Cincinnati

Cleveland

Columbus

Pittsburgh

Neighborhood Change in the Fourth Federal Reserve District

A Multivariate Approach

Kyle Fee

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Neighborhood Change in the Fourth Federal Reserve District

A Multivariate Approach

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This special report provides a description of neighborhood change in the four largest cities of the Fourth Federal Reserve District, Cincinnati, Cleveland, and Columbus, Ohio, and Pittsburgh, Pennsylvania, from 1970 to 2010. The analysis relies on a statistical method of categorizing neighborhoods into a typology that is based on various quantitative characteristics of the residents and the housing stock. The typology captures the distribution of neighborhood types found in each city and provides a way to track how those neighborhoods have changed. Multiple variables are used to create each typology based upon the belief that urban neighborhoods are composites of many factors and that the methods used to study them should reflect that. In general, this analysis shows that from 1970 to 2010, most neighborhoods tended to remain the same from decade to decade. However, the overall rate of neighborhood change has increased in all four of the cities studied during the past two decades, with Cincinnati and Pittsburgh experiencing the greatest change from the 1990s to the 2000s.

Every strategy to foster any type of neighborhood change is a based upon assumptions about local conditions. It is difficult to develop an effective strategy either to move the housing market or mitigate its effects unless one understands the neighborhood's market conditions and dynamics. Without that information, many neighborhood strategies are little more than guesswork.

—Alan Mallach, "Managing Neighborhood Change"

This special report provides a historical account of neighborhood change in the four largest cities of the Fourth Federal Reserve District, Cincinnati, Cleveland, and Columbus, Ohio, and Pittsburgh, Pennsylvania. To do so, this analysis creates a separate typology of neighborhoods for each city using demographic and housing information to establish local neighborhood conditions at the census tract level. The typologies capture the distribution of neighborhood types found in each city and serve as a way to signify when a neighborhood is changing. Each typology is created using 20 variables for the years 1970, 1980, 1990, 2000, and 2010, allowing one to see how neighborhoods have changed during that 40-year period.

This report is written with the intention of pursuing two main objectives. The first objective is to gain a better understanding of neighborhood conditions and change in each city from 1970 to 2010. This analysis provides a quantitative method of organizing many of the positive and negative stories one hears regarding neighborhoods and neighborhood change. The second objective is to promote multivariate statistical methods as a way to measure or identify neighborhood conditions. Urban scholar George Galster likens neighborhoods to "a bundle of spatially based attributes," a definition which leads some scholars to suggest that "using the change of a single indicator as a proxy for neighborhood transition may neglect other important factors that crucially shape the trajectories of neighborhood change."[1] More simply, neighborhoods are composites of many factors, and the methods used to study them should reflect this.

To better understand neighborhood conditions and change, two key questions are posed for each city:

- How often does the character of a neighborhood change?
- What are the most common types of neighborhood change?

1. Wei and Knox, 2014.

Additional findings and observations outside of these questions are also presented. In general, this analysis shows that from 1970 to 2010, most neighborhoods tended to remain stable from decade to decade. However, the overall rate of neighborhood change has increased in all four of the cities studied during the past two decades, with Cincinnati and Pittsburgh experiencing the greatest change from the 1990s to the 2000s. Interestingly, though, Cleveland has the highest number of gentrifying[2] neighborhoods in the 2000s. The most common type of neighborhood change found in three of the four cities studied was neighborhood churning, or when some aspect of the neighborhood's demographic composition changed but the household income and home values remain at similar points in the city's distribution.

This document is organized as a summary of the methodology and findings followed by profiles of each of the cities. The summary first describes the different types of neighborhood change and the simple framework used to identify neighborhood change. It then briefly describes the methodology and data used to create each neighborhood typology[3] and ends with a discussion of trends and unifying themes across the four cities. The city profiles contain in-depth examinations of neighborhood change in Cincinnati, Cleveland, Columbus, and Pittsburgh. Each city profile begins with a description of the city's neighborhood typology. The 2010 composition of neighborhoods is noted along with how that composition has changed since 1970. Citywide neighborhood change rates by decade are then presented, followed by individual neighborhood change rates by typology. Finally, a series of maps is presented to illustrate spatially how neighborhoods have changed from 1970 to 2010.

A Framework for Neighborhood Change

The core of this analysis looks at the frequency at which neighborhoods change from one type of neighborhood to a different type of neighborhood within each city's typology during the course of a decade. In this framework, there are five potential outcomes for a neighborhood in a ten-year period:

- **No change:** remains the same type of neighborhood
- **Incumbent upgrading:** retains its demographic character but sees home values and household income levels increase
- **Churning:** retains its home value and household income levels while experiencing demographic changes
- **Declining:** experiences declines in home values and household income levels

2. It should also be noted that any evidence highlighted as consistent with gentrification is just that. Technically, for any neighborhood change to be considered "gentrification," displacement must be shown in addition to a changing neighborhood character. However, because this analysis does not include displacement, gentrification is not identified.
3. Additional methodological details related to data transformation, choosing the number of neighborhood types, and grouping interpretation can be found in the technical appendix.

- **Gentrifying:** experiences demographic changes and increasing home value and household income levels

Because of missing data points, a sixth outcome of "Not applicable" (NA) is possible, as residential development along with mixed-use zoning practices have expanded into many formerly nonresidential areas during the past 40 years, creating gaps in the dataset.

Methodology and Data

To study changes in neighborhoods, we first develop a limited number of neighborhood types and use this typology to classify the neighborhoods of each city. There are numerous methodological approaches at our disposal for this purpose. Several studies (Goldstein, 2012; Mikelbank, 2011; Owens, 2012; Wei and Knox, 2014; Delmelle, 2015) use multivariate techniques to create neighborhood typologies in order to study neighborhood conditions. The novel thing about using multivariate methods to produce neighborhood typologies is that the approach relies for classification on where a neighborhood lies within the overall city distribution, a method which allows for better comparisons over time.

To create a typology of neighborhoods in Cincinnati, Cleveland, Columbus, and Pittsburgh, this analysis uses cluster analysis to group together statistically neighborhoods with common collective characteristics. Next, discriminant analysis is employed to validate the differences between groupings statistically and to help develop descriptions of neighborhoods. This analysis follows steps laid out in Hill, Brennan, and Wolman (1998) that "develop[ed] techniques to minimize the role of judgment in selecting the appropriate cluster solution."[4]

Despite following previous literature closely, we employed some necessary deviations in completing our analysis. First, rather than using a single typology for all four cities, a typology is created for each city. Attempts to use a single typology for all four cities produced results that did not depict qualitative observations accurately across cities. This issue is further addressed in the discussion section below and highlights the importance of local knowledge when doing this type of work. Second, this analysis uses census tracts as a proxy for a neighborhood, and we focus on only those in the central city for the current study.

Data are from the Neighborhood Change Database, which has consistent geographic boundaries from 1970, 1980, 1990, 2000, and 2010, allowing for a historical look at neighborhood change. Twenty variables were chosen to develop the neighborhood typology for each city. Those variables are listed in table 1 and are meant to capture the household structure, racial composition, housing stock, socioeconomic status, and resident tenure of a neighborhood. These 20 variables allow

4. See the technical appendix for additional information on selecting the number of and validation of clusters for each city.

Table 1. Variables used to create neighborhood typologies

Household Structure
% of households that are married families with children
% of households that are single female with children
% of households that are nonfamily
Race
% African American
% White
Housing Stock
Average owner-occupied home value ($)
% of units that are owner occupied
% of units that are single-family attached
% of units that are single-family detached
% of units that are doubles
% of units that are 3 to 4 units
% of units that are 5+ units
Socioeconomic
% of adults without a GED
% of adults with only a high school diploma/GED
% of adults with some college
% of adults with a bachelor's degree
% of high-school-aged youth not in high school
Average household income ($)
% of population in poverty
Tenure
% of people living in the same house as they did 5 years ago

one to tease out nuanced differences between neighborhoods that help to illuminate neighborhood change in Cincinnati, Cleveland, Columbus, and Pittsburgh during the past 40 years.

