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Evaluating drivers of housing vacancy: a longitudinal analysis of large U.S. cities from 1960 to 2010

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Abstract

Housing vacancies have become a major issue in depopulating, or shrinking, cities. All urban areas, however, are subject to some degree of vacant housing. A small percentage is necessary to allow mobility and sufficient space for growth, and is an indicator of healthy urbanization. Conversely, widespread housing vacancies may indicate structural crisis due to property abandonment. Land area and population changes, shifts in employment, demographic trends, development intensity, and economic conditions are primary drivers of housing vacancies. The degree to which these interrelated factors contribute can fluctuate by city. This paper explores relationships between factors contributing to housing vacancies over time to identify changes in underlying factors. The research examines U.S. cities of over 100,000 population over the period of 1960–2010, conducting multivariate regression analyses in 10-year periods and performing longitudinal panel analyses. The regressions examine changes in urban housing vacancy factors over time while the panel models assess which factors have remained consistent. The panel model results indicate that population change, percent nonwhite populations, unemployment and density are consistent, significant predictors of housing vacancies, The incremental regression models suggest that unemployment and regional location have also been strong indicators of housing vacancies. These results, while somewhat exploratory, provide insight into long-term data that cities should track over time to determine the optimal policy approaches to offset housing vacancies.

Keywords

Urban regeneration; Housing vacancies; Vacant land; Longitudinal analysis; Regression

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1 Introduction

Elevated levels of urban housing vacancies are a consistent concern to communities and policymakers in the U.S (Fields and Uffer 2016). While the 2008 foreclosure crisis placed the housing vacancy issue under a spotlight and further amplified such concerns, what we know about long term neighborhood housing vacancy is still limited (Immergluck 2016). Communities exemplifying the post-2008 glut of abandoned homes helped both researchers and practitioners to notice a widespread pre-existing condition of urban abandonment in many cities that recalled the conditions that triggered Urban Renewal programs in the 1960s. Few attempts, however, have been made to measure both the extent of and conditions contributing to housing vacancies since that time; instead, most research focuses on recessionary periods and related economic shocks that are more short-lived (Newman et al. 2016a).

Recent vacancy and foreclosure literature largely assumes that the drivers of housing vacancy are contemporaneous and not easily predictable based on long-term data (Han 2013). Oliner's (2016) research, which examines data before the Great Recession, shows an increase in U.S. housing vacancies of nearly 2 million units from 2000 to 2010. This surplus of vacant houses is not equally distributed across municipalities. For example, when identifying which neighborhood characteristics predict changes in long-term housing vacancy for the 50 largest metropolitan areas, Immergluck (2016) found that high vacancy rates persisted in high-poverty neighborhoods and that depopulating cities sustained the bulk of negative impacts from housing vacancies. Factors other than population change typically associated with increases in urban housing vacancies include increases in urban land area due to annexation, employment losses, increases in minority proportions, worsening economic conditions, and conversion of land to industrial uses (Newman et al. 2016b). The degree to which these interrelated factors contribute to housing vacancy vary by city and over time. What remains unclear is (1) how and whether these factors have fluctuated in their relationship to housing vacancy over time; and (2) which factors have remained constant in relation to increasing housing vacancies through time. This paper seeks to answer these questions by (1) examining descriptive statistics on housing vacancy in U.S. cities of over 100,000 persons from 1960 to 2010 (with 1940 and 1950 serving as baseline years prior 1960); (2) conducting multivariate regression analyses on these data in 10-year periods from 1960 to 2010; and (3) performing a longitudinal panel analysis on these data in 10-year periods from 1960 to 2010. The regressions examine how factors of urban housing vacancy have changed over time while the panel models assess which factors have remained consistent.

2 Literature review

2.1 Overview

All cities have some proportion of vacant housing, but excessive amounts of long-term housing vacancies and abandonment can ultimately lead to widespread urban and economic decline (Goldstein et al. 2001). Disproportionate amounts of long-term housing vacancies can trigger many urban problems (Zhang et al. 2015). The presence of vacant and abandoned housing can disconnect the local community, amplify criminal activity, and decrease the

quality of life of residents (Kivell 1993). Vacancies are not typically randomly distributed, and as they mount within neighborhoods, clusters can cause whole neighborhoods to become blighted, decreasing property values and development potential, stymieing economic growth and undermining the city's tax base (Goldstein et al. 2001; Setterfield 1997). Given that the real estate appraisal process calculates housing values in part based on the values of nearby comparable housing, it creates a circle of declining property values that drives further vacancy. Vacant housing is, in reality, a driver of itself, in that vacancy will beget more vacancy if not managed properly. To assist in preventing such circumstances, it is important to understand the drivers which are associated with urban housing vacancies. Factors widely discussed as contributing to increased supplies of vacant housing include population loss or out-migrations (Rieniets 2009), policy modifications (Németh and Langhorst 2014), local economic instability (Ryan 2012), urban land area increase (Audirac 2007), and built environment spatial characteristics such as neighborhoods with high densities (Henry et al. 2001). While these drivers have been repeatedly shown to be factors contributing to housing vacancy in individual cities, attempts at generalizing these findings have been severely limited.

2.2 Drivers of housing vacancies

2.2.1 Population change—By 2050, the global population is projected to rise by 2.3 billion persons, with urban populations expected to double; in the U.S., projections estimate that by 2050, 87.4% of the population will live in urban areas (United Nations 2012). Assuming a relatively consistent population density, this prediction suggests an increase in demand for developable urban land. Many depopulating urban areas are already characterized by high amounts of vacant land and/or abandoned structures, providing an adequate existing land bank for much of this projected growth (Lee and Newman 2017). Glaeser and Gyourko's (2005) research shows that, of the 15 largest U.S. cities in 1950, eight have lost population in each succeeding decade. By examining both growing (populating) and shrinking (depopulating) cities, they found that population shifts were highly correlated with concomitant shifts in housing vacancy. Most research on the subject has repeatedly shown that a city's population profile can influence its housing vacancy rates (Liner and McGregor 2002). When a city experiences population growth, housing occupancy typically increases; inversely, populations can move out of urban areas (into suburbs or other cities), leading to increased vacancies (Goldstein et al. 2001). In this sense, as is the situation characterizing many depopulating cities, the city itself (the urban area) is shrinking in population, but the surrounding metro area is not. The regional population is simply sprawling.

