residents in the same magnitude as by White residents.

In the U.S. context, Allen et al. (2015) study Interstate 110 in Orlando, Florida. They find an accessibility benefit of 2.5% higher house prices for homes that are shorter drive time from the highway, while the nuisance discount (from noise and congestion) led to a 4% discount for properties that are next to the highway. Chernobai et al. (2011) consider Interstate 210 in the Los Angeles area, and underscore the importance of nonlinear effects on property values. They find relatively low benefits for those properties that are closest to the highway, but increasing benefits moving away up until an optimal distance, further beyond which the benefits fall. These nonlinear effects motivate our analysis of multiple distance bands or cutoffs, which also yield different proximity effects in our context for proximity to I-84. Chernobai et al. (2011) also find that there are essentially no "announcement" effects; most beneficial impacts on home values occur immediately or very soon after the completion of construction and opening of the highway.[3]

This literature review underscores the need for the empirical analysis of how highways have been correlated with wealth accumulation. Also, analysis of the wealth distribution associated with house price changes near new interstate highways would be desirable. These are among the focal points of our methodologies below.

Approach

There are several prongs to our analysis of real estate wealth accumulation and wealth inequality associated with new interstate highways. Regression analysis – and more specifically, a variation of a long-differences approach - is a useful analytical tool for this problem. Separately, changes in the values of real estate near the highways, between 1940 and the 1960s,

[3] Several recent papers explore the issue of transportation and inequality through the spatial linkage between residence and employment opportunities. For instance, Wellman (2014) argues that transportation policy is correlated with inequality, given that many individuals in poor areas have limited access to transportation and in general exhibit lower car ownership rates. More generally, the notion of the "disconnect" in the relationship between housing location and the ability of residents to travel to job opportunities has been described as "spatial mismatch". Gobillon et al (2007) describe the theory of the spatial mismatch hypothesis and summarize the literature in this area. However, little research has been done to directly examine the relationship between transportation access and wealth inequality. In fact, Chatterjee and Turnovsky (2012), who develop a theoretical model to address this issue, note that the empirical literature on public infrastructure investment and inequality more generally is "sparse, inconclusive, and largely anecdotal." They cite several papers that address the empirical issue of public infrastructure investment and inequality, but the vast majority of this research is focused on developing countries in Asia and Africa, with extremely little applied research on the U.S. Also, subsequent recent research, including that by Getachew and Turnovsky (2015), Turnovsky (2015), Mattauch et al (2014), and Gibson and Rioja (2016), tends to focus on theoretical models and/or numerical simulations.

can be visually demonstrated using GIS mapping. These changes over time can also be useful in determining whether there is a severe degree of inequality in the distribution of wealth changes, by plotting these changes using Lorenz Curves. Below we discuss these methodologies in detail, as applied to the problem of determining how the announcement and construction of I-84 has been correlated with real estate wealth changes, the spatial distribution of the changes in property values over the time period under consideration, as well as the extent of any potential inequality in the accumulation of real estate wealth during this timeframe.

A promising econometric approach would be to estimate a hedonic housing price long-differences model, with the change in value of each individual property, i, in 1940 and the 1960s (i.e., before vs. after the announcement and construction) as a function of distance from property i to the highway. In such a specification, the time-invariant property characteristics drop out of the long-differenced hedonic house price function.[4] One can control for national-level increases in real estate values over the period of 1940 to the 1960s with the Case-Shiller home price index (Shiller, 2015). Also, general city-wide price differences across various years in the 1960s can be controlled for with including a dummy (i.e., 1/0 indicator) variable for each year of the sample (in the years 1960-1969). Variation across geographic space can be controlled for by including a dummy variable for each Census tract. The initial value of houses in 1940 can also be a control variable in the regression analysis. Starting with the basic relationship, more formally, this can be written as:

$$\%\Delta\text{Property Value}_{it} = f([\text{Proximity to Highway}]_{it}, X, D_C, D_t) + \varepsilon_{it} \qquad (1)$$

where D_t is a dummy variable that equals 1 if observation i sold in year t during the 1960s, and 0 otherwise; D_C is a dummy variable that equals 1 if observation i was in census tract C; and $\%\Delta\text{Property Value}_{it}$ is the percent difference between the assessed value of property i in the 1960s and the value of the property in 1940, after adjusting the 1960s value for "inflation" in home prices since 1940 using the national-level Case-Shiller single family home price index (Shiller, 2015). The variable $[\text{Proximity to Highway}]_{it}$ is a dummy variable that takes the value of 1 if a house is "close" to the highway, and 0 otherwise. Varying definitions of "close" are considered in the regressions, in 0.25 mile increments ranging from as small as 0.25 miles up to 1.50 miles. The variable X represents other "control" variables, which may include the value of the property in 1940; and possibly other control variables in more general settings when such data are available. With the assumption of long-differences using Ordinary Least Squares (OLS) with fixed effects, a simplified version of the model (1), would be written as follows:

$$\%\Delta\text{Property Value}_{it} = \beta_1 + \beta_2 * [\text{Proximity to Highway}]_{it} + \beta_3 X_i + \beta_C D_C + \beta_t D_t + \varepsilon_{it} \quad (2)$$

where β_1, β_2, β_3, β_C and β_t are parameters to be estimated, and D_C and D_t represent "fixed effects" (or indicator variables). D_C is a "fixed effect" that controls for the Census tract where property i is located, and D_t represents a "fixed effect" for the year in the 1960's when property i was sold. X_i is the value of property i in 1940. Finally, ε_{it} is a random error term assumed to be normal distribution with mean 0 and constant variance. Including X as a regressor enables the

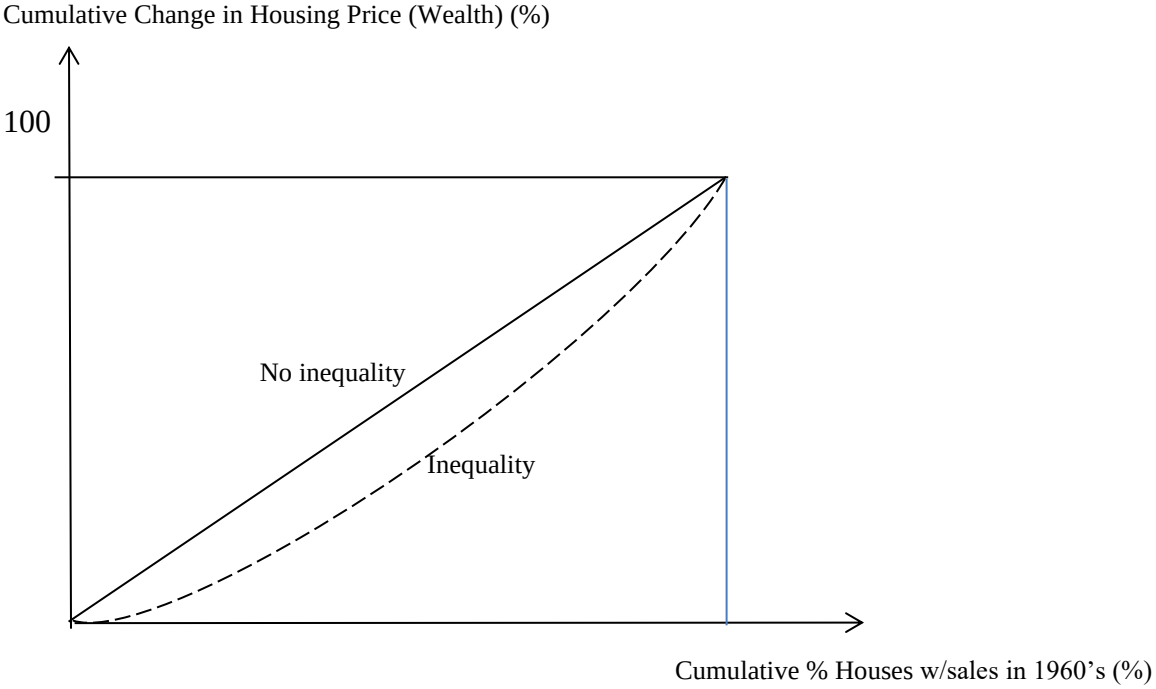
[4] The time-invariant characteristics assumption underlies the Bailey et al. (1963) repeat sales model.

researchers to control for how more valuable properties experienced price changes between 1940 and the 1960s. Results are presented below from (2), with varying proximity definitions.