As with any analysis, there are a few caveats worth mentioning. First, some may say a census tract might be the wrong geographical unit by which to study neighborhood change. A case could be made that neighborhoods change at even smaller geographies than a census tract, for example, a block or even a street corner. Conversely, many of the local neighborhood designations in each of these four cities consist of several contiguous census tracts. In light of these considerations, analysis at the census tract level seems appropriate, especially given the richness of the data in the Neighborhood Change Database. Relatedly, the dataset consists of data for 1970, 1980, 1990, 2000, and 2010, data points that force the analysis to consider neighborhood change during 10-year periods. It also means that this analysis is largely an after-the-fact exercise, or backward, rather than forward, looking.

The second caveat involves the naming convention used to label each neighborhood type. Naming is simply a way to condense the dominant trends found in a neighborhood and to differentiate neighborhood types from one another. Important to note, however, is that such naming does not prevent those groups outside the label description from living in certain areas. For example, if a neighborhood is designated as a "nonfamily middle income" neighborhood, that designation does not mean that individuals from only that demographic reside in that neighborhood. It does not preclude an "African American low income family," for instance, from living there, as well. The name offers the primary demographic designation that is itself not all encompassing. Moreover, there are examples of where most but not all of the dominant trends align with the typology assigned to an area. A good example of this is the Hough neighborhood in Cleveland, Ohio: Census tract 1128 is classified as "white upper-middle income owner occupied" because even though the neighborhood is 93 percent African American in 2010, household income, home values, home ownership rates, and educational attainment are similar to neighborhoods on the near-west side of Cleveland. This caveat clearly reinforces the importance of qualitative information when doing this type of work. Accordingly, these cluster descriptions were vetted with local practitioners to ensure accuracy. A table with 2010 mean values for several variables according to the neighborhood typology is included in each city section to help aid in differentiating between neighborhood types.

The third caveat to this analysis is that it considers only three racial designations for a neighborhood: white, African American, and mixed. This decision is the result of incorporating only two racial composition measures (percent white and percent African American) into the clustering procedure used to produce each neighborhood typology. Collectively, the two racial groups account for greater than 90 percent of the population found in the average census tract in each city. Importantly, this analysis found that the racial composition of a census tract was a primary factor for how neighborhoods sorted into groups.

The fourth caveat to this work is that some neighborhoods are classified as "outliers," and subsequent neighborhood changes involving these neighborhoods are considered NA. Combining all years and cities, outliers account for 2.3 percent of census tracts, while NA neighborhood changes account for 2.7 percent of all neighborhood outcomes. This result happens for two main reasons. First, there are issues related to data availability, as noted above. Second, extreme statistical outliers cannot be classified into a neighborhood typology because they have values that are +/- 5 standard deviations away from the mean, translating into the 0.0001 percentile or the 99.9999 percentile.

Six Key Findings

This section discusses several observations and trends related to neighborhood change across the cities of Cincinnati, Cleveland, Columbus, and Pittsburgh. The analysis produced a number of findings. Each of these is examined in turn.

Each city has its own unique set of neighborhoods

Initial attempts to produce a singular typology of neighborhoods across all four cities failed to reproduce qualitative on-the-ground observations of these neighborhoods. Using a singular typology across all four cities most often mislabeled the racial composition of a neighborhood. This mischaracterization is likely caused by a step in the methodology that requires the computation of a standardization (or z-score) at the city level of all variables across all years. This step is necessary in order to compare a city to itself across time, but it makes comparison across cities difficult because variables are relative to each city. For example, in 2010, the African American population in the average Cleveland neighborhood is roughly 60 percent, whereas the average for Pittsburgh's neighborhoods is about 30 percent African American. Standardizing a variable puts it into a form that is relative to the city average. Operationally, a neighborhood in Cleveland could be 80 percent African American with a z-score of 1.7, whereas a neighborhood in Pittsburgh could have the same z-score with only 45 percent of the population as African American. Although these are quite different neighborhoods, they would be grouped similarly because of the z-scores. A unique typology was thus created for each city in this analysis in order to avoid potential mischaracterization.

Despite each city's having a unique set of neighborhoods, cities do have some neighborhood types in common. Table 2 presents each city's neighborhood typology and its 2010 share of city neighborhoods according to income level. Each city has an African American low-income neighborhood and a low-income neighborhood, yet in 2010, they account within each city for vastly different shares of the city's neighborhoods. In Cleveland, African American low-income neighborhoods account for 35.2 percent of city neighborhoods compared to 0.7 percent in Pittsburgh. Low-income neighborhoods account for 19.1 percent of Pittsburgh neighborhoods compared to 2.8 percent in Cleveland.

The distribution of neighborhoods is also somewhat different across income groups for each city. Table 3 presents the share of each city's neighborhoods according to a low-, middle-, or high-income neighborhood label. Low-income neighborhoods of various types account for almost 50 percent of neighborhoods in Cleveland and Columbus, compared to 27.9 percent in Pittsburgh and 20.7 percent in Cincinnati. The opposite is true for middle-income neighborhoods, with 61.3 percent of Cincinnati and 49.3 percent of Pittsburgh middle income. In terms of high-income neighborhoods, Columbus stands out among the four cities at 23.3 percent compared to the lower teens for the other three.

Table 2. City neighborhood typologies and the share of city census tracts, 2010

	Cincinnati (% of tracts)	Cleveland (% of tracts)	Columbus (% of tracts)	Pittsburgh (% of tracts)
Low income (less than 80% of city average household income)	African American very low income (2.7)	African American very low income (5.7)		
	African American low income (9.9)	African American low income (35.2)	African American low income (26.7)	African American low income (0.7)
	Low income (8.1)	Low income (2.8)	Low income (16.5)	Low income (19.1)
		Low income rental (5.1)		
			White nonfamily low income (6.3)	
				African American low income rental (8.1)
Middle income (80% to 130% of city average household income)	African American middle income (18.0)	African American middle income (5.1)		
	Middle income (18.9)			
	Middle income owner occupied (9.0)			
	Middle income rental (2.7)			
	Nonfamily middle income (12.6)			
				Nonfamily middle income (13.2)
		White middle income (18.2)	White middle income (21.8)	
		White upper-middle income owner-occupied (9.1)		
		White upper-middle income rental (5.1)		
				White lower-middle income (11.0)
				White nonfamily middle income (5.1)
				White family middle income (18.4)
				Nonfamily upper-middle income (1.5)
High income (greater than 130% of city average household income)	White nonfamily high income (8.1)			White nonfamily high income (8.1)
	White family high income (4.5)			White family high income (5.1)
		White high income (10.8)	White high income (23.3)	

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Table 3. Share of neighborhoods according to typology income designations, 2010

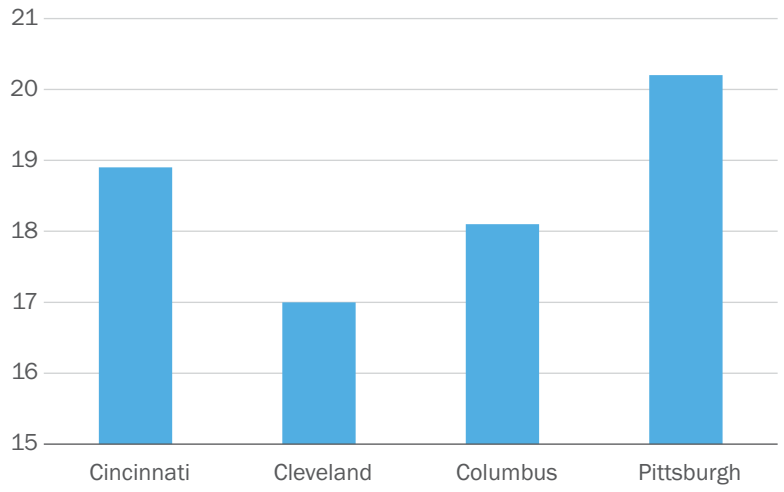
	CIN	CLE	COL	PIT
Low income (less than 80% of city average household income)	20.7	48.9	49.5	27.9
Middle income (80% to 130% of city average household income	61.3	37.5	21.8	49.3
High income (greater than 130% of city average household income)	12.6	10.8	23.3	13.2
Outlier	5.4	2.8	5.3	9.6

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Most neighborhoods do not change

In all four cities, a majority (80 percent) of the neighborhoods experienced no change from decade to decade during the past 40 years. Figure 1 presents the aggregate neighborhood change rate for each city from 1970 to 2010. The neighborhood change rate is the share of neighborhoods that started a decade as one type of neighborhood and ended that decade as another type of neighborhood. Pittsburgh has the highest rate of neighborhood change at 20.2 percent, and Cleveland has the lowest at 17.0 percent. This finding that neighborhoods do not change most of the time is similar to results found in Wei and Knox (2014).