2.2.2 Boundary Change—The relationships between urban expansion/compaction and housing vacancies is not fully understood (Williams et al. 2000). Some research has shown that, in populating cities with elastic (expanding in size over time) boundaries, urban vacancies can be an important indicator of healthy economic growth (when amounts are not excessive) and low amounts can indicate adequate economic competition (Rieniets 2009). In contrast, other studies have shown that as cities expand, they can leave high quantities of vacant housing in their wake (Treib 2008). Others hypothesize that urban expansion is a necessary ingredient for obtaining lost tax base in cities characterized by negative population

trends and high housing vacancy amounts (Berger 2007). While the effect of urban boundary enlargement and contraction on vacancies is somewhat contested, it is clear that the amount of vacant housing in a city is associated with the way the city expands or is limited by its boundary (Rusk 2006).

Pagano and Bowman (2000) found that cities which expanded their territory and experienced high population growth reported higher amounts of vacant land than did fixed-boundary cities, which reported higher levels of structural abandonment. Since we know that a high proportion of abandoned structures are residential land uses (Newman et al. 2016a), it is safe to infer that a majority of these abandoned structures are housing vacancies. If a city is aggressively annexing to expand it boundary while also increasing its population, typically its economic base is also enlarging, thereby increasing housing demand (Rusk 1998). Alternatively, vacancy rates have been shown to increase due to unnecessary annexation and overbuilt housing units, but primarily within depopulating cities (Hollander and Németh 2011). Rusk (1993) argues that urban expansion strengthens the overall housing demand in a city and creates a stronger tax base. Others, such as Smirnova and Ingalls (2007), suggest that decreasing the rate of urban boundary growth (or leaving its sized fixed) provides greater opportunities for central city growth through infill, thereby increasing the rate of reused urban lots and decreasing vacancies. Xiao et al. (2006) found that cities which rapidly enlarge their urban boundary size have less fiscal rationale to encourage infill, resulting in a greater likelihood of urban abandonment and decline. It is important to note that, while larger rates of infill development occur in cities with limited to no urban boundary growth, shrinking cities typically do not have the population to support such investments, regardless of urban land area change.

2.2.3 Changes of socioeconomic conditions

2.2.3.1 Economic stability, neighborhood stability, and homeownership: Ideally, there would be perfect equilibrium between housing supply and demand, with price points for all segments of the population in that city. Yet such cities do not exist, and the constant state of disequilibrium in the housing market fluctuates based on economic stability and housing vacancy. The relationship between economic stability and housing vacancy revolves around the underlying connections between homeownership, neighborhood stability, public policy, and urban economics (Lowry 1960). These relationships, while existing before World War II, became far more obvious during the post-World War II construction boom. This construction boom led to the rise of the suburbs and planted the seeds of the urban unrest and resulting public policies of the 1960s. During this time, housing became a focal point of economic stability, specifically through the concept of filtering and the provision of housing for low-income populations (Baer and Williamson 1988). The overall goal was the use of public policy to stimulate neighborhood stability, but these policies tend to focus on households rather than the lifecycle of the housing unit (Galster and Rothenberg 1991; Rohe and Stewart 1996).

One useful resource related to housing vacancy is the early attempt by Baer and Williamson (1988) to provide an analytical framework for filtering theory and causes of housing vacancy. While earlier research on housing vacancy focused solely on the issue of outdated

units, Baer and Williamson introduce additional factors that can impact vacancy, including the rise of retirement communities, the rise of divorce rates, and the rise of nontraditional households occupied by unrelated tenants as contributing factors to vacancy. These factors were never included in earlier research on housing vacancy. From the perspective of location, the policy focus tends to be on the national level at the expense or exclusion of factors at the local and neighborhood levels.

The long history of homeownership and stability is well-documented throughout the literature, with most of the literature suggesting a positive association between homeownership rates and an increase in property values while a decrease in homeownership rates leads to an associated decrease in property values (Rohe and Stewart 1996; Bier 2001). Rosenthal (2008), using a panel methodology similar to the one utilized in this research, examined neighborhood change using decennial census data at the tract level from 1950 to 2000. His research determined that neighborhood economic status changed at a rate of 13% per decade, indicating that a city's status changes significantly every decade and even more dramatically every 20–40 years. This time period far exceeds the time period that much of the literature covers.

Economically stable cities also tend to have more active housing markets and lower vacancies (Henry et al. 2001). Couch and Cocks (2013) suggest that the consequences of excess housing vacancies are an indicator of crises within the local economy. While population loss can result in increased housing vacancies, population relocation dynamics are also often associated with urban economic vitality (Couch et al. 2005). As urban populations decrease, many once-occupied housing units can become obsolete, resulting in disinvestment in the local economy and local economic downturns. Due to this interrelated nature, population change, the primary driver of urban vacancy and abandonment, heavily impacts economic activity, housing stock quantities, and market conditions (Johnson et al. 2014; Heckert and Mennis 2012). Rusk (2006) claims that urban expansion is also an important variable contributing to economic health and capabilities to reuse vacant urban areas. He found that cities with enlarging urban boundaries were strongly positively correlated with better local economies; the increased tax base from annexed populations allowed for more capabilities to manage housing vacancies. While demand increased in peripheral urban areas, inner urban areas did not see as strong an increase.

Expanding cities and the ability to employ more aggressive expansion strategies to control the city-region and have been shown to result in higher population increases, stronger tax bases, and healthier urban-regional economies than non-expanding cities (Meligrana 2007). Inversely, Genske and Ruff (2006) found little evidence to suggest that a municipality's elasticity was related to changes in its economic base. Liner and McGregor (2002) found that annexing municipalities that increased their total land area did not experience significantly stronger population growth, new housing construction, or economic development when compared with non-annexing ones.