An alternative way to view the changes in homeownership wealth over time is development of a set of GIS maps showing how individual property values changed between 1940 and the 1960's. Both GIS maps include the locations of the I-84 highway (as well as another major highway that was built in the 1960's – I-91 – although our focus is on properties near I-84). The I-84 maps also include a set of "buffer" zones, shown in various shades of grey, denoting 0.10, 0.25, and 0.50 miles, etc., from I-84. The intent is to visually demonstrate how many properties in the sample are located close, opposed to slightly further away from the I-84.

Finally, inequality in the accumulation of wealth from housing is demonstrated visually with Lorenz Curves. Separate sets of Lorenz Curves are developed – one for properties that appreciated after the development of I-84, and another for properties that fell in value after the highway opened – compared with the same property's value in 1940 (i.e., before the announcement and construction of the highway). Lorenz Curves demonstrate whether a small number of homeowners realized a disproportionate gain in wealth. For instance, in Figure 1, percentiles of homeowners with wealth increases are on the horizontal axis, and the cumulative wealth change corresponding to each percentile of homeowners is on the vertical axis. The dashed line is the set of points that the researcher observes in the house value appreciation data, and if this dashed line is below the 45-degree line, this implies a disproportionately small amount of wealth is realized by a large proportion of homeowners. But if the dashed line is very close to the 45-degree line, this represents a relatively equitable distribution of house price appreciation wealth. If the dashed line is above the 45-degree line, which may occur due to a disamenity such as noise or pollution, for instance, then a large portion of this disamenity is distributed to a small proportion of the population. One objective of this study is to examine whether there is equity or relative inequality in the distribution of homeowners' wealth accumulation. Separately, we consider those properties that experienced a decrease in value after the opening of I-84, and then another analysis is done to determine whether the depreciation in wealth is disproportionately borne over a small percent of the homeowners. We also consider how the Lorenz Curves differ in "high" Black and high "White" population Census tracts.

Figure 1: Lorenz Curve - How do wealth changes track number of property owners?
Example of relative inequality



Source: Authors' adaptation of Nijssen *et al.* (1998) general exposition of Lorenz Curves for inequality.

Data

In order to compare housing wealth accumulation before versus after the highway announcement and opening, one approach is to examine individual house prices from before (1940) and after (1960s) the announcement. Data on property-level residential real estate values from recent decades (going back to the early 2000s) are typically well-documented and generally available from a variety of sources. But earlier data – such as from dates in the 1960s – sometimes exist and other times do not, depending on the city. When they do exist, usually they are in hard-copy format and involve intensive digitization efforts. Similarly, the house value data from the 1940 Census is available on microfiche in most public libraries, but often there is the need to digitize the data as well (unless the researcher has access to the 1940 Census data that is available through IPUMS, which we did not have at the time of this research). The analysis here relies on house value data from the 1940 Census and data for the corresponding properties from the 1960s obtained from our digitization efforts undertaken as a part of this project based on hard copy records at the office of the City of Hartford Assessor.

While the entire U.S. interstate highway system, for example, constitutes a complex inter-connected network, which was planned and built over decades, it is possible (and relatively tractable) to begin an analysis of exploring local impacts in one city using a counterfactual approach. This approach is based on repeated observations of the same properties. For instance, in Hartford, Connecticut, the property-level sales data available through the assessor's hard-copy

land records were traced back to the early 1960's. This data involved the research team compiling the data from hard copies of land records at the city of Hartford assessor's office, and then digitizing the data. This timeframe under consideration would be crucial because it enabled examination of how property values changed over an extended period of time where property value information was available for specific properties, both before and after the "announcement" of the interstate highways in a major city. See Figure 2 below for a map of Connecticut and the major interstate highways. It is noteworthy that several of the largest cities in the state – including the state capital of Hartford - have major highways passing directly through these cities.

This study centered around the assessed values of single-family residences near I-84 in Hartford that sold in the 1960's. For each of those residential addresses near I-84 in the City of Hartford, Connecticut, the publicly available 1940 U.S. Census files were utilized to obtain information on the exact property addresses, whether each property was owned or rented, and the associated residential property values (if owned).[5] By comparing the property appreciation – i.e., the difference between the assessed value for properties in the sample from the 1960's and the estimated value in the 1940 Census, estimates of wealth accumulation (through home value appreciation or depreciation) are obtained. The 1960s sample was collected based on the properties in and around the highway in multiple census tracts (with 1960 census tract boundaries indicated in the maps). The key feature for a property to be included in our 1960s sample was that it needed to have data in the 1940 census files, and also sold in the period 1961-1974 (around the time the highways opened). There were few sales of single family housing in the "downtown" area that met this criteria. There were also few houses very close to the highway (within 1/10 of a mile), presumably because most of the houses in that vicinity of the highway were destroyed for the construction of the highway (and were therefore not there in the 1960s).

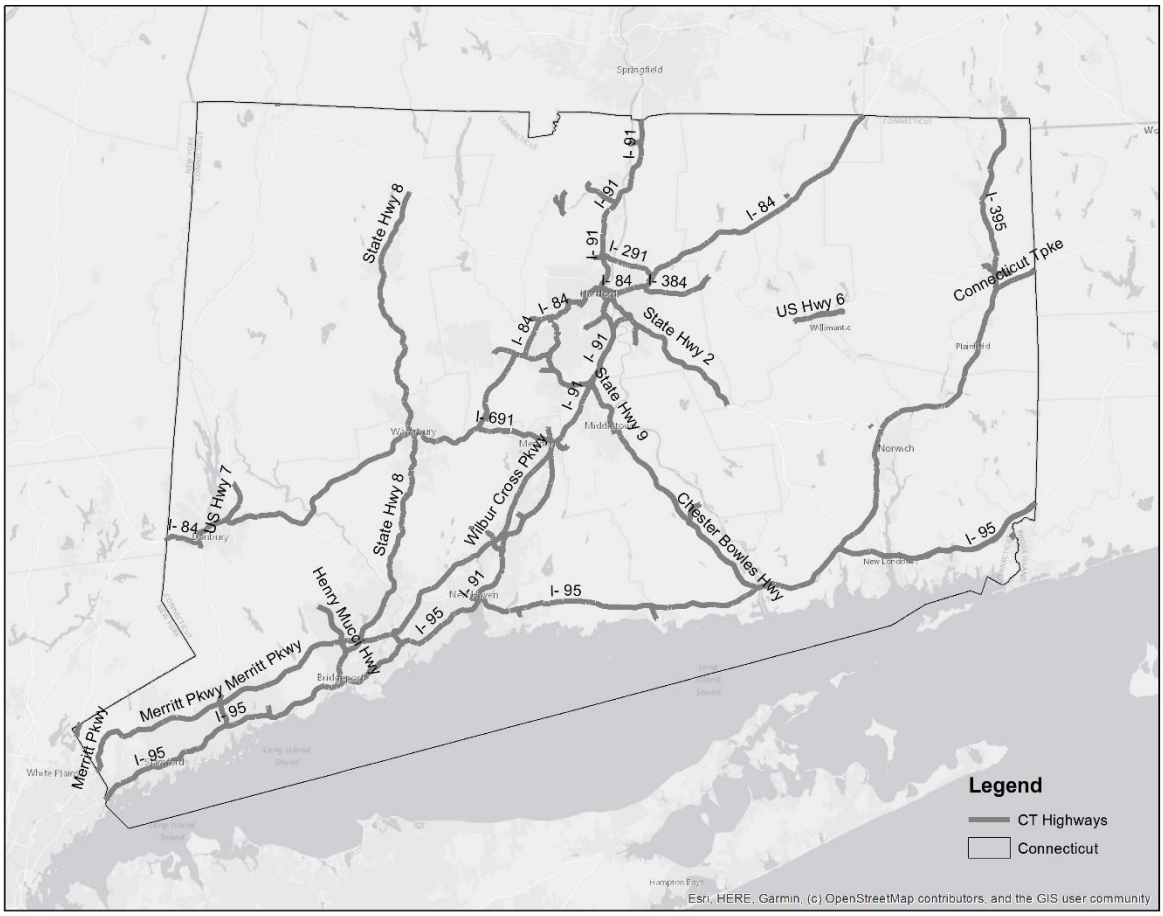
To purge the effects of general home price appreciation throughout the U.S., the 1960s prices are "deflated" using the Case-Shiller home price index, which covered this period. Figure 3 shows the overall U.S. price fluctuations of residential real estate from 1890-2018.