Figure 1. Neighborhood change rates, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Individual neighborhood change rates indicate neighborhoods of stability and change

Neighborhood change can be better understood by looking at the transition rates by neighborhood types. Table 4 shows the neighborhood types with the highest and lowest neighborhood change rates during the past 40 years. The neighborhoods with the lowest rates can be thought of as stable neighborhoods, while those with the highest rates of change are more likely to transition to another neighborhood type. Interestingly, in Cincinnati and Pittsburgh, white high-income neighborhoods are most stable, while the most stable neighborhoods in Cleveland and Columbus are African American low-income neighborhoods. The income levels of those neighborhoods that are most likely to change are also noteworthy in that they, too, differ across the four metro areas. Low-income neighborhoods are most likely to change in Pittsburgh and Cleveland, whereas it is white high-income neighborhoods in Columbus and middle-income neighborhoods in Cincinnati that are most likely to change.

Table 4. Neighborhood type with highest and lowest change rates by city, 1970–2010

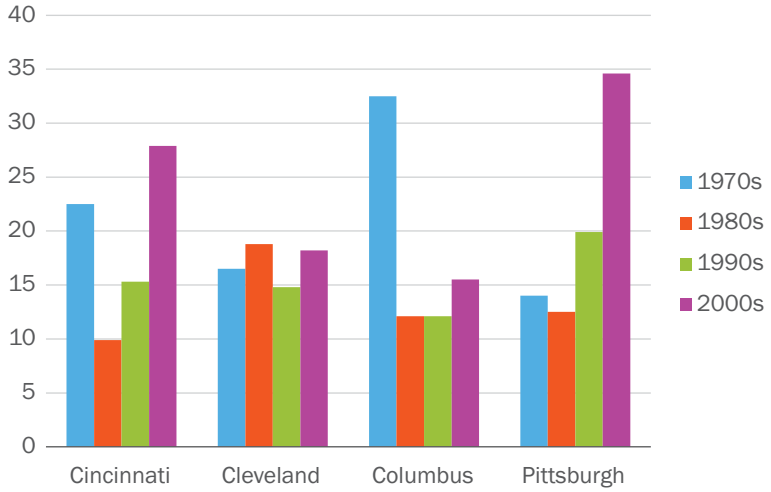
City	Highest change group (%)	Lowest change group (%)
Cincinnati	Middle income rental (41.3)	White family and nonfamily high income (0)
Cleveland	Low income (34.1)	African American low income (3.6)
Columbus	White high income (24.0)	African American low income (8.8)
Pittsburgh	African American low income (30.4)	White nonfamily high income (8.0)

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Neighborhood change has picked up in all cities during the 2000s

Despite having very similar overall rates of neighborhood change, breaking the change rates down by decade provides some additional information. Figure 2 presents the neighborhood change rate for each city across the four decades. Neighborhood change rates have increased in all cities during the 2000s, but to varying degrees. In Cincinnati and Pittsburgh, neighborhood change rates are up almost 15 percentage points. Conversely, neighborhood change rates in Cleveland and Columbus are up from the 1990s, but only by 3 percentage points to 4 percentage points. Columbus had a flurry of neighborhood change during the 1970s: 32.5 percent of the tracts changed from one neighborhood type to another. Cleveland's rate of neighborhood change has been the most consistent during the 40-year period.

Figure 2. Neighborhood change rate by city and decade

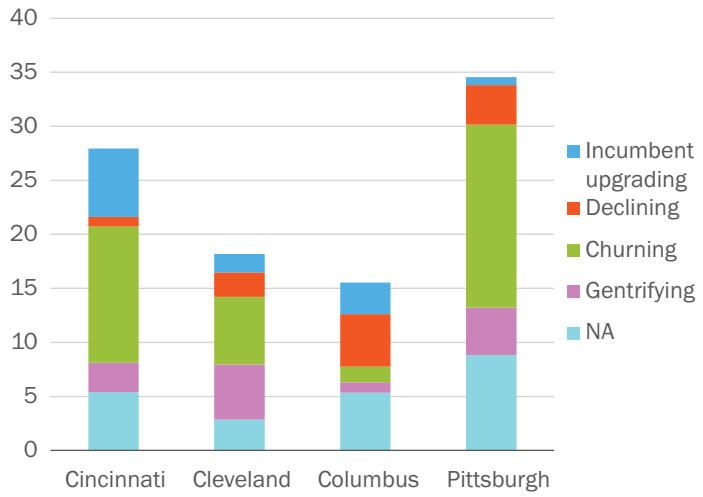


Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Churning is the most common type of neighborhood change found in three of the four cities during the 2000s

Breaking down each city's neighborhood change rate into different types of neighborhood change illustrates the most common type of neighborhood change found in each city. Figure 3 shows that during the 2000s, the most common neighborhood change in Cincinnati, Cleveland, and Pittsburgh is churning. Alternatively, the most common type of neighborhood change in Columbus during the 2000s is declining and NA. Surprisingly, declining neighborhoods are more common than gentrifying neighborhoods in Columbus and Pittsburgh during the 2000s. Across all four cities, gentrifying neighborhoods account for 14.1 percent of all neighborhood change during the 2000s but only 3.1 percent of all neighborhood outcomes.

Figure 3. Neighborhood change rates, 2000s



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Neighborhood changes during the last 40 years are consistent with a lack of affordable housing for low-income populations

Even though gentrification comprises a small share of neighborhood outcomes, declines in low-income neighborhoods across the four cities are suggestive of a lack of affordable housing. Table 5 shows the share of low-income city neighborhoods that has declined in each city. Cincinnati had the largest decline of low-income neighborhoods at 22.5 percentage points, followed by Pittsburgh, Columbus, and Cleveland. While some may view the decline of low-income neighborhoods as a sign that the country is winning the war on poverty, this perspective fails to recognize that low-income populations need somewhere to live, and that place is often in cities because of the location of social service organizations and public transportation, as noted by Glaeser, Kahn, and Rappaport (2008).

Table 5. Declining share of low-income neighborhoods by city, 1970–2010

City	Neighborhood type(s)	Change in city share from 1970 to 2010 (ppts)
Cincinnati	African American low income; low income	–22.5
Cleveland	African American very low income; low income	–7.5
Columbus	Low income	–10.0
Pittsburgh	African American low income; African American low income rental	–13.9

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Summary

This analysis shows that using multivariate methods can be informative for studying neighborhood change. These methods have proven useful in developing unique neighborhood typologies for Cincinnati, Cleveland, Columbus, and Pittsburgh. Ultimately, while most neighborhoods do not change during a 10-year period, the 2000s saw the rate of neighborhood change increase in all four cities. In terms of the most common type of neighborhood change, churning has been the most common in Cincinnati, Cleveland, and Pittsburgh. However, neighborhood changes during the past 40 years are consistent with a lack of affordable housing, especially for low-income populations. While neighborhood changes that are consistent with gentrification have increased in Cleveland and Pittsburgh during the 2000s, these changes account for less than 5 percent of all neighborhood outcomes. Finally, the typologies developed for each city provide policymakers with a 40-year history of neighborhood change that can inform a wide variety of policy questions.