2.2.3.2 Social status: Studies have shown that neighborhoods with low social status may be associated with longer-term vacancies. For instance, Immergluck (2016) found that neighborhoods with higher proportions of Hispanic and Asian residents experienced larger

declines in long-term vacancy. Silverman et al.'s study (2013) shows that black neighborhoods with increases in foreclosures also tend to show long-term vacancies. Ryan (2012) also points out that neighborhoods with high socioeconomic status are less likely to confront the problem of high vacancies.

The US history of racial inequality considered along with models of neighborhood change (Schwirian 1983) suggest that changes in neighborhood sociodemographic change may be good proxies for urban vacancy trends. However, these trends may be sensitive to city-wide demographic composition. For example, if a city has a large minority population, changes in neighborhood-level proportions may not be strongly associated with vacancy trends.

2.2.4 Regional Location—As shown, housing vacancies are heavily dependent upon demographic and economic factors, but how these driving forces manifest themselves can differ from region to region (Mallach et al. 2017). Urban vacancies have been shown to vary by region by both amount and type (Pagano and Bowman 2000, Bowman and Pagano 2004). U.S. Census Bureau regions are often used to group cities to control for unmeasured regional level characteristics varying over time when assessing urban vacancies across cities (Bollen and Brand 2010). For instance, Midwestern and Northeastern cities tend to have more abandoned units than those in other regions due primarily to depopulation, economic decline, and deindustrialization (Newman et al. 2016a). Similarly, the Frostbelt-to-Sunbelt shift during the postwar period has continually had implications for regional vacancy ratios. The Frostbelt, with higher density cities, report higher levels of structural abandonment, while the larger and lower density cities in the Sunbelt report high amounts of vacant land (Carlino and Chatterjee 2002). Employment trends also differ. For example, average annual private sector job growth rates were shown to be significantly different as Frostbelt job rates decrease, and Sunbelt rates increase (Gordon et al. 1998).

2.2.5 City type—Many scholars now examine the relationship of urban housing vacancies to their regional location, but some also have begun to combine location with demographic changes to define city typologies. For example, Newman and his colleagues (2016b) include U.S. Census regional location, population change, and city boundary elasticity (growing, fixed, or contracting) as factors for vacant urban areas. The study sought to capture the interrelated nature of population and land area change by classifying cities into typologies. Their classification scheme was as follows: cities experiencing population and land area growth were labeled 'inflating;' those that lost population and land area (or remained the same) were 'deflating;' cities that increased in population and decreased in land area (or remained the same) were 'compressing;' and those with population loss but land area growth were 'diluting.' It was found that inflating and diluting cities report similar vacant land amounts while diluting and compressing cities had higher rates of abandonment.

2.2.6 Urban Density—Scholars have theoretically explored the relationship between density change and housing vacancies, but no empirical explanation has been made (Zhang et al. 2015). It is obvious, however, that urban density is likely to decrease with the city expansion and annexation ("dilution"). For instance, elastic cities have more space for new development on the periphery than do inelastic cities, but typically a lower population density (Aryeetey-Attoh et al. 1998; Meligrana 2007). Changes to a municipality's density

are therefore also partly related to the amount of unincorporated fringe areas that are annexed over time. Carruthers and Ulfarsson (2002) suggest that a trade-off occurs between urban expansion and densification; in the short-term, densities typically decrease as cities expand their boundaries. However, long-term densities have been shown to increase in some rapidly expanding cities when regulations are put in place to control the development of newly annexed fringe areas. Poorly designed and executed municipal and fringe land management paired with population losses can result in increased urban vacancies (Johnson et al. 2014). Likewise, existing studies have pointed out the possible relationship between urban density, land expansion, and potential increases in vacant land.

2.2.7 Housing vacancy policy—During the period of Urban Renewal, there were many federal policies aimed at stabilizing urban neighborhoods to try to stem population losses. In a controversial article at the turn of the century, John Metzger (2000) claimed that national urban policy in the post-riot period of the 1960s and 1970s was a purposeful attempt ("planned abandonment") by the federal government to invoke the neighborhood life-cycle theory (see Temkin and Rohe 1996 for a review of this and alternative theories of neighborhood change) to deliberately disperse low-income and minority populations from urban areas for the purpose of urban renewal. Meztger's many critics, however, point out that he conflates several related theories and provides unsubstantiated claims to develop what is essentially a conspiracy theory (Galster 2000). While perhaps not intentional, the federal policies of the Urban Renewal period did little to stem the population losses and neighborhood change that took place at that time.

Varady (1984) reports that most federal programs focused on meeting housing needs and addressing superficial environmental concerns, but failed to address the larger socio-economic changes that were occurring during the Civil Rights Era. One ambitious program in the 1970s called the Urban Homesteading Demonstration was promising because it attempted to retain existing populations (Varady 1984). However, in a methodologically sophisticated study of the demonstration program's impact on mobility of original residents, Varady found that the program had little impact on the retention of middle-income households in urban neighborhoods.

In the late 1970s, federal policy began shifting from direct intervention to neoliberal support for private markets through community reinvestment. Specifically designed to counteract disinvestment, the Community Reinvestment Act of 1977 sought to counteract redlining by requiring lenders to lend in neighborhoods they served. The implementation of the Act has been the subject of political debate and has been widely blamed for the subprime lending crisis that led to the Great Recession of the late 2000s. However, most housing scholars agree that unethical and illegal banking practices, and not forced lending to high-risk borrowers, were to blame (Aalbers 2009). In fact, a special issue of Cityscape to celebrate the 40th anniversary of the CRA, found consistent evidence that the CRA has led to reinvigorated investment in once disinvested neighborhoods (see Silver 2017, for a review of the issue).

At the local level, many communities design and implement policies to try to counteract increasing vacancies and their associated negative consequences (Accordino and Johnson

2000). Most notable are “early warning” systems that track administrative data to identify properties at risk, spurring interventions to try to stave off abandonment (Hillier et al. 2003). These programs have been adopted in several Rust Belt cities, including Chicago and Philadelphia, but have also been employed in Los Angeles and Minneapolis (Snow et al. 2003). Other programs include those that attempt to spur adaptive reuse of abandoned properties through land banking or urban homesteading (Accordino and Johnson 2000; Jourdan et al. 2010). These types of programs offer underutilized properties at under-market values (sometimes just $1) to investors that make a long-term commitment to rehabilitate and maintain the property. Careful studies of these types of programs are rare, and so the lasting impacts are unclear.