The 1940 Census data collection was a very labor intensive process, as the data were located on microfiche in the West Hartford Public Library (through Ancestry.com) and had to be manually entered into an Excel spreadsheet for the approximately 2,500 properties in this analysis. Before the 1940 Census data were collected, the property information for those single-family homes in Hartford near I-84 that sold in the 1960s had to be manually entered into an Excel spreadsheet. The data from the 1960s included the property address, the sale price, and the assessed value of the property at the time of the sale. The corresponding addresses for the 1940 Census data properties were then matched with the properties that sold in the 1960s, leading to two observations for each of the approximately 2,500 properties in the dataset – one before the announcement and construction of I-84 (in 1940), and another after the construction (in the 1960s).[6]

[5] John Logan provided data on the race of the head of household for individuals who owned each property according to the 1940 Census.

[6] Regarding potential concern with the possible changes in the composition of houses in the two time periods, our including time (i.e., year) fixed effects may be one way to address this potential issue.

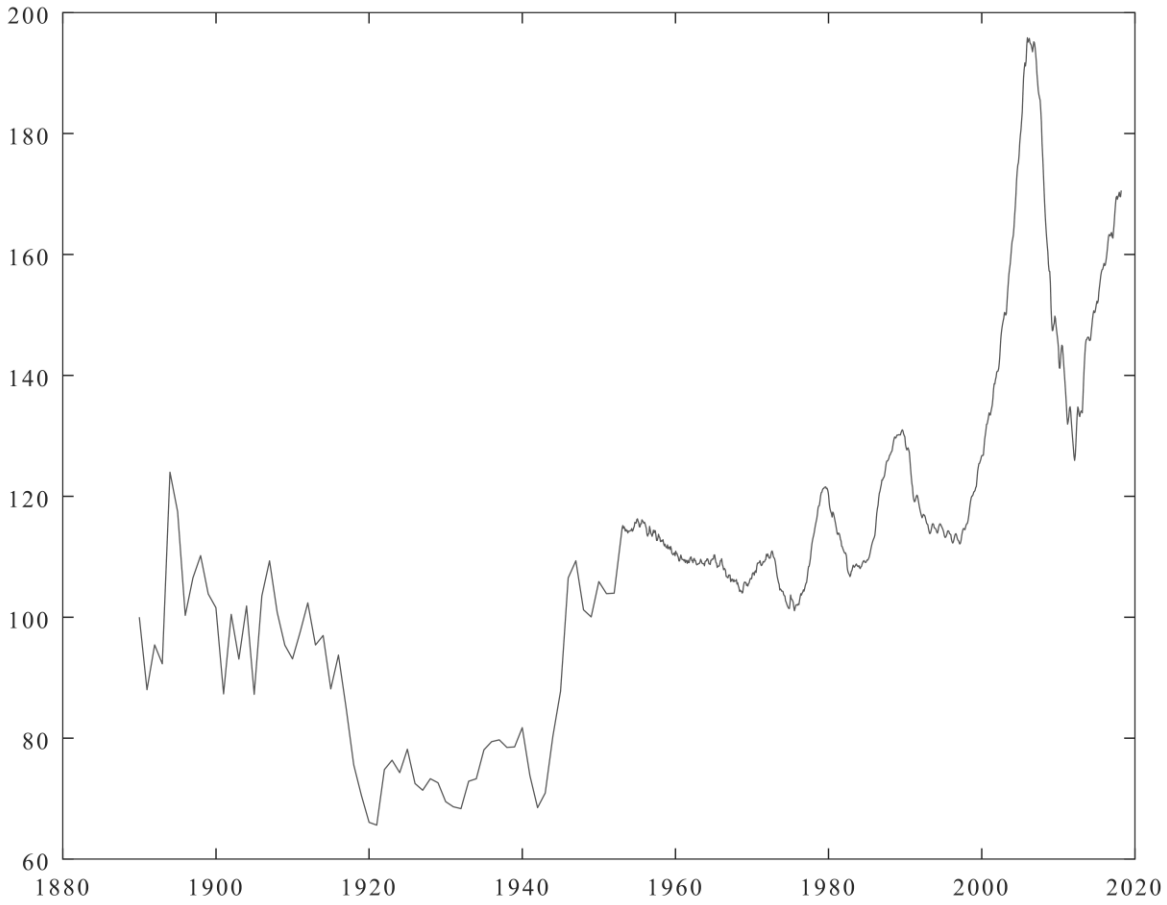
Figure 2 – Current Interstate Highways in the State of Connecticut



Source: authors' calculations and ArcGIS. The prefix "I-" represents an Interstate highway.

Notes: Hartford, the state capital, is located slightly north of the center of Connecticut, where I-84 and I-91 intersect. I-84 stretches from the west at the New York State border, to the northeast at the Massachusetts border.

Figure 3 – Case-Shiller House Price Index, 1890-2018 (1890=100)



Source: Shiller (2015), http://www.econ.yale.edu/~shiller/data/Fig3-1.xls . This Case-Shiller house price index is used to deflate the house values in Figures 4 and 5 below when calculating the change in house values between 1940 and the 1960s. [7]

Finally, a 1940 street map GIS layer[8] of the City of Hartford was used together with the properties in the dataset described above, to geocode and overlay the property information with a map of the location of I-84. Distance between each property and I-84 was calculated. A set of descriptive statistics of the data is in Table 1. The sample size in Table 1 is 2,494 and this

[7] The repeat-sales approach was developed by Bailey et al. (1963), and more recently popularized in the price indexes that became widespread in acceptance via Case and Shiller (e.g., Shiller, 2015). When used together with a hedonic house price model, as first developed in Rosen (1974), the repeat-sales approach assumes all of the property characteristics (such as number of bedrooms, bathrooms, living area square footage, etc.) drop out of the regression as they are time-invariant between the dates of the two house value observations. There would be some potential limitations to our findings if in fact there were quality changes in a substantial number of the regressors (i.e., characteristics of individual houses) that are being compared in 1940 versus the 1960s, although it is unclear the extent of this happening in our dataset and likely impossible to determine how many houses experienced such quality changes.

[8] This 1940 Hartford street layer was obtained from John Logan.

includes all observations that were able to be matched from the 1960s property sales files with the 1940 Census data file. In the regression analysis presented in Table 2 of the results section, properties with 1940 home value less than $1,000 were dropped from the sample, yielding 2,477 observations.

In the neighborhoods near I-84 in Hartford, the mean home value change was approximately 250% between these time periods, with the median home value change of 150%. Relatively few properties were located within 0.25 miles of I-84 (3% of the sample), while 72% of the sample was within 1.50 miles of I-84.[9] The mean (median) home value in 1940 was $6,063 ($5,000).

Table 1 – Descriptive Statistics – Houses That Sold in the 1960s Near I-84 in Hartford

	Real Home Value Change (%), between 1940-1960s	% Near (0.25 mi)	% Near (0.50 mi)	% Near (0.75 mi)	%Near (1 mi)	% Near (1.25 mi)	% Near (1.50 mi)	Home Value (1940)
Mean	250.59	3	11	24	37	54	72	6,063.14
Median	149.49	0	0	0	0	100	100	5,000
Max	5,206.66	100	100	100	100	100	100	82,600
Min	-78.82	0	0	0	0	0	0	250
StDev	331.33	16	32	42	48	50	45	4,953.40
N	2,494	2,494	2,494	2,494	2,494	2,494	2,494	2,494