Cincinnati

The composition of Cincinnati neighborhoods in 2010 is presented below along with the change in this composition since 1970. Citywide neighborhood change rates by decade are also presented along with individual neighborhood change rates by typology. Finally, a series of maps is presented to spatially illustrate the neighborhood typology and neighborhood change from 1970 to 2010.

Neighborhood Typology

Cincinnati includes 10 different types of neighborhoods, excluding outliers,[5] from 1970 to 2010. Table 1-CIN provides the 2010 mean value for a series of variables by neighborhood type and aids in developing the following descriptions of each type of neighborhood (see technical appendix for additional information). Please note that these descriptions are relative to the city of Cincinnati only and not to the entire metropolitan statistical area. Income designations follow the general guidelines of the following: "low income" equals 80 percent or less of city average household income (CAHI); "middle income" equals 80 to 130 percent of CAHI; and "high income" equals 130 percent or higher of CAHI.

- African American very low income: predominately African American, well-above-average share of households comprising single females with children, above-average share of rental units, above-average share of single attached housing, well-below-average home value and household income levels, well-above-average poverty rates
- African American low income: predominately African American, above-average share of housing with 5+ units, above-average poverty rates, below-average home value and household income levels
- Low income: mixed racial composition, above-average share of households comprising single females with children, above-average share of housing as doubles and 3- to 4-unit residences, below-average home values and household income levels, below-average share of college-degreed adults, below-average resident tenure

5. Outliers are not placed into a neighborhood type because they have either missing data points or values that are +/- 5 standard deviations away from the mean, translating into the 0.0001 percentile or the 99.9999 percentile.

- African American middle income: majority African American, above-average share of households comprising single females with children, average home value and household income levels
- Middle income: mixed racial composition, above-average share of single-family detached housing, average home values and household income levels. Middle income rental: mixed racial composition, above-average share of rental housing with 5+ units, average home values and household income levels
- Middle income, owner occupied: mixed racial composition, above-average share of households comprising married couples with children, above-average share of owner-occupied single-family homes, average home values and household income levels
- Nonfamily middle income: mixed racial composition, above-average share of nonfamily households, above-average share of rental housing with 5+ units, above-average share of college-degreed adults, below-average resident tenure
- White nonfamily high income: predominately white, above-average share of nonfamily households, well-above-average home value and household income levels, above-average share of college-degreed adults
- White family high income: predominately white, above-average share of married couples with children, above-average share of owner-occupied single-family homes, well-above-average home value and household income levels, above-average share of college-degreed adults, above-average resident tenure

It is important to note that the typology created for a neighborhood simply describes the dominant trends in that neighborhood and does not mean that every individual living in the neighborhood will share these dominant characteristics.[6]

6. See the "Framework for Neighborhood Change" section above for additional information.

Table 1-Cin. 2010 averages for selected variables by neighborhood type

2010 Averages	African American very low income	African American low income	Low income	African American middle income	Middle income	Middle income rental	Middle income owner occupied	Non-family middle income	White non-family high income	White family high income	City average
Population	2,545	2,083	2,239	3,029	3,177	4,727	3,218	2,340	2,786	3,156	2,795
% White	7.6	14.5	68.0	24.6	60.1	46.0	65.8	62.7	81.5	94.2	50.6
% African American	90.4	84.0	27.5	72.5	36.9	49.8	31.4	29.4	13.5	2.1	45.7
% Owner occupied	9.6	12.7	26.9	29.7	45.1	23.4	62.6	18.1	40.7	69.2	33.4
% Rental	63.7	45.2	45.0	47.2	38.6	62.2	28.4	57.0	46.6	22.0	44.7
% Vacant	26.6	42.1	28.1	23.1	16.3	14.4	9.0	24.8	12.7	8.8	21.9
% Households married with kids	2.9	2.9	9.4	7.0	10.8	9.5	14.0	3.3	8.0	21.2	8.2
% Households single female with kids	43.3	18.4	19.8	22.6	10.2	10.0	8.4	4.5	4.0	2.6	13.8
% Nonfamily households	33.7	57.9	42.3	44.6	50.8	53.1	39.8	75.4	64.6	44.1	52.4
% Single-family dettached	13.8	16.5	41.0	42.9	50.4	25.8	68.8	17.5	34.7	73.2	38.9
5+ Units	39.5	47.3	19.1	31.1	24.4	56.0	12.3	50.5	35.9	11.9	32.9
Average home value ($)	87,273	129,172	90,642	106,614	149,958	78,965	129,571	174,941	328,321	442,422	156,610
Household income ($)	19,674	29,792	34,101	38,769	55,067	43,486	55,681	41,574	84,883	146,568	50,815
% Poverty	67.0	48.3	40.6	31.4	18.4	18.0	12.8	36.0	13.8	4.2	29.2
% No GED	27.0	21.4	26.5	18.3	9.1	8.4	9.8	9.3	4.3	1.5	13.8
% Some college	20.8	18.2	15.2	24.2	20.2	19.1	23.5	16.9	14.9	9.5	19.3
% Bachelor's degree	6.9	14.1	9.1	12.7	33.1	19.4	24.5	46.9	59.2	77.0	29.0
% Same house 5 years ago	78.3	73.5	64.4	76.0	78.0	70.4	86.2	60.2	76.8	86.3	74.8

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Neighborhood Composition

Table 2-CIN lists the share of Cincinnati census tracts according to the neighborhood typology in 2010, the difference in neighborhood shares from 1970 to 2010, and the difference in shares from 2000 to 2010. Interestingly, the various types of middle-income neighborhoods collectively account for slightly more than 60 percent of 2010 census tracts found in Cincinnati. In 2010, African American middle-income and middle-income neighborhoods each account for the largest shares of Cincinnati neighborhoods at roughly 18.5 percent.

Table 2-CIN. Share of city neighborhoods by neighborhood type, 2010

Cluster description	2010	1970 to 2010	2000 to 2010
African American very low income	2.7	0.9	–1.8
African American low income	9.9	–8.1	–3.6
Low income	8.1	–14.4	–5.4
African American middle income	18.0	10.8	8.1
Middle income	18.9	9.0	1.8
Middle income rental	2.7	–12.6	–3.6
Middle income owner occupied	9.0	–3.6	–1.8
Nonfamily middle income	12.6	6.3	0.9
White nonfamily high income	8.1	5.4	0.9
White family high income	4.5	1.8	0.9
Outlier	5.4	4.5	3.6

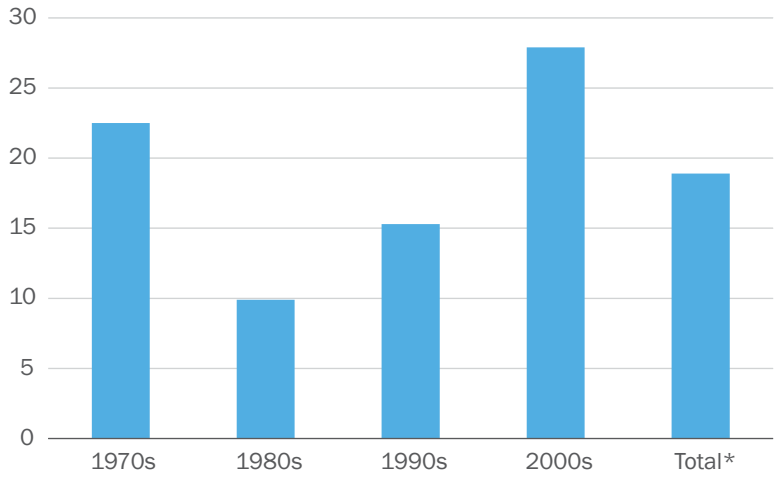
Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

In terms of changes to Cincinnati's neighborhood composition from 1970 to 2010, the share of African American middle-income and middle-income neighborhoods increased 10.8 percentage points and 9.0 percentage points, respectively. African American middle-income neighborhoods experienced most of these gains after 2000, whereas most of the increases in middle-income neighborhoods took place prior to 2000. Nonfamily middle-income and nonfamily upper-income neighborhoods also saw their shares of Cincinnati's neighborhoods increase, but most of those increases took place prior to 2000. Conversely, low-income, middle-income rental, and African American low-income neighborhoods declined 14.4, 12.6, and 8.1 percentage points, respectively, from 1970 to 2010. Most of the declines in low- and middle-income neighborhoods took place prior to 2000, whereas declines in African American low-income neighborhoods are roughly split between the pre- and post-2000 period.