3 Methods

3.1 Constructs and variables

This study explores associations between urban vacant housing units and population, land area, density, city typology, socioeconomic status, and regional impact. All information was retrieved from the U.S. Census Bureau from 1940 to 2010 using 10-year increments (United States Census Bureau 2016a). Population change was measured as the percentage change of the total population; we also examined the percentage change of land area (both in 10-year increments). Cities that were consolidated at some time between 1940 and 2010 were likely to have had an extreme increase in land area or population, and were excluded from this study in order to avoid the outlier bias. While, as noted, land area and population change play an important role in urban vacancy, observing the combined impacts of those two has also been shown to help better assess conditions related to housing vacancies (Newman et al. 2016a). The use of Newman et al.’s (2016a) city classification scheme, or city typology,—captured by the change of population and land area at the same time—was used as a comparison measure. City types were identified by four categories: inflating, compressing, diluting, and deflating.

We also include population density as a variable to control for different types of cities. Differences in central cities and cities in suburbs are captured using a density variable. Density, in this research, is calculated as the average land area per capita by city. The use of density helps indicate how urbanized a city is (Gordon et al. 1998) and using change in density helps capture how much each city has developed over time (Rusk 1993).

This study also used two variables to measure socioeconomic conditions: economic stability (Katyoka and Wyatt 2008) and racial composition (Pearsall et al. 2014). Economic stability is measured by unemployment rate, as cities with less competitive economies tend to have higher unemployment rates and fewer jobs available (Hollander et al. 2009; Mallach and Brachman 2013), which result in fewer development activities due to the decreased demand and depreciated housing values (Silverman et al. 2013). The use of unemployment rate may seem to conceptually somewhat overlap with population change because population trends may be partially influenced by economic conditions within a given city. However, unemployment rate and population change indicate different constructs. Unemployment rate captures the economic condition of the cities while population change captures the change of total demographic size, which does not fully capture economic condition (Newman et al.

2016b). For example, cities experiencing economic growth with a higher employed population do not always gain population in-migration.

Based on the previous literature, this study includes racial composition to help understand the influence of demographic status on urban vacancy. Racial composition is measured by percentage change of non-white population to capture the changes of minority populations. Assessing the change of each race/ethnicity type would ideal, but longitudinal racial data from the U.S. Census makes this difficult as it only started to track Hispanic origins in 1980 and its categories of race and ethnicity change from census to census.

3.2 Data collection

To explore the longitudinal trends of U.S. housing vacancy, we focus only on U.S. cities with populations of 100,000 or more based on the 2010 Census. This measure excludes cities that once had populations over 100,000, but which currently have populations under 100,000. This criteria of being a 'large' city was adopted by Pagano and Bowman (2000), Bowman and Pagano (2004), and Newman et al. (2016a) to define "large American cities" when examining vacancies. Excluding cities located in Hawaii, Alaska, or Puerto Rico due to their isolation from the U.S. economy as a whole, a total of 280 cities were initially included in this study with the data between 1940 and 2010. However, data prior to 1960 had several issues, and therefore, were incomplete. There were cases where cities were consolidated and were no longer individually trackable. Some records in earlier years were also incomparable to the later years with historical fluctuations (For example, World War II). Due to these data issues, we had to exclude the data prior to 1960 and used the data only from 1960 to 2010 to perform the regressions. Finally, with the limited historical data available even after 1960, especially for more recent cities, such as the boom towns in the southwest that grew drastically during the 1980s, 130 cities remained with complete information available for analysis between 1960 and 2010.

It is important to note that the variables we measure are all the percentage changes from the prior decennial census. Thus, the model of the year 1970 captures the change between 1960 and 1970. Thus, we had to exclude the model of the year 1960 or before because of the issues stated above regarding the data availability prior to 1960. Additionally, multiple databases were utilized because of limited access to the digitally recorded longitudinal data while data from 1990 to 2010 were retrieved from the U.S. Census Bureau (United States Census Bureau 2016b). Data earlier than 1990 were collected from multiple sources including a government report of Gibson and Jung (2005) and other government online databases (United States Department of Commerce, Census Bureau 2008a, b). These databases are based on the same U.S. Census Bureau data, ensuring that all data used in this study are consistent.

3.3 Analysis

This study uses two different analyses: multivariate regression and panel models. First, cross-sectional multivariate regressions are performed every 10 years from 1960 to 2010 to examine the contributing factors of urban housing vacancies over time. This analysis gauges the longitudinal trends and possible fluctuations of the significant factors contributing to

urban housing vacancy at singular points through time. Equations used for each model are supplied via a supplemental online download (See Supplemental File 1). Because associations vary by each multivariate regression model for each decennial year we sought to also identify the driving forces of vacant housing which had a constant influence on over time. Thus, as an extension to the multivariate analysis identifying factors contributing to urban housing vacancies from each historical period, a two-way fixed effect model was performed to measure the time-invariant effects with the panel data. This method allows the examination of varying intercepts between the four regional groups and time periods. By accumulating cross-sectional data from 1960 to 2010, a balanced panel data with 650 observations on the 130 cities was created.

Panel models are used to look at the consistency of factors contributing to vacancy over the decades. The panel analysis methodology was based on a three-step process: Model 1) base model estimation, Model 2) population and area change model estimation, and Model 3) typology model estimation. This process allowed us to test the influence of two sets of independent variables and any potential changes in the control variables compared with the base model. The base model measured vacancy rate change with region and time effects to capture the effect of socioeconomic factors and population density. After analyzing the vacancy rate through the base model, the population and area change independent variables were added for Model 2 to estimate the effect on the vacancy. Population density change, nonwhite population change, and unemployment rate change were included as control variables. Lastly, the population and land area change variables were specified into four city typologies. The city typology variables were tested as independent variables instead of the population and area change variables, to assess different combinations of population and land area change over time.