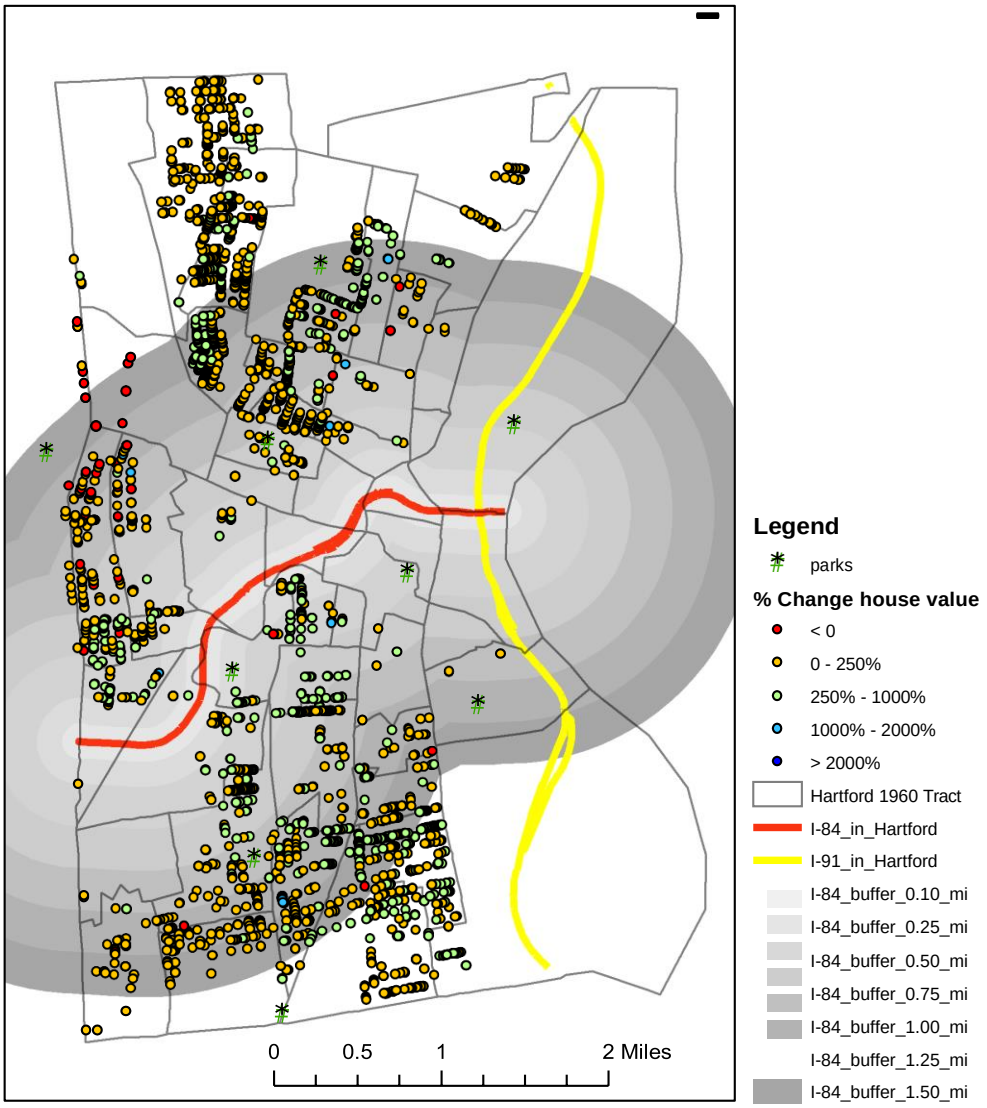
For the inequality analysis, there are several separate sets of calculations that are done with the data – one for properties that appreciated in value between 1940 and the 1960s, and a separate calculation for those properties that depreciated in value between those two time periods. We also stratify the samples by 1960 Census tracts with at least 50% Black population, and tracts with at least 50% White population. Then, a separate set of Lorenz Curves are calculated and plotted for each. Specifically, the cumulative % change in real estate wealth is plotted on the Y-axis, and the percentile of homeowners with wealth gains is plotted on the X-axis. In theory, there would be equality in the distribution of wealth if the Lorenz Curve coincided with the 45-degree line. Thus, one objective of the Lorenz Curve analysis is to gather visual evidence regarding the distribution of wealth accruing after the construction of I-84 that may have been correlated with proximity of those houses to I-84.

The locations of the 2,494 properties are shown in Figures 4 and 5 below. Figure 4 shows the percent change in value between 1940 and the 1960s. Figure 5 shows the dollar ranges of the changes in property values between these two periods, in constant (1940) dollars. These figures also show buffer zones of 0.10 miles, 0.25 miles, and 0.50 miles. Properties located in the western edge of Hartford, due west of I-84, are concentrated in an area where there is decreased values after vs. before the construction of I-84 (i.e., between 1940 and the 1960s). Many properties throughout the neighborhoods near I-84 experienced property value increases of more than $15,000. As can be seen in Figure 4, there are some properties near the center of the map

[9] Although not shown in Table 1, more than 90% of the houses in our sample were within 2 miles of I-84.

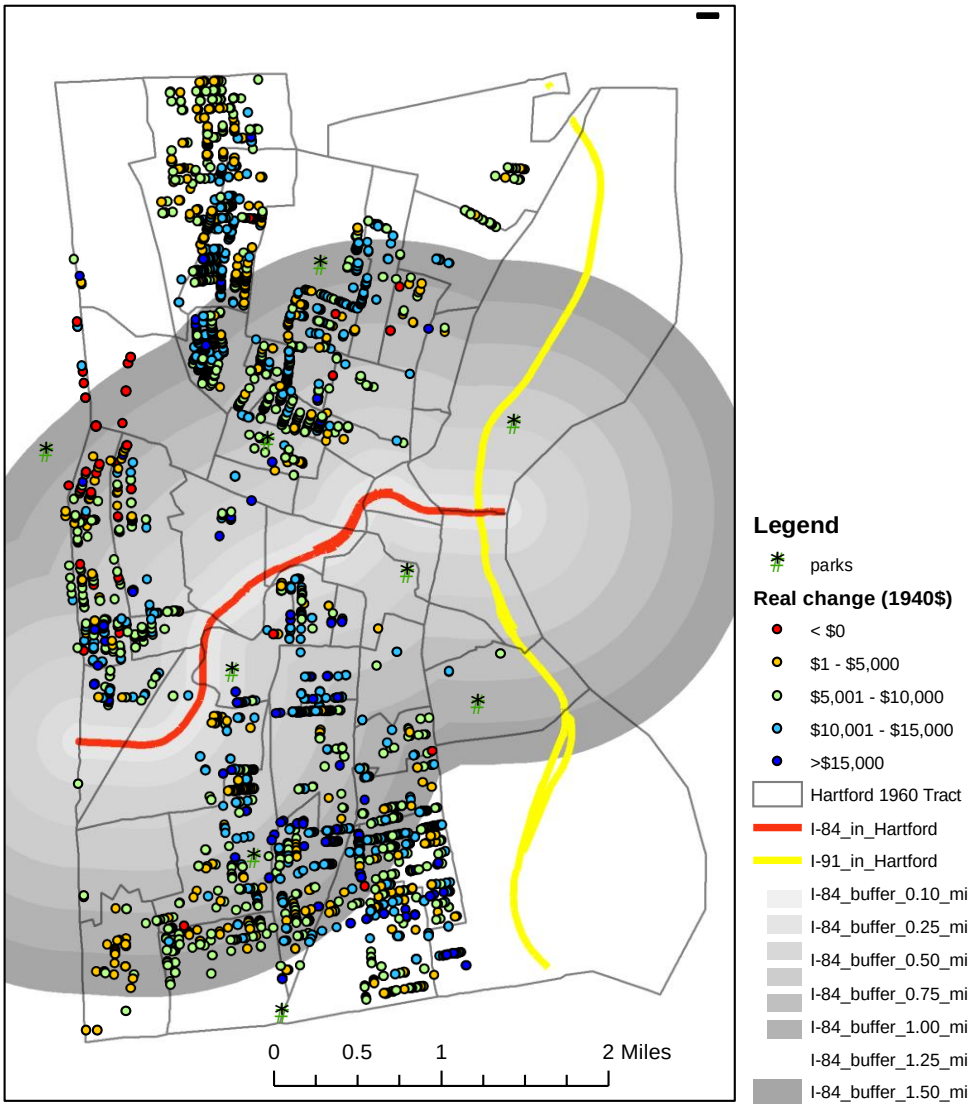
and just south of I-84, which experienced gains of 250%-1000% between 1940 and the 1960s. Both directly south and directly north of I-84 at the center of the map, there are clusters of properties with appreciation of up to 1000%.

Figure 4-Percent Change, Property Values (1940$) Near I-84, 1940-1960s



Source: 1940 Census, City of Hartford Assessor's data, Authors' calculations, and ArcGIS.

Figure 5 – Change in Property Values (1940$) Near I-84, 1940-1960s



Source: 1940 Census, City of Hartford Assessor's data, Authors' calculations, and ArcGIS.

But there are very few houses that experienced negative appreciation in these neighborhoods. Overall in this sample of houses, approximately 60 houses experienced a fall in value between 1940 (pre-announcement of I-84) and the 1960s (period of I-84 construction), while slightly more than 2,400 houses rose in value during this same time-period. Perhaps the houses that would have seen substantial depreciation were so close to the proposed highway that they ended up being demolished prior to the highway construction, however we do not have data on those teardown properties since we only include in our sample those houses that had at least one sale in the 1960s (after construction).