Neighborhood Change

Neighborhood change can be better understood by looking at how frequently a transition between neighborhood types occurs. Figure 1-CIN charts the overall neighborhood change rate for Cincinnati by decade. The neighborhood change rate is the share of neighborhoods that start the decade as one type of neighborhood and end the decade as another type of neighborhood. The 2000s had the highest rate of neighborhood change at 27.9 percent of neighborhoods, followed by 22.5 percent in the 1970s. The 1980s marked the lowest rate of neighborhood change, at just 9.9 percent. However, it appears that neighborhood change in Cincinnati may be cyclical, as the rate of neighborhood change steadily increases in the 1990s and 2000s. Overall, Cincinnati's neighborhoods have been largely similar, with just 18.9 percent of all neighborhoods changing during the 40-year span included in this study.

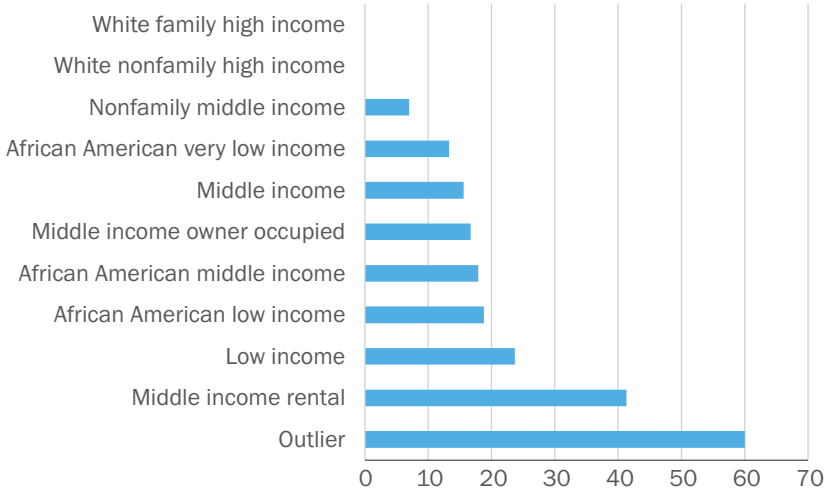
Figure 1-CIN. Neighborhood change rate by decade, 1970–2010



*Total refers to the aggregate neighborhood change for all four decades.
Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

As indicated above, across all decades, most neighborhoods do not change. Breaking down the neighborhood change rates into transitions from one type of neighborhood to another allows one to observe some additional nuances. It shows that not all neighborhood types change at the same rate. Figure 2-CIN presents the rate at which specific neighborhoods change from one decade to the next for the period of 1970 to 2010. White nonfamily high-income and white family high-income neighborhoods did not change into other neighborhood types during this time period. Nonfamily middle-income neighborhoods also showed very low rates of change, remaining the same neighborhood type 93 percent of the time. On the other hand, middle-income rental neighborhoods experienced the most change, ending the decade with a different neighborhood designation 41.3 percent of the time.

Figure 2-CIN. Neighborhood change rates by neighborhood type, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Further classifying each neighborhood transition into the different types of neighborhood change provides additional insight. Table 3-CIN presents a breakdown of all neighborhood transitions by neighborhood change type. During the four decades, churning has generally been the most common type of neighborhood change experienced in Cincinnati, while incumbent upgrading transitions have been more common than gentrifying neighborhoods. Most recently during the 2000s, churning and incumbent upgrading neighborhood changes have been the most common, accounting for 45.2 and 22.6 percent, respectively.

Table 3-CIN. Neighborhood change breakdown in Cincinnati, 1970–2010

Type of Neighborhood Change	1970s	1980s	1990s	2000s
Incumbent upgrading	20.0	0.0	35.3	22.6
Declining	12.0	9.1	11.8	3.2
Churning	40.0	54.5	17.6	45.2
Gentrifying	20.0	36.4	17.6	9.7
NA	8.0	0.0	17.6	19.4
Neighborhood change rate	22.5	9.9	15.3	27.9

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Table 4-CIN lists the seven most common neighborhood transition combinations found in Cincinnati, in what decades those changes took place, and the types of neighborhood change. The most common neighborhood transition combinations tend to involve various types of middle-income neighborhoods, especially those that are rental. The most common transition during the past 40 years took place during the 2000s, when four middle-income rental neighborhoods transitioned to middle-income neighborhoods. Again, the most common neighborhood transitions fall into the churning category of neighborhood change.

Table 4-CIN. Most frequent neighborhood transition combinations in Cincinnati, 1970–2010

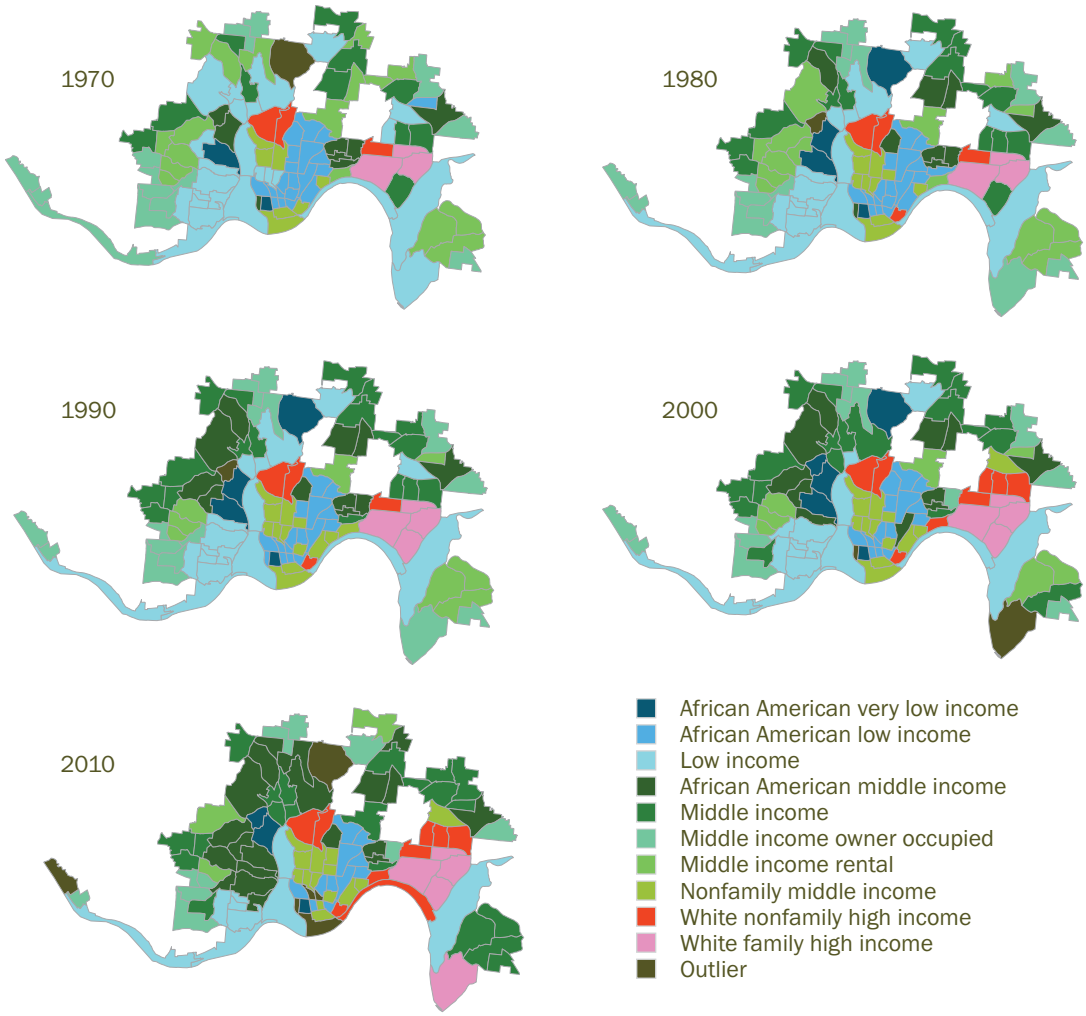
Initial neighborhood type	New neighborhood type	Decade	Transition	Count
Middle income rental	Middle income	2000s	Churning	4
Low income	Nonfamily middle income	1970s	Gentrifying	3
Middle income rental	Middle income	1970s	Churning	3
Middle income rental	African American middle income	1980s	Churning	3
Middle income	White nonfamily high income	1990s	Gentrifying	3
Low income	African American middle income	2000s	Incumbent upgrading	3
Middle income	African American middle income	2000s	Churning	3