4 Results

4.1 Descriptive statistics

Initial analyses of the data show interesting trends nationally as well as by region from 1940 to 2010 (See Fig. 1). The percentage of elastic cities has declined since 1950, reaching its peak in 1960 (86.1%) and its lowest point in 2010 (74.1%), while the large majority of U.S. cities are elastic, or have expanding boundaries (Rusk 2006). Inelastic cities, having fixed boundaries or decreasing in size (Rusk 2006), have increased in percentage of total U.S. city types by over 5% since 1950, now currently at their peak. The percent total of shrinking cities increased nearly 5 times its original amount from 1950 to 2010. However, the most recent total of shrinking cities is only around 1/2 that of the total in 1980. Relatedly, populating city amounts have decreased by nearly 14% since 1950. When assessing the shift from inelastic to elastic cities, most cities tended to retain their boundary type (inelastic or elastic) but the ones that changed the boundaries generally altered from inelastic to elastic. Around 88% of cities maintained their boundary type from 1950 to 1960, but this portion decreased to 75.7% by 2010. In the 1960s and 1970s, some cities (11.4%) that were once populating began to lose population. But by 1990, many cities started to regain population (14.3%).

More diverse types of cities have accrued in the U.S. since 1950 (See Fig. 1). The number of deflating cities has doubled since 1970 while inflating cities have decreased by around 4%. In the 1950s, city types were monotonic. Among the 121 observed cities in 1950, 113 cities (77.9%) were inflating; inflating and compressing cities counted for almost 97% of the total. By 2010, although both inflating and compressing city types were still dominant, only 64% of the total cities were inflating while the other three types comprised nearly 1/3 of the total. The portion of compressing cities decreased starkly from 18.6% in 1950 to 4.3% in 1960. After this decline, they showed a steady increase to 18% by 2010. The number of diluting cities peaked in 1980 (22.0%) but began to decrease to around 9.7% by 2010 (27 cities out of 278 cities). Deflating did not actually appear in the U.S. until 1960 and occupy around 8% of the total observed cities as of 2010.

When evaluated by U.S. Census region, inelastic cites can be found more over time (See Fig. 2). The proportion of expanding cities in the Midwest decreased from 84.6 to 74.5%, the Northeast from 54.2 to 16.0%, the South from 82.0 to 81.1%, and the West from 87.5 to 81.1%—yet the differences are not large, other than the Northeast region. The majority of the cities with inelastic, or contracting, boundaries primarily characterized the Northeast region through time. In 1950, almost 45.8% of the cities in the Northeast were inelastic, and this proportion increasing to 84.0% by 2010.

Population change by region primarily fluctuated around the 1980s (See Fig. 2), with the Northeast region showing the most drastic changes over time. Both the Northeast and Midwest regions showed high proportions of depopulating cities, 61.7% and 96.0%, respectively. In 2010, the proportion of depopulating cities decreased to 40.4% in the Midwest and 28.0% in the Northeast. At the same time, a majority of the cities in South and West remain populating, over 80% of the total cities since the 1950s.

When assessed by city typology by region (See Fig. 2), the Midwest and Northeastern regions show more various types of cities over time than other regions. Other than in the Midwest and Northeast, inflating cities characterize around 70–80% of city types. In the Northeast especially, inflating cities occupy less than 50% of the total cities at any given point between 1950 and 2010, whereas inflating cities in South and West occupy from 70.5 to 87.5% in anytime. The Midwest had over 84% inflating cities in 1950, but this total decreased to around 53.2% by 2010.

Housing vacancy rates in large U.S. cities have nearly tripled since 1950 (3.6% in 1950 to 9% in 2010) (See Figs. 1, 3). The Midwest and Northeast have nearly 5 times as many housing vacancies than in 1950, while the South has over double the amount and the West only 1.5 times is 1950 proportion. Interestingly, inelastic cities have 1.7% more housing vacancies than do elastic cities. Less surprisingly, depopulating cities tend to have 3% higher housing vacancy rates than depopulating. Housing vacancy rates in depopulating cities have more than quadrupled since 1950 and more than doubled in populating cities. Compressing, deflating, diluting, and inflating cities have all increased in housing vacancies since 1950. Deflating cities, with decreasing populations and fixed or contracting land area, have over 9 times the amount of housing vacancies they did in 1950.

4.2 Multivariate analysis

The results from the five multivariate models using data from 1960 to 2010 were consistent and showed significance while varying at some detailed significance-levels (See Table 1). While the impact of population and land area changes are not always statistically significant and the signs are not consistent, the models indicate that vacancy increases when total population decreases and the city area expands in general. Noticeably, population change has more effect on vacancy in more recent periods than in earlier eras. In the case of area change, although all but the time period between 2000 and 2010 were not significant, increasing land area is associated with increased housing vacancy.

Many of the variables measuring city characteristics were statistically significant predictors of the increases and decreases of vacancy rate changes. The variables representing socioeconomic status require two separate interpretations. First, the increase of unemployment rate significantly predicts increasing vacancy throughout the models. The effect size ranges between 0.4 and 0.5% constantly across the five models and they are statistically significant at the 0.01 level. On the other hand, nonwhite population did not explain vacancy well. Although the variable was significant in the recent time period (2000 and 2010), indicating a one percent increase in nonwhite population can decrease vacancy by 0.1%, throughout the timeline this variable was not statistically significant. The regional differences were all significant in the models from 1960 to 1970 ($p < 0.01$), but the effect began to diminish after 1970.

4.3 Panel model results

Table 2 presents the results from the panel models. The adjusted R-squared values indicated that the base model (Model 1) explained 42% of the variance. The models with population change and area change (Model 2) and city typology (Model 3) had a higher explanatory power than the base model (Adjusted R2 are 0.43 and 0.44, respectively). The deflating and diluting dummy variables were found significant at the 0.01 level while the population change variable was marginally significant only at the 0.1 level. To elaborate, Model 2 suggests that if a city had a history of population expansion, the vacancy rate would decrease. In regards to city typology, the deflating and diluting cities had higher levels of vacancy rate than inflating cities (1.1 and 1.0% point, respectively). Figure 4 shows predicted vacancy rate change by city types based on Model 3, which illustrates the persisting relationship of deflating and diluting cities on the vacancy rate change. For example, there are overall increases in vacancy rate change during the last decade 2000–2010. On the other hand, the average increase of vacancy rate for deflating and diluting cities is almost two times higher than those of compressing and inflating cities: 4% point increase and 2% point increase in 2010, respectively. Note that the area change variable itself was not significant in Model 2 while the deflating and diluting cities were significant in Model 3.