More specifically, the data collected for this paper are unique in the sense that they consist of matches between properties in the 1960s Hartford Assessor's roll (that had arms-length property sales in the 1960s) and data for corresponding properties from the 1940 U.S. Census. The spatial locations of different houses, and how their values have changed between 1940 (before the announcement of I-84) and the 1960s (period of I-84 construction) are mapped, so that visual representations of the changes in values are observable. While the visual changes are interesting, these relationships are explored with regression analysis in the results section below.

Results

There are two major sets of results that are discussed below. First, the regression results (using a variation of long-differences) are presented and discussed as a technique to demonstrate the correlations between I-84 proximity and house value changes. Second, the Lorenz Curve results are presented and analyzed, in order to study the wealth distribution related to the house value changes near I-84.

Table 2 presents the regression results that are described in equation (2) above. Each separate column in this table represents a regression using a different proximity to the highway, for instance, cutoffs for the "near I-84" variable including 0.25 miles, 0.50 miles, 0.75 miles, 1.0 mile, 1.25 miles, and 1.50 miles.

Before presenting the regression results, note that it might be possible to include both an "as-the-crow-flies" distance indicator variable and a driving distance indicator variable, to try and disentangle the benefits from access to I-84 from the drawbacks of proximity due to noise and pollution. But this would raise other undesirable complications. Ross et al. (2011) highlight an inherent concern with such an approach of including multiple distance indicator variables (or multiple continuous distance variables) in the same regression model. Specifically, Ross et al. (2011) note that interpreting the marginal effect of a primary distance variable is problematic when there are other distance variables in the same regression, since the marginal effect on the primary distance variable assumes all other variables are held constant. But when the primary distance variable changes, this likely also changes other distance variables in the same regression, which negates the *ceteris paribus* interpretation on the primary distance variable. Therefore, the focus here is on including only one distance indicator variable and varying that indicator across different regressions to examine whether the sign and significance changes across different cutoff distances. The distance variable used here is an "as the crow flies" indicator variable. Using a drive distance indicator variable does not substantively impact the results. Using the range of distance indicator variables in separate regressions is our approach to capturing the heterogeneous correlations with distance to the highway. We also control for the latitude and longitude coordinates of each property, which Ross et al. (2011) suggest as a more viable alternative to including multiple distance regressors.

Table 2 – Regression Results

Dependent Variable: Percent Change in House Value, 1940 to 1960s

	Cutoff for Near I-84 Dummy:					
Regressor:	Near I-84= 0.25 mi	Near I-84= 0.5 mi	Near I-84= 0.75 mi	Near I-84= 1.00 mi	Near I-84= 1.25 mi	Near I-84= 1.50 mi
Constant	564.76	787.82	804.81	798.82	825.79	853.92
t-stat	*2.24*	*3.08*	*3.12*	*3.08*	*3.14*	*3.33*
Near I-84 Dummy	-0.07	0.55	0.39	0.30	0.27	0.45
t-stat	*-0.31*	*4.37*	*4.03*	*3.52*	*3.24*	*4.96*
House Value in 1940	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
t-stat	*-27.87*	*-27.26*	*-27.12*	*-27.55*	*-27.83*	*-27.69*
R-Squared	0.30	0.30	0.30	0.30	0.30	0.30
F-Statistic	18.49	18.98	18.90	18.80	18.75	19.12
P-Value (F-Statistic)	0.00	0.00	0.00	0.00	0.00	0.00
N	2,477	2,477	2,477	2,477	2,477	2,477
Year FE	Y	Y	Y	Y	Y	Y
Tract FE	Y	Y	Y	Y	Y	Y

Notes: N=2,477. Sample includes properties with value of at least $1,000 in 1940 (which is the reason for the discrepancy between the sample size here and that of Table 1). Distance calculated "as the crow flies". Latitude and Longitude coordinates are included as regressors (estimates not shown here), following the suggested approach of Ross et al. (2011).

There are 2,477 observations in each of the regressions in Table 2. The regressors include a constant, a dummy for Near I-84 (which is the variable of interest), and the house value in 1940. The dependent variable is the percent change in house value between 1940 and the 1960s (in 1940 dollars). We do not include the property characteristics since, based on Bailey et al. (1963), the assumption that they are time-invariant implies they drop out when taking their long-difference (and also, we do not have data on these property-level characteristics). For all regressions, the R-squared is approximately 0.30, which is in the general range of many hedonic studies. The proximity indicator with cutoff very close to I-84 (i.e., 0.25 miles) is statistically insignificant.[10] The proximity indicator for 0.50 miles is positive and statistically significant, and equal to 0.55. This implies that properties within 0.5 miles of I-84 appreciated approximately 55% more than properties outside of 0.5 miles from I-84. The proximity indicators gradually diminish (but are still statistically significant) as the distance cutoffs increase to 0.75 miles, 1.00 mile, and 1.25 miles, which is intuitive, as the benefits from proximity are reduced with less accessibility benefits. Finally, the proximity indicator with 1.50 miles cutoff is positive and equal to 0.37, which is larger than the corresponding effects for 0.75 miles, 1.00 mile, and 1.25 mile.[11]

[10] Given that the sample of properties within 0.25 miles of I-84 includes only 3 percent of the entire sample, perhaps there are too few properties within 0.25 miles to be able to offer strong statistical power for that radius.

[11] To test whether the various distance coefficients in each model from Table 2 are statistically different from each other, we performed robustness tests for various coefficient pairs, using the approach similar to Paternoster et al.

While one might conjecture that further distance from I-84 is correlated with lower accessibility benefits, there are some houses within 1.5 miles of I-84 that are relatively close to I-91.[12] The benefits of proximity to I-91 for these houses could be the source of the relatively higher proximity indicator estimate for the 1.50 mile from I-84 cutoff.[13]

Regarding the coefficients on the "House Value in 1940" variable, they are generally negative and very small, but statistically significant. These parameter estimates are approximately -0.00023 in all model specifications. This implies that for every $1,000 lower a house was valued in 1940, that house tended to be worth approximately 23% more in the 1960s. In other words, lower-valued houses appreciated more than higher-valued houses in these Hartford neighborhoods over the time-period of 1940 to the 1960s.

There may be other factors related to the house price increases. For instance, we consider the Hartford assessor's database of all houses in the city, which contains some historical data on construction dates. We observe a differential rise in the number of new houses built around this time, near the highway versus far. Construction of I-84 in Hartford started in 1959 and was completed in 1969.[14] Among all houses built in the City of Hartford, there were 2,452 houses that were built between 1950 and 1970 within 1 mile of I-84, while only 2,003 houses in that same time period within 2 miles but more than 1 mile of I-84. This implies that more houses were built near the highway after the late-1940s announcement of the highway. From 1970 to 1975 (shortly after the completion), there were 463 houses built within 1 mile to the highway while 241 were built between 1 mile and 2 miles from the highway. Thus, increases in the housing stock may be related to the overall rises in house prices, possibly due to an increased desire of residents to live close to the highway; the greater housing stock may have accommodated the higher demand for houses near the highway.

Next, the Lorenz Curves are presented in Figures 6, 7, 8 and 9. Figure 6 presents the Lorenz Curve for the houses with positive appreciation between 1940 and the 1960s, while the Lorenz Curve in Figure 7 is the Lorenz Curve for the houses that experienced a depreciation in

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(1998). The coefficient on the 0.25 mile indicator is statistically different from each of the other distance cutoffs (i.e., 0.50 miles, 0.75 miles, 1.00 miles, 1.25 miles, and 1.50 miles). The coefficients for 0.50 miles and 1.25 miles are significantly different from each other at slightly less than the 10% level of significance (using a two-tailed z-test; z-value = 1.84). The coefficients for 0.50 miles and 1.00 miles are marginally significantly different from each other at the 10% level (z-value = 1.64). All of the other combinations of distant coefficient pairs not mentioned above are insignificantly different from each other.

[12] We performed a robustness test where we kept the latitude and longitude in the regressions, as suggested by Ross et al. (2011), but we added an additional regressor for distance from I-91. This I-91 distance regressor was very small in all models, but statistically significant, and including the regressor did not notably affect the sign and significance of the distance to I-84 indicators. Given the concerns of Ross et al. (2011) with including multiple distance regressors, we decided that the results without the I-91 distance regressor were superior to the results that include it.

[13] We also tried running an alternative model that was suggested by a reviewer, with the 0.25 mile indicator variable as the "base" and including all other distance cutoffs as indicators in the same regression. The coefficients on the 0.50 mile and 1.50 mile indicators were positive and significant, while all of the others in-between these (i.e., 0.75 mile, 1.00 mile, and 1.25 mile) were statistically insignificant.