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Mapping Neighborhoods and Neighborhood Change

The following series of maps illustrates the spatial aspect of neighborhood change within Cincinnati. Figure 3-CIN depicts Cincinnati's neighborhood typology by decade. First, the increase in both African American middle-income and nonfamily middle-income neighborhoods is apparent in the series of maps. African American middle-income neighborhoods are prevalent on Cincinnati's north and west sides in 2010, whereas nonfamily middle-income neighborhoods have emerged in the urban core of Cincinnati. Second, the shrinking number of low-income neighborhoods is on display. African American low-income neighborhoods in the urban core and low-income neighborhoods on the west side of Cincinnati are less prevalent in 2010 than they are in 1970.

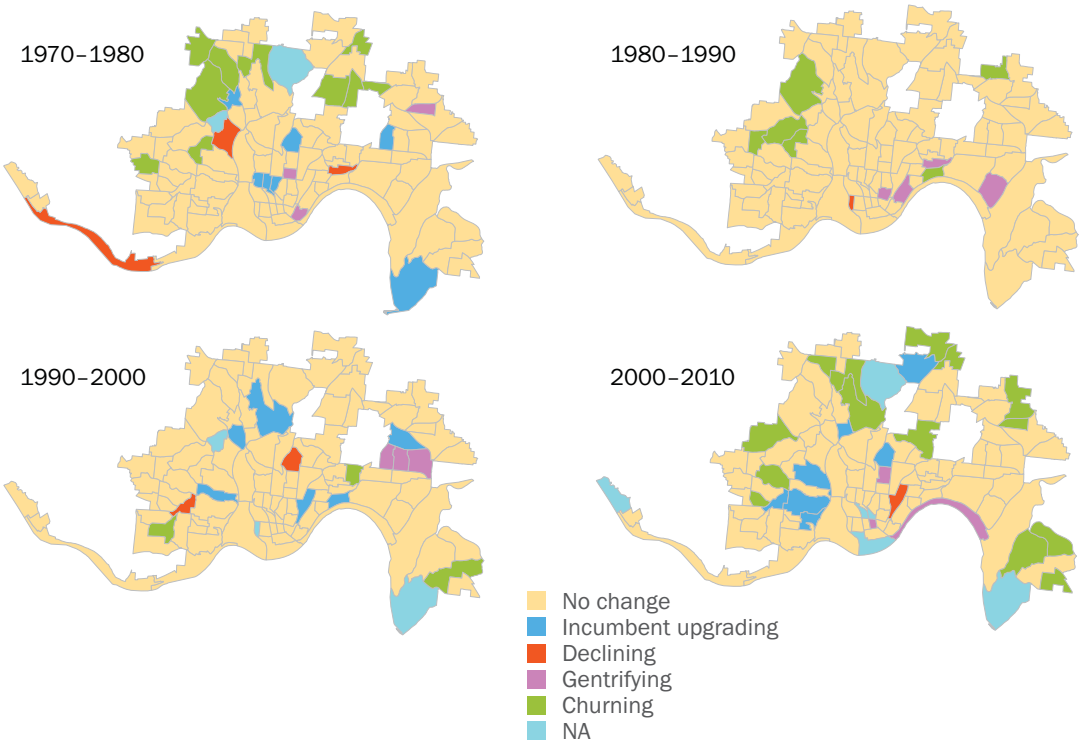
Figure 3-CIN. Neighborhood typologies in Cincinnati, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Mapping the different types of neighborhood change reveals where most of the change took place. Figure 4-CIN depicts maps of Cincinnati's neighborhood change by decade. Generally speaking, the majority of the neighborhood changes took place on the periphery of the city. While most of the neighborhood changes on the periphery can be classified as churning neighborhoods, those neighborhood changes taking place closer to the urban core tended to be gentrifying neighborhoods. Relatedly, neighborhoods experiencing incumbent upgrading are generally found in between the urban core and the city's edge.

Figure 4-CIN. Neighborhood change in Cincinnati, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Summary

Overall, most neighborhoods in Cincinnati retain the same character, income, and home price levels over time. However, some neighborhoods did change during the past 40 years, and the rate at which neighborhoods have been changing has increased markedly during the 2000s. These changes have led to a compositional change in Cincinnati's neighborhoods, as the share of low-income neighborhoods has declined while the share of middle-income neighborhoods has increased. Despite this, the most common type of neighborhood change found in Cincinnati since 1970 has been a churning of middle-income neighborhoods.

Cleveland

The composition of Cleveland neighborhoods in 2010 is presented below along with the change in this composition since 1970. Citywide neighborhood change rates by decade are also presented along with individual neighborhood change rates by typology. Finally, a series of maps is presented to spatially illustrate the neighborhood typology and neighborhood change from 1970 to 2010.

Neighborhood Typology

Nine different types of neighborhoods, excluding outliers,[7] are found in Cleveland from 1970 to 2010. Table 1-CLE provides the 2010 mean value for a series of variables by neighborhood type and aids in developing the following descriptions of each type of neighborhood (see technical appendix for additional information). Please note that these descriptions are relative to the city of Cleveland only and not to the entire metropolitan statistical area. Income designations follow the general guidelines of the following: "low income" equals 80 percent or less of city average household income (CAHI); "middle income" equals 80 to 130 percent of CAHI; and "high income" equals 130 percent or higher of CAHI.

- African American very low income: predominately African American, above-average share of rental housing with 5+ units, well-below-average home values and household income levels, above-average rates of poverty
- African American low income: predominately African American, above-average share of households comprising single females with children, below-average home values and household income levels
- Low income: mixed racial composition, above-average share of households comprising single females with children, above-average share of doubles and 3- to 4-unit residences, below-average home values and household income levels

7. Outliers are not placed into a neighborhood type because they have either missing data points or values that are +/- 5 standard deviations away from the mean, translating into the 0.0001 percentile or the 99.9999 percentile.