The region and year dummy variables captured regional and chronological characteristics based on the West region and year 1970. In Model 1, the Midwest and Northeast regions respectively showed 0.6 and 0.5% point higher vacancy rate change compared to the West region. However, in Models 2 and 3, the region variables were not significant with the

population and area change variables or the typology variables. The year variables in the three models were significant at the 0.01 level except the year 1990 to 2000. The year variables' coefficients had the same trend; they increased in 1980 and 1990, decreased in 2000, and drastically increased in 2010. We assume that this trend represents the gap between historical housing demand and supply.

The density change and unemployment change variables were significant only at the 0.01 level in all three models. The density change variable had a negative coefficient after controlling area and population changes, indicating that cities developed as high density could help mitigate the vacancy rate change and that dispersed cities are likely more vulnerable to the vacancy rate change.

Unemployment rate change shows a regional economic condition, and it had a positive coefficient, indicating that an increase in the unemployment rate could increase vacancy rate change. The unemployment change coefficient is 0.35, and it indicates that one percentage point increase in the unemployment rate will add 0.35% point to vacancy rate. The non-white population change was not significant in all three models.

5 Conclusions and discussion

This paper analyzes relationships underlying housing vacancies in large cities from 1960 to 2010. Rather than focus on a single economic flashpoint, such as the 2008 Recession, this research shows that factors contributing to housing vacancy primarily reflect conditions of city population and land area trends over an extended period of time. Population alteration, percent nonwhite populations, unemployment and density were all significant predictors of housing vacancies in the longitudinal model, while the regression models show unemployment as the only significant factor across each interval. Regional location was a strong predictor until more recently while population has become a stronger predictor in recent years (Fig. 5).

Interestingly, urban land area showed to be a significant factor of housing vacancies in the most recent regression interval. One possible explanation is cities with shrinking populations that are annexing land may actually be creating more vacancies in their urban areas. In other words, annexation may be used as a tool to increase the taxed population, but it may also lead to an increase in vacant housing proportionately. As prior research has shown, vacancy can begat more vacancy over time if not treated (Newman et al. 2016b). Therefore, in such cases, regeneration policy in such areas must proactively try to provide some sort of temporary or community function in vacant areas prior to long term vacancy duration. Overall, the number of cities that have decreased in boundary size or have fixed boundaries are increasing, especially in the Northeast. The Northeast region has also lost the most population, but the proportion of depopulating cities has actually slightly decreased. This may reflect many of the well-known recent efforts of declining cities the in Northeast to restructure industry from manufacturing and industrial jobs to tech, artists, and service based jobs, their pursuit of the development of regeneration plans, and the recent increase in inventorying and analysis of vacant lands for better management. Decreased population and

increased urban area are likely to increase housing vacancy; this trend has become truer in recent years.

In contrast, another explanation based on the 1970 to 1980 period showed that as population increased, so did housing vacancies. This inconsistency might be explained by the housing market crash and economic downturn. In 1973, the Arab oil embargo strained the economy (Hamilton 2011). The 1979 oil crisis, coupled with a jump in mortgage rates in the late 1970s and early 1980s also impacted the housing market (Bokhari et al. 2013). The panel analysis may better explain the long-term effects of these two variables while minimizing the fluctuation between decades. The panel model confirms that population decrease has an inverse relationship with vacancy, but land area change did not show significant impacts across the longitudinal observation period. One possible cause of the insignificance could be generally healthy economic conditions and less structural abandonment. In this situation, the model may not fully explain these conditions.

While urban shrinkage has become a timely topic recently, this research also shows that depopulation is not a new issue. In fact, prior to 2010, the U.S. had an abundance of depopulating cities; the country actually reached it its peak in total number of depopulating cites in 1980. This trend suggests that American cities may only be in the formative stages of treating the urban shrinkage condition, but the condition may also be on the decline. Current research showing that vacant land amounts in large U.S. cities have increased by 1.4% since 2000 (Newman et al. 2016a) suggest that there is much more to do, however.

City typology (accounting for both population and land area change simultaneously) shows interesting findings. Inflating cities are the most common city type in the U.S., suggesting that expanding and populating cities are abundant. However, compressing cities, presumably cities with growing density, are escalating, increasing from their lowest amount in 1960. These findings are complimented by the finding that diluting cities have also decreased from their peak in 1980. These may indicate that recent planning efforts to create more compact cities and decrease the abundance of unmanaged urban sprawl is beginning to achieve some desired outcomes. While there are not many deflating cities in the U.S., planning strategies for these cities tend to respond slowly to population loss (Rybczynski and Linneman 1999). Or possibly, these cities are chasing expansive developmental strategies including substantial expansion of residential peripheral areas. In these areas, the suburban populations may be increasing regionally while the urban populations may be demising. Deflating and diluting cities demonstrated a higher vacancy rate compared to other city types. While both city types suffer from population decrease, the land area of deflating cities decreased while diluting cities increased. This may partially reconfirm the result of model 2 that includes population and land area change separately, finding land area change insignificant. Population, therefore, may be a more critical factor to determine urban housing vacancy.

To understand the impact of city typologies better, density should be discussed. Density is negatively and significantly related to housing vacancy across all longitudinal models. This implies that land area itself may not fully explain housing vacancy conditions, but the combination of population and land area change measured by city typology with density can mostly fully explain urban housing vacancies. (E.g., a deflating city would have a lower

density change if land area decreased less than population). As expected, economic stability (reflected by unemployment rate) has a constant impact on urban housing vacancies regardless of analytical model. It is well known that economic downturn, employment decline, population loss result in increased stock of vacant housing (Martinez-Fernandez et al. 2012).