[14] One reason for the location of I-84 was its proximity to downtown Hartford; in fact, one of the highway exit ramps connected directly to the entrance of the parking garage of a major department store called G. Fox (McWilliams, 2014).

value between 1940 and the 1960s. As also noted above, when the blue curve in Figures 6 and 7 is close to the 45-degree line, there is equal distribution of cumulative wealth appreciation (or depreciation) across homeowners. But when the blue curve is very bowed from the 45-degree line, there is unequal distribution of cumulative wealth appreciation (or depreciation) across homeowners.

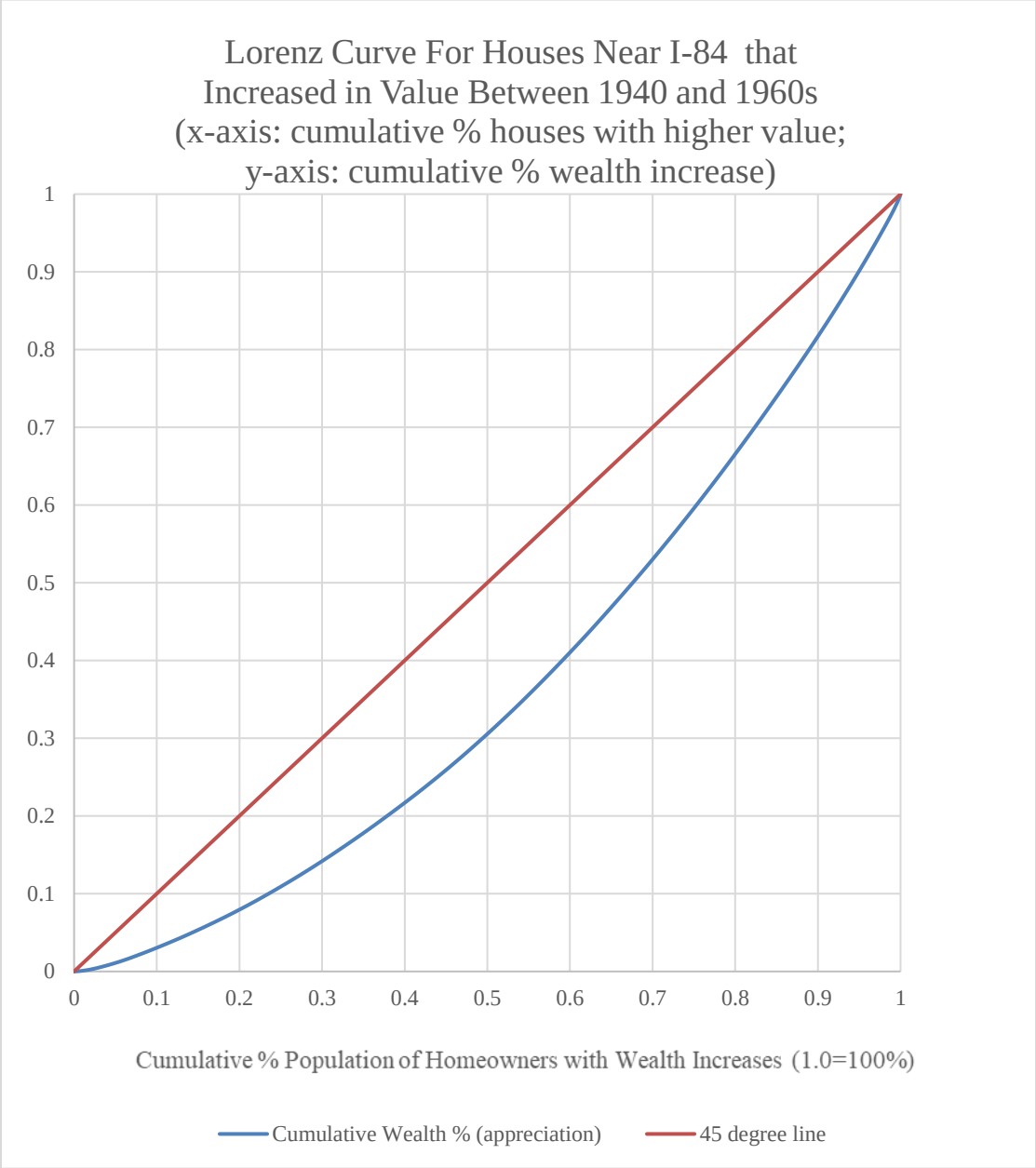
In Figure 6, for instance, 20% of the homeowners experience approximately 8% of the cumulative house value wealth increase. Similarly, 60% of the homeowners experience slightly over 40% of the cumulative house value wealth increase associated with proximity benefits of the highway. This implies some evidence of inequality here, given the blue Lorenz Curve is below the equal distribution line (i.e., the 45-degree line).[15]

Figure 7 represents a Lorenz Curve for the homeowners whose property values decreased between 1940 and the 1960s.[16] This Lorenz Curve demonstrates extreme inequality in the distribution of the wealth losses in houses that decreased in value. For instance, 20% of the homeowners bear more than 70% of the losses in housing wealth associated with the pollution and noise of the highway. This extreme inequality is apparent visually with the severely bowed-upward shape of the Lorenz Curve in Figure 7.

[15] Note that this does not imply causality, rather a correlation between wealth distribution across various homeowners that is related to house value appreciation in the two periods.

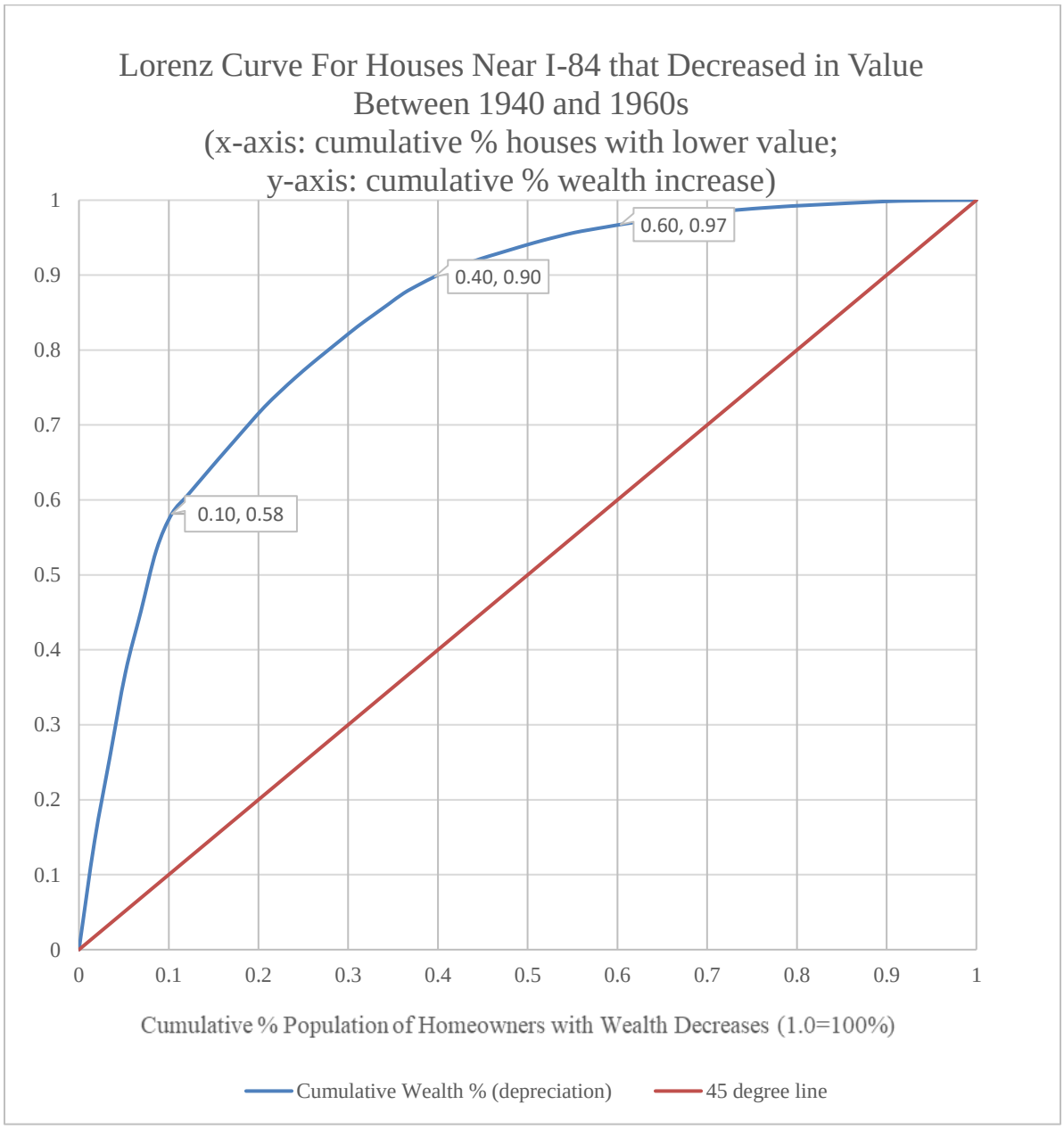
[16] One might attribute these decreases to the impacts of being close to the air pollution and noise pollution associated with very close proximity to I-84. However, the Lorenz Curves do not intend to represent this type of causality.