- Low income rental: mixed racial composition, above-average share of non-family households, above-average share of rental housing with 5+ units, above-average rates of poverty, below-average home values and household income levels, below-average resident tenure
- African American middle income: predominately African American, above-average rates of owner-occupied single-family housing, average home values and household income levels, above-average rates of adults with some college, above-average resident tenure
- White middle income: majority white, above-average share of households comprising married couples with children, above-average share of doubles and 3- to 4-unit residences, average home values and household income levels
- White upper-middle income owner occupied: majority white, above-average rates of owner-occupied housing, above-average home values and household income levels, below-average rates of poverty
- White upper-middle income rental: majority white, above-average share of nonfamily households, above-average share of rental housing with 5+ units, above-average home and household income levels, well-above-average rates of college-degreed adults, below-average resident tenure
- White high income: predominately white, above-average share of households comprising married couples with children, above-average rates of owner-occupied single-family housing, well-above-average home values and household income levels, below-average rates of poverty, above-average rates of college-degreed adults, above-average resident tenure

It is important to note that the typology created for a neighborhood simply describes the dominant trends in that neighborhood and does not mean that every individual living in the neighborhood will share these dominant characteristics.[8]

8. See the "Framework for Neighborhood Change" section above for additional information.

Table 1-CLE. 2010 averages for selected variables by neighborhood type

2010 Averages	African American very low income	African American low income	Low income	Low income rental	African American middle income	White middle income	White up-per-middle income owner occupied	White upper middle income rental	White high income	City average
Population	2,111	1,888	1,896	1,902	2,511	2,454	2,479	2,812	3,183	2,256
% White	5.7	5.9	49.0	45.6	1.5	53.7	55.0	55.5	80.0	32.9
% African American	92.7	92.8	43.9	44.7	97.6	29.4	35.0	34.1	13.1	60.3
% Owner occupied	16.3	31.4	22.6	16.3	62.3	35.6	45.4	15.8	68.7	36.1
% Rental	62.0	38.9	43.8	67.2	22.3	41.1	39.7	68.3	22.2	41.7
% Vacant	21.8	29.7	33.6	16.5	15.4	23.2	14.9	15.9	9.0	22.2
% Households married with kids	3.2	5.2	7.9	3.7	6.2	10.9	9.9	3.5	14.1	7.4
% Households single female with kids	22.1	27.3	25.0	10.9	18.7	19.2	11.9	3.6	8.7	19.7
% Nonfamily households	52.5	41.0	46.6	68.0	37.1	38.9	48.3	76.1	43.5	45.8
% Single-family dettached	20.1	43.9	32.1	17.8	85.3	49.7	50.8	14.5	77.6	46.1
5+ Units	57.7	10.1	7.2	58.1	9.0	8.3	15.5	60.6	11.7	18.7
Average home value ($)	77,441	75,876	62,250	62,850	86,825	82,553	113,405	127,312	115,780	86,782
Household income ($)	21,500	30,447	30,920	30,601	41,289	33,358	44,036	48,857	52,132	35,455
% Poverty	55.7	36.4	38.0	39.9	18.1	35.6	20.4	28.8	11.6	32.4
% No GED	27.2	20.1	20.9	20.2	14.6	23.2	14.5	10.9	10.7	18.8
% Some college	20.0	22.8	21.8	16.9	29.4	18.7	21.5	16.5	23.6	21.8
% Bachelor's degree	6.8	7.1	10.2	18.1	10.5	7.4	16.4	45.1	18.7	12.1
% Same house 5 years ago	77.2	82.7	77.4	68.2	89.0	80.1	81.9	62.1	88.8	80.6

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Neighborhood Composition

Table 2-CLE lists the share of city census tracts according to the neighborhood typology in 2010, the share difference from 1970 to 2010, and the share difference from 2000 to 2010. African American low-income neighborhoods account for 35.2 percent of Cleveland's neighborhoods, followed by white middle-income, white high-income, and white upper-middle-income owner-occupied neighborhoods at 18.2 percent, 10.8 percent, and 9.1 percent, respectively. Not surprisingly, given Cleveland's persistent poverty problems, almost 50 percent of city census tracts fall into the various types of low-income neighborhoods.

Table 2-CLE. Share of city neighborhoods by neighborhood type, 2010

Cluster description	2010	1970 to 2010	2000 to 2010
African American very low income	5.7	–3.4	–2.3
African American low income	35.2	12.5	1.7
Low income	2.8	–4.0	–1.7
Low income rental	5.1	–0.6	–2.3
African American middle income	5.1	1.1	–1.1
White middle income	18.2	–2.8	2.3
White upper middle income owner occupied	9.1	–7.4	–1.1
White upper middle income rental	5.1	2.8	3.4
White high income	10.8	–0.6	–0.6
Outlier	2.8	2.3	1.7

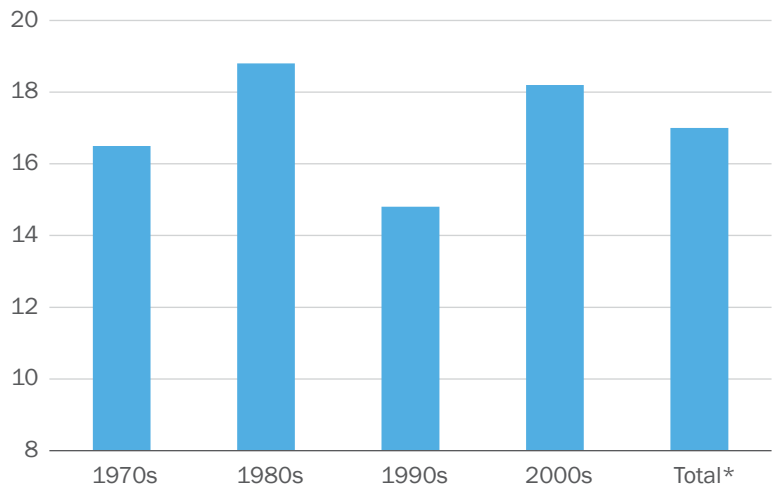
Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Switching to changes in Cleveland's composition of neighborhoods from 1970 to 2010, only three neighborhood types saw their shares increase. African American low-income neighborhoods increased 12.5 percent, while white upper-middle-income rental neighborhoods increased 2.8 percent, and African American middle-income neighborhoods rose 1.1 percent. African American low-income neighborhoods saw most of its share of neighborhoods increase from 1970 to 2000, with only 1.7 percentage points of the 12.5 percentage points added between 2000 and 2010. Interestingly, for white upper-middle-income rental neighborhoods, the opposite is true. Because they accounted for just 1.7 percent of Cleveland's neighborhoods in 2000, from 2000 to 2010, white upper-middle-income rental neighborhoods increased 3.4 percentage points to 5.1 percent. Conversely, white upper-middle-income owner-occupied neighborhoods declined 7.4 percentage points from 1970 to 2010, with only 1.1 percentage points of the decline taking place in the 2000s. Low-income and African American very-low-income neighborhoods also saw their shares decline 4.0 and 3.4 percentage points, respectively.

Neighborhood Change

Neighborhood change can be better understood by looking at how frequently a transition between neighborhood types occurs. Figure 1-CLE charts by decade the neighborhood change rate for Cleveland. The neighborhood change rate is the share of neighborhoods that starts the decade as one type of neighborhood and ends the decade as another type of neighborhood. The 1980s and 2000s had the highest rates of neighborhood change, at 18.8 percent and 18.2 percent, respectively. The 1990s marked the lowest rate of change, with 14.8 percent of neighborhoods changing types. During the past 40 years, the rate of neighborhood change in Cleveland has been relatively stable, with only a 4 percentage point difference between its high during the 1980s and its low in the 1990s. Overall, Cleveland neighborhoods remain the same 83 percent of the time during the 40-year span included in this study.