Population change is the primary driver of urban housing vacancies, but population is difficult to control solely through planning and policy. Therefore, planners should highlight the role of density in reducing housing vacancies and their accompanying social problems. Right-sizing strategies such as de-annexation or consolidation, infill instead of new residential developments on the fringe, brownfield developments within city limits, or adaption and reduction of infrastructure to encourage planned abandonment for the future developments are all options for helping to regulate population change through density management.

This research demonstrates the importance of looking long-term at transformative policies to reduce housing vacancy at the city level. Despite many existing policies that may alleviate or address housing vacancy, many of these policies only focus on short-term issues, such as foreclosure caused due to an economic downtown. The drivers of housing vacancy have a much longer time horizon than economic cycles, and this research begins the discussion of looking beyond short-term solutions for long-term housing policies to address vacancy. Long-term strategies that focus on growing economies and populations simultaneously may have a longer lasting impact on transforming and stabilizing a city's housing stock. This result provides evidence for new research avenues to look beyond the next crises and focus on policies for the next 50 years.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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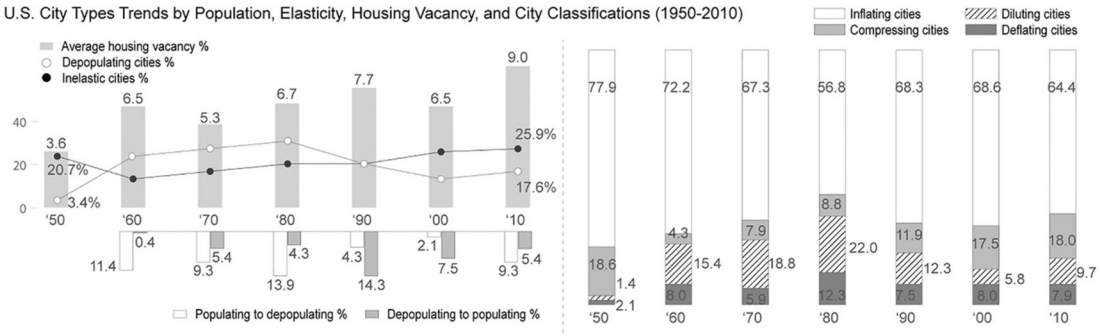

Figure 1.

National longitudinal trends of housing vacancies by city typology

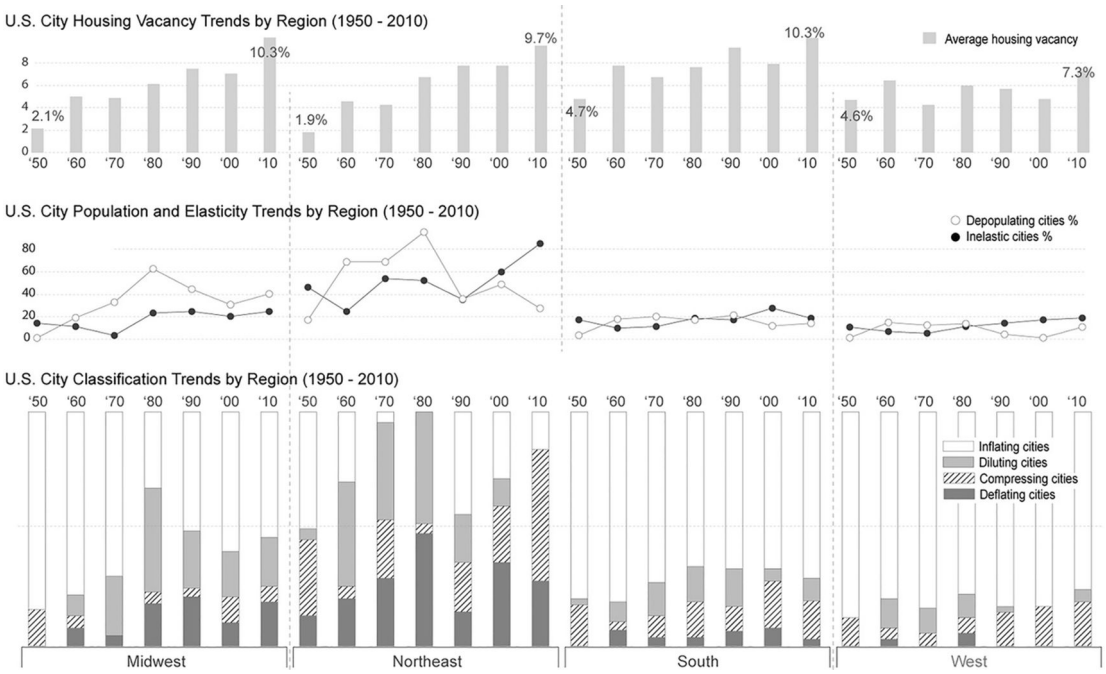

Figure 2.
City typologies and housing vacancy trends by region

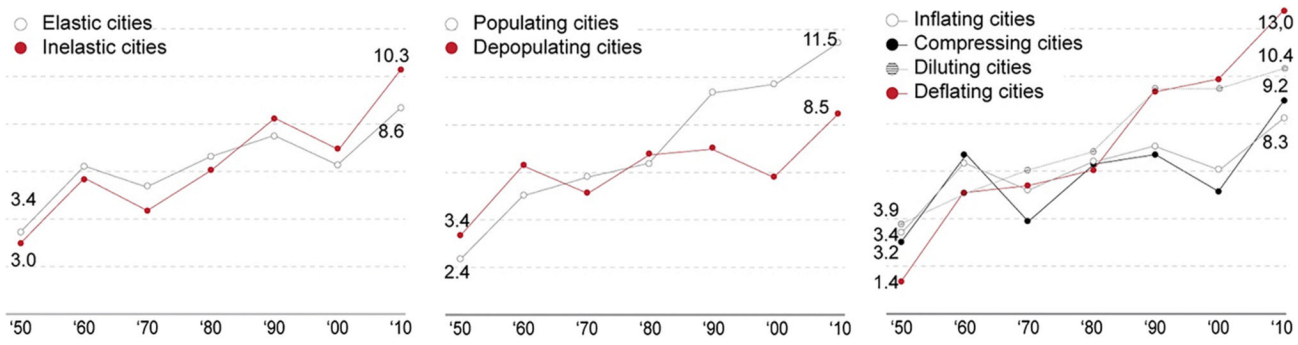

Figure 3.
Housing vacancies (%) by elasticity, population change and city typology