Figure 6 – Lorenz Curve – Houses with Higher Value between 1940-1960s



N=2,404. Source: 1940 and 1960 Census data, Hartford Assessor, and authors' calculations.

Figure 7 – Lorenz Curve – Houses with Lower Value between 1940-1960s



N=58. Source: 1940 and 1960 Census data, Hartford Assessor, and authors' calculations.

Differences Between Neighborhoods: High Black versus High White Populations

Here we consider two separate aspects of discerning housing wealth accumulation inequality – (i) the number of Black homeowners (in 1940) in the neighborhoods under consideration in the previous parts of this paper; and (ii) Lorenz Curves for houses that increased in value. These neighborhoods are categorized by 1960 Census tracts with at least 50% Black population, and separately, tracts with at least 50% White population. Note that very few houses in high Black population tracts had decreases in wealth, which precludes us from showing them in a Lorenz Curve.

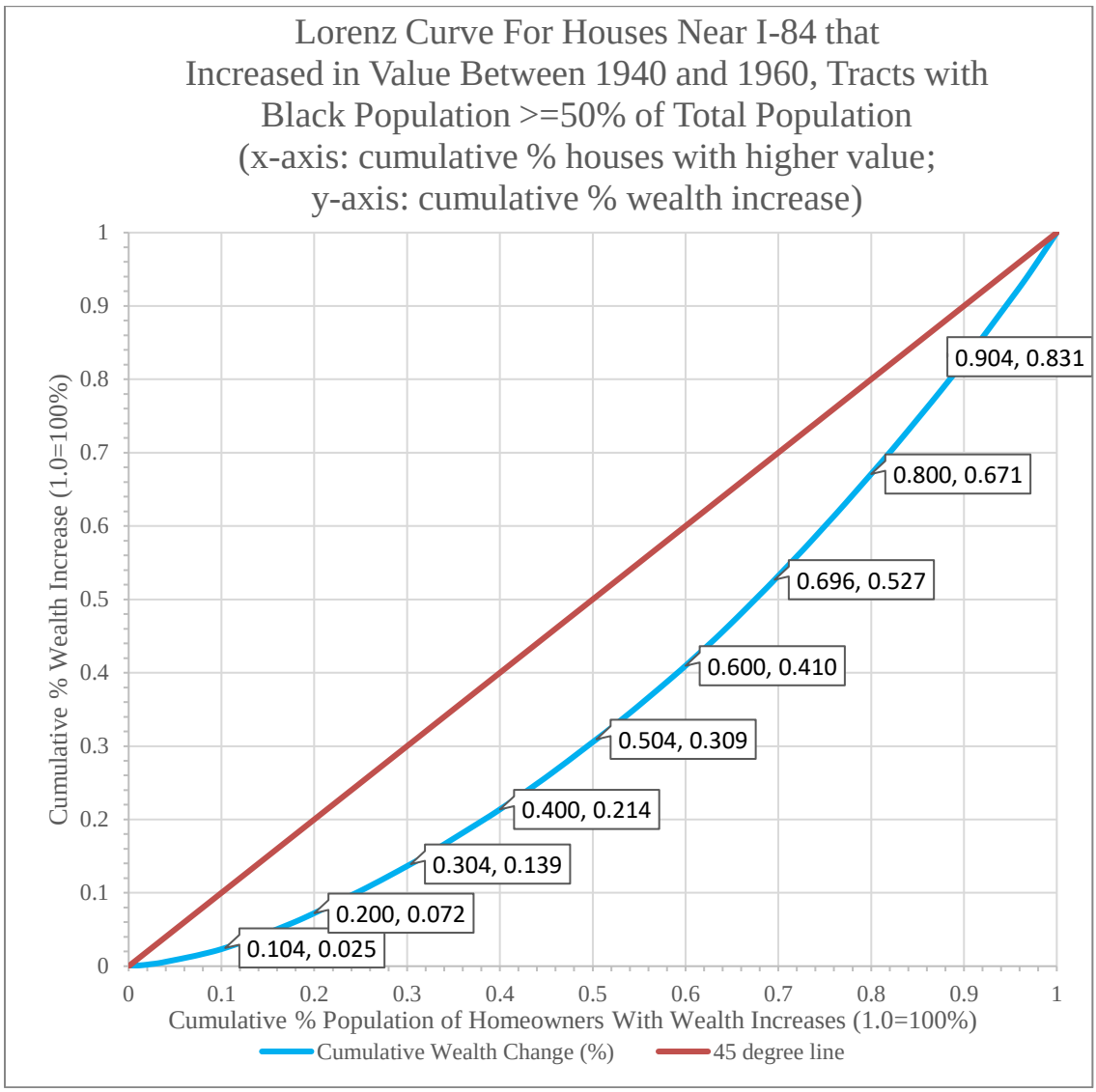
First, there were 2,477 houses in our sample that sold in the 1960s in these neighborhoods near I-84. Among these, 13 houses (i.e., approximately 0.5% of the sample) were owned by a Black head of household. Also, in the 1960s there were approximately 125 houses sold in neighborhoods where the Black population exceeded 50% of total population.[17] [18] Apparently, there were serious barriers to homeownership for Black residents of Hartford. These barriers may have precluded most Black residents from accruing wealth effects associated with owning a home in proximity to I-84.

Second, we develop an additional set of Lorenz Curves – one for properties in (1960) tracts with at least 50% Black population, and another for properties in (1960) tracts with at least 50% White population. These are shown in Figures 8 and 9, respectively. In Figure 8, for the high Black population tracts, 10% of the homeowners experienced 2.49% of the increases in price appreciation. Also, in Figure 8, 20% of the homeowners in high Black population tracts experienced 7.2% of the increases in wealth appreciation associated with proximity to I-84. In contrast, for the high White population tracts, 10 % of the homeowners experienced 3.13% of the increases in house price wealth. Also, in Figure 9, 20% of the homeowners experienced 8.03% of the increases in housing price wealth in these high White population tracts.

As a way to interpret these Lorenz Curves, we can focus on the 10^{th} percentile of the population that experienced wealth increases, separately in these "high" Black and "high" White population tracts. These Lorenz Curves imply the "high" White population tracts experienced 25.7 percent higher wealth accumulation than the "high" Black population tracts. Similarly, we can consider the 20^{th} percentile of the population that experienced wealth increases. Here the "high" White population tracts experienced 11.5 percent greater wealth accumulation than the "high" Black population tracts. This implies the difference between the housing wealth accumulation in the two types of tracts ("high" Black and "high" White population) is larger for homes with lower appreciation.[19]