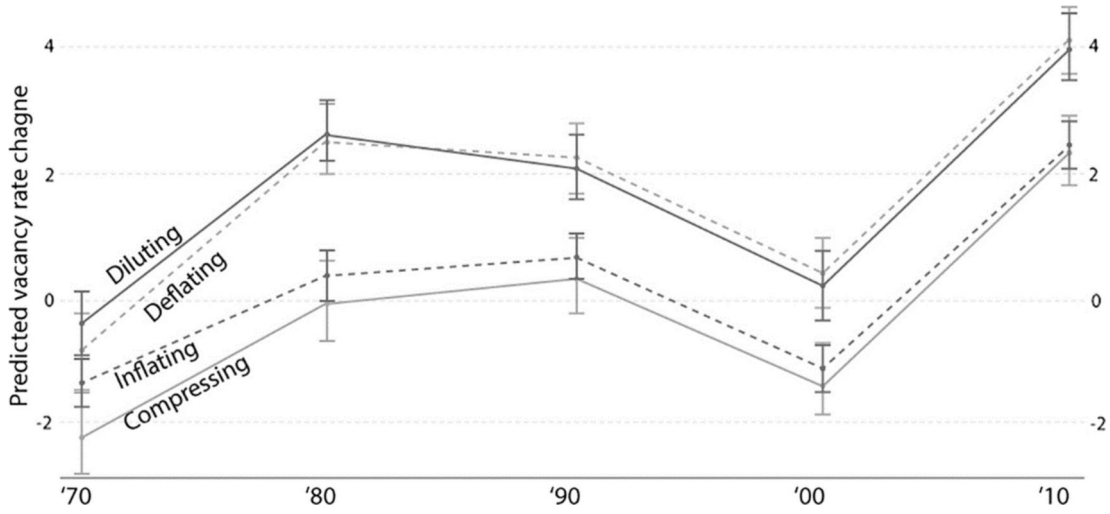

Figure 4.
Predicted vacancy rate change by city types with 95% CI

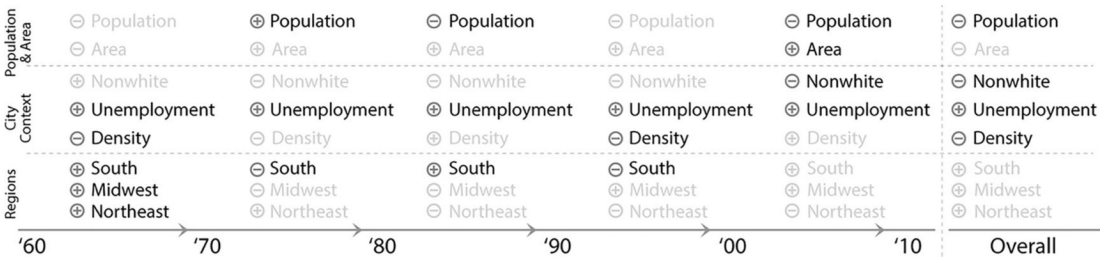

Figure 5.

Factors contributing to housing vacancies in 10 year regression intervals and overall longitudinal modeling

Table 1.

Multivariate analysis results

Dependent: vacancy rate change	Description Percent change of vacant housing unit (%) in 10 years	1960–1970	1970–1980	1980–1990	1990–2000	2000–2010
Population change	Percent change of total population (%) in 10 years	− .0112	.0332 *	− .0577 **	− .0337	− .0998 **
Area change	Percent change of land area (%) in 10 years	− .0064	.0002	.0134	.0247	.0683 *
Nonwhite Pop. change	Percent change of nonwhite population (%) in 10 years	.0026	− .0405	− .0167	− .0109	− .1076 *
Unemployment change	Percent change of unemployment rate (%) in 10 years	.5591 **	.4095 **	.4360 **	.3376 **	.5256 **
Region West (omitted)	Location as determined by U.S. census					
South		1.7029 **	− 1.2658 **	1.3745 **	− 1.8250 **	.7945
Midwest		1.6320 **	− .7033	− .3696	.0606	.7794
Northeast		1.8291 **	.7624	− .5984	− .3665	− .2521
Density change	Percent change of density (mi^2/person, %) in 10 years	− .0008 **	− .0003	.0000	− .0019 **	.0005
Constant		− 1.8184 **	.9458 *	1.0651 *	.3237	2.0145 **
Adj. R-sq		.3917	.2798	.4637	.3068	.3969
Obs. (N)		130	130	130	130	130

** $p < .01$,

* $p < .05$

Table 2.

Panel modeling results

Dependent: vacancy rate change	Model 1 Base model	Model 2 Population and area change model	Model 3 Typology model
Population change		− 0.0162 *	
Area change		− 0.0015	
Inflating (omitted)			–
Compressing			0.0880
Deflating			1.0995 **
Diluting			0.9633 **
Non-white population change	− 0.0176	− 0.0256 †	− 0.0216
Unemployment change	0.3621 **	0.3569 **	0.3482 **
Region West (omitted)	–	–	–
South	0.2864	0.1747	0.2043
Midwest	0.5895 *	0.2686	0.2567
Northeast	0.5055 †	0.0981	0.0326
Density change	− 0.0007 **	− 0.0007 **	− 0.0006 **
Year			
1980–1990	1.6663 **	1.4680 **	1.6268 **
1980–1990	2.1325 **	1.9041 **	2.1251 **
1990–2000	0.6637 *	0.4117	0.7020 *
2000–2010	3.4658 **	3.0977 **	3.4773 **
Constant	− 1.5174 **	− 0.8596 **	− 1.6146 **
Adjusted R^2	0.4180	0.4336	0.4359
Number of observation (N)	650 (130 cities)	650 (130 cities)	650 (130 cities)

** $p < 0.01$,

* $p < 0.05$,

† $p < 0.10$