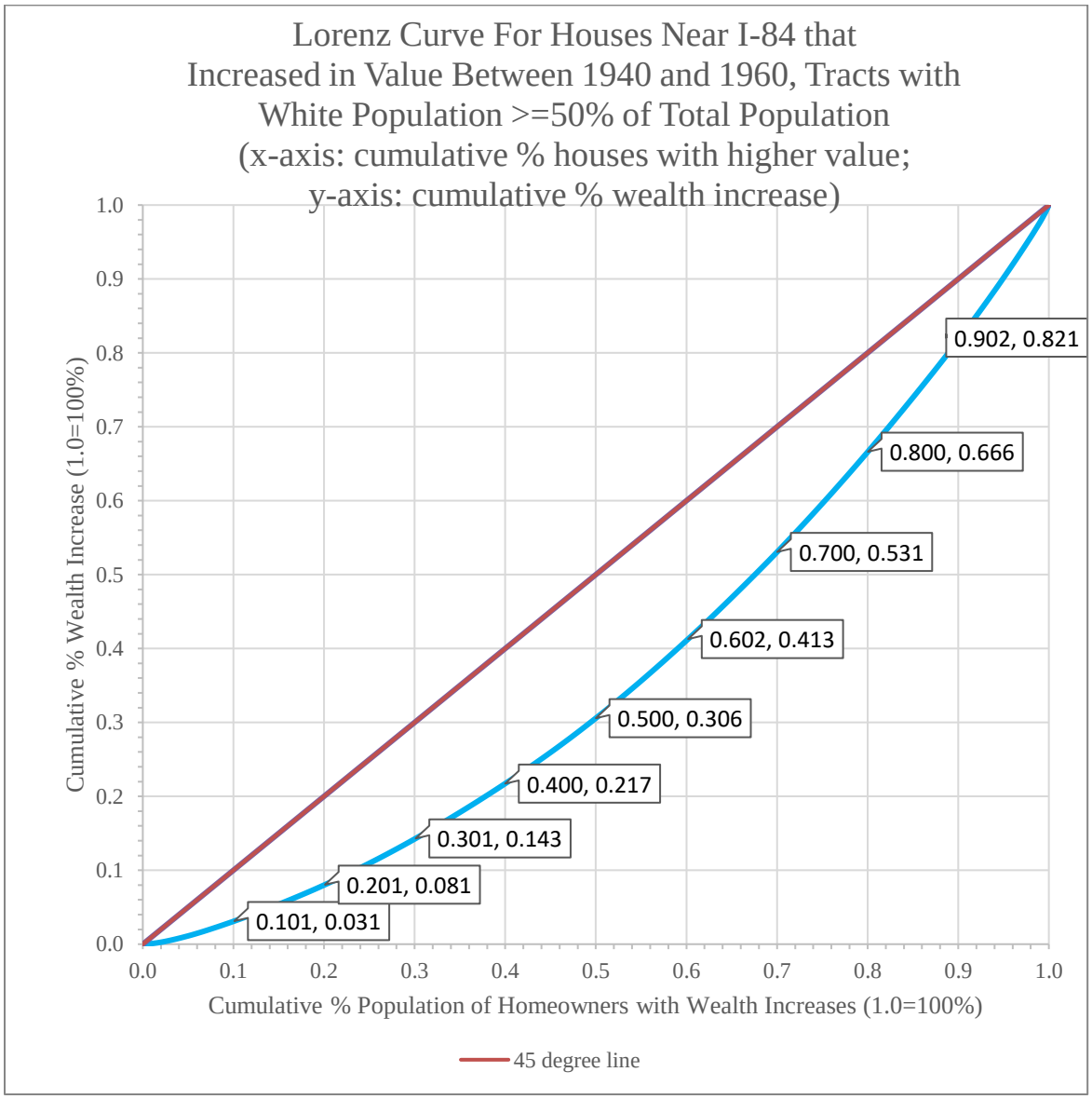
[17] This information was obtained when we compared John Logan's 1940 Census data with the 1940 Census data that we obtained from the Ancestry.com microfilms (and overlaying it with 1960 Census data at the tract-level).
[18] John Logan's 1940 Census data recognizes a 3rd category for race titled "Other", and there are 0 houses in our sample of 2,477 houses that are owned by individuals classified in this "Other" category.
[19] That is, the difference in wealth accumulation is greater in the lower end of the distribution of population with wealth increases.

Figure 8 – Lorenz Curve – Houses with Higher Value between 1940-1960s, in Tracts With Black Population at Least 50% of Total Population



N=125. Source: 1940 and 1960 Census data, Hartford Assessor, and authors' calculations.

Figure 9 – Lorenz Curve – Houses with Higher Value between 1940-1960s, in Tracts With White Population at Least 50% of Total Population



N=2,278. Source: 1940 and 1960 Census data, Hartford Assessor, and authors' calculations.

Conclusion

This study explores the housing wealth accumulation and its distributional effects, related to the announcement and construction of a major interstate highway in Hartford, Connecticut (I-84). The approach here is unique in that it relies on data that have not been used together to develop regression estimates of how proximity to a highway is correlated with home values. Specifically, data from the 1940 U.S. Census on home values are combined and matched with 1960s data from the Hartford assessor's office, to develop a dataset of nearly 2,500 properties

with two values for each home – one in 1940 (before the announcement of I-84) and another in the 1960s (construction period).

Our approach to estimating the correlations between I-84 proximity and house values relies on the fact that the 1940 data are from a time-period before the "announcement" of the interstate highway system, and the data from the 1960s are from post-construction. Therefore, by using a proximity indicator variable for near versus far from I-84, this has led to an empirical estimate.

We have demonstrated that for properties located relatively "close" to I-84 (i.e., within 0.25 miles of I-84), there was an insignificant correlation between house values and highway proximity. But for properties that were within some wider critical point – within 0.50 miles from I-84 – the benefits from being closer to I-84 were positive and significant. Compared with the 0.50 miles cutoff, the proximity indicator variables diminish as the distance of the proximity indicator rises. Houses that were "close" to the highway sold for 27% to 55% more. This implies that homeowners experienced an increase in their value as they come closer to I-84, but if their homes are too close (i.e., within 0.25 miles), there is no correlation between proximity and their house values. Finally, there is strong evidence of unequal wealth distribution for properties that saw decreases in their values. But there is moderate evidence of unequal wealth distribution for houses with higher percent changes in values in the 1960s compared with 1940. We discuss the implications of these findings for highway investment policy, and other policy implications, below. But first we drill deeper by looking at Lorenz Curves in neighborhoods with high Black and "high" White populations. In the 10^{th} percentile of population with wealth increases, the "high" Black population tracts had 25% less wealth accumulation than the "high" White population tracts.

We also considered the inequality of declining wealth related to I-84 proximity. Some properties in our sample (approximately 60) experienced price declines over the period of 1940 to the 1960s. A disproportionate amount of the cumulative wealth deterioration was borne by a very small percentage of the houses. Specifically, roughly 70% of the cumulate wealth decline was realized by only about 20% of the cumulative houses. This result represents a very strong degree of inequality. In contrast, for the approximately 2,400 houses with price increases over the same time-period, the additional housing wealth was relatively equitably distributed. In those houses with price appreciations, 20% of the cumulative homeowners had approximately 8% of the cumulative wealth increases. While this is not representative of equality, these wealth gains are not as unequally distributed as the wealth losses for the houses discussed above.

There are a number of potential areas for future research. First, a more comprehensive set of data variables could enable a deeper dive into the regression analysis by enabling for additional control variables, although such data may be challenging to obtain. In the regressions approach used above, the (time-invariant) property characteristics cancel out when taking the long-differences. We include census tract fixed effects, which can proxy for neighborhood demographics in our analysis. Second, it would be of interest to determine whether similar results hold for other cities with interstate highways, using comparable property value datasets. This could happen if it were possible to identify some cities with rich historical property value records that date back to the 1960s (highway construction period).

These results can also have important policy implications for future highway construction, removal, and relocation decisions. If a comparison analysis of many cities can be done that leverages the approaches developed here, it would be possible to consider targeting new projects in locations where there is an expectation of relative equality in the house price appreciation/depreciation that is associated with the new highways. Similarly, it might be more desirable to target highway removal projects in cities where there is an unequal distribution of housing wealth accumulation, when the goal is to achieve a more equitable distribution of wealth. Such policy decisions would benefit from a more comprehensive analysis across many cities of the type performed in this study.

Finally, one might wonder whether the net housing wealth changes from interstate highways in the U.S. (or in one particular city) are positive or negative. This also provides important policy implications because if highways have a positive net correlation with housing wealth while rail and/or airports are associated with a net negative change in housing wealth, this could imply that federal infrastructure resources should target highways and perhaps resources drawn away from other modes. A first step would be to conduct a similar set of inequality analyses for other transportation modes, such as transit and/or airports.

This could be particularly relevant in the times of a pandemic where residents may feel "safer" from a contagious disease when riding in their own cars opposed to flying or traveling by train. For these reasons, it could be instructive to trace forward the values of residential properties to more recent time periods, such as from the 1970s to the present, to consider a longer term trajectory of the relationships between house prices and highway proximity. Clearly, as interstate highways are modified over time (perhaps with new exits and/or with new connectivity to other parts of the country with new highways in distant states), the net benefits from highway proximity can change as well. Therefore, consideration of the full lifespan of the entire U.S. interstate highway system – from the planning stages in the early 1940s to the present – could glean substantial information to support policy decisions at a nationwide, system level.

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