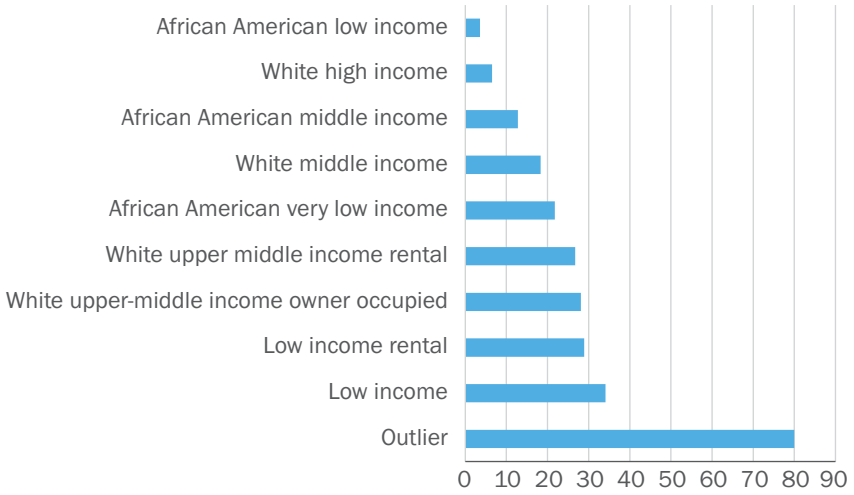
Figure 1-CLE. Neighborhood change rate by decade, 1970–2010



*Total refers to the aggregate neighborhood change for all four decades.
Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

As indicated above, across all decades, most neighborhoods do not change. Breaking down the neighborhood change rates into transitions from one type of neighborhood to another allows one to observe some additional nuances. It shows that not all neighborhood types change at the same rate. Figure 2-CLE presents the rate at which neighborhoods change from one decade to the next for the period of 1970 to 2010. African American low-income neighborhoods tend to change the least, changing just 3.6 percent of the time. White high-income neighborhoods also experience very little change, at 6.5 percent. Low-income neighborhoods change the most frequently, changing to another neighborhood type 34.1 percent of the time during the past 40 years.

Figure 2-CLE. Neighborhood change rates by neighborhood type, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Further classifying each neighborhood transition into the different types of neighborhood change provides additional insight. Table 3-CLE presents a breakdown of all neighborhood transitions by neighborhood change type. Declining neighborhoods have been the most common type of neighborhood change experienced in Cleveland, accounting for 50 percent of all neighborhood changes in the 1990s. However, declining neighborhoods accounted for just 12.5 percent of all neighborhood changes a decade later, as churning became the most common type of neighborhood change. Interestingly, gentrifying neighborhoods in Cleveland accounted for almost 30 percent of neighborhood changes during the 2000s.

Table 3-CLE. Neighborhood change breakdown in Cleveland, 1970–2010

Type of neighborhood change	1970s	1980s	1990s	2000s
Incumbent upgrading	20.7	9.1	7.7	9.4
Declining	37.9	30.3	50.0	12.5
Churning	17.2	21.2	19.2	34.4
Gentrifying	10.3	18.2	7.7	28.1
NA	13.8	21.2	15.4	15.6
Neighborhood change rate	16.5	18.8	14.8	18.2

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Table 4-CLE lists the nine most common neighborhood changes found in Cleveland, the decades in which those changes took place, and the types of neighborhood change. It is clear from this chart that the most common neighborhood change types are consistent with a declining neighborhood. These most frequent neighborhood changes in Cleveland during the past 40 years took place prior to the 2000s. Some evidence of gentrification is apparent in these neighborhood transition rates as neighborhoods changed to white upper-middle-income rental neighborhoods, but this is far from the dominant trend during the 40 years included in this study.

Table 4-CLE. Most frequent neighborhood transition combinations in Cleveland, 1970–2010

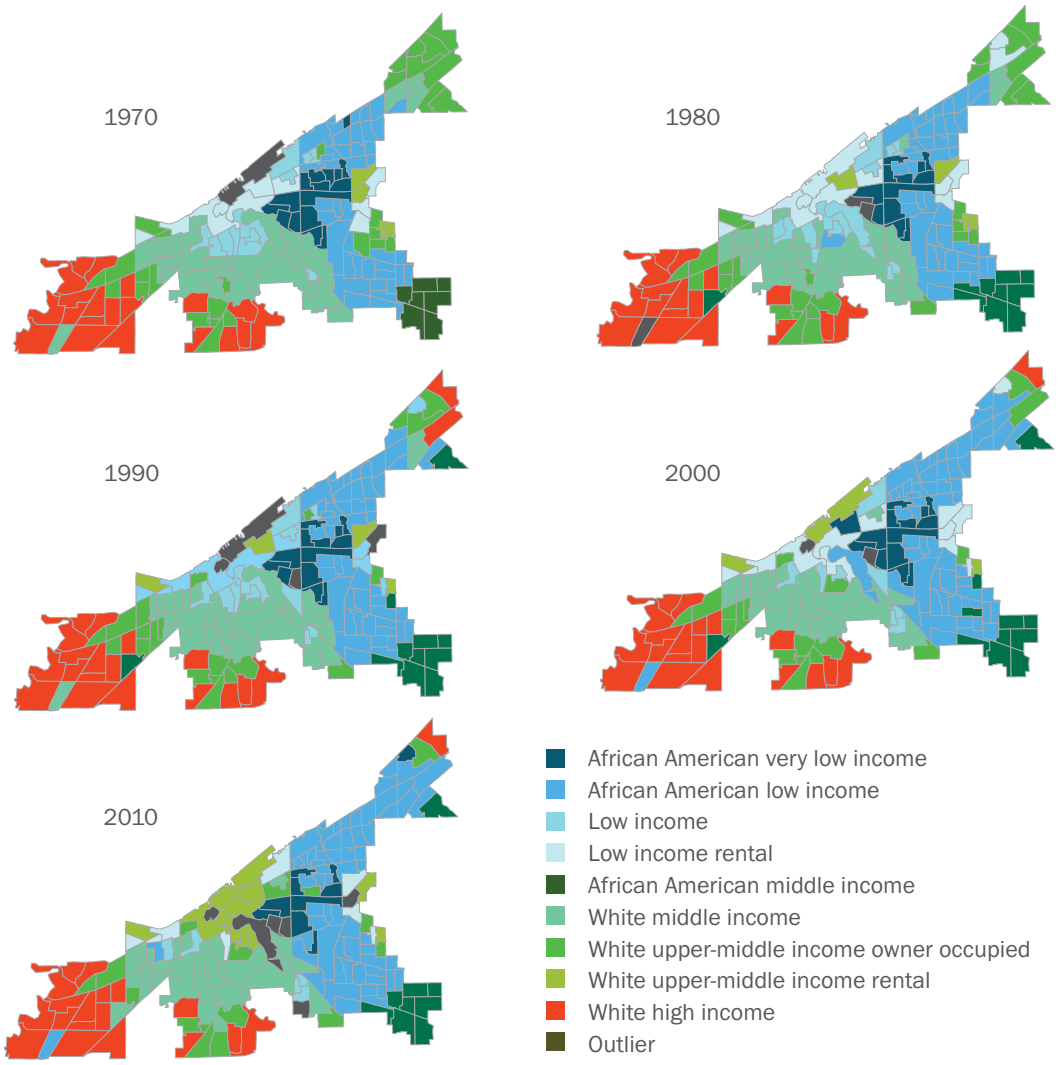
Initial neighborhood type	New neighborhood type	Decade	Transition	Count
White middle income	African American low income	1990s	Declining	6
White upper-middle income owner occupied	White middle income	2000s	Churning	5
White middle income	Low income	1970s	Declining	4
White upper-middle income owner occupied	African American low income	1980s	Declining	4
Low income rental	White upper-middle income rental	2000s	Gentrifying	4
African American very low income	African American low income	1970s	Incumbent upgrading	3
Low income	White middle income	1980s	Gentrifying	3
White upper-middle income owner occupied	White high income	1980s	Churning	3
White upper-middle income owner occupied	African American low income	1990s	Declining	3

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Mapping Neighborhoods and Neighborhood Change

The following series of maps illustrates the spatial aspect of neighborhood change within Cleveland. Figure 3-CLE depicts Cleveland's neighborhood typology by decade. First, the increase in African American low-income neighborhoods is evident throughout the east side of Cleveland, as the number of African American very-low-income neighborhoods and white middle-income neighborhoods declined. Second, the increase in white upper-middle-income rental neighborhoods around the urban core and the near west side is apparent as they change from low-income rental and low-income neighborhoods. Third, the decline of white upper-middle-income owner-occupied neighborhoods is apparent as these neighborhoods largely do not exist on the east side of Cleveland in 2010 as they did in 1970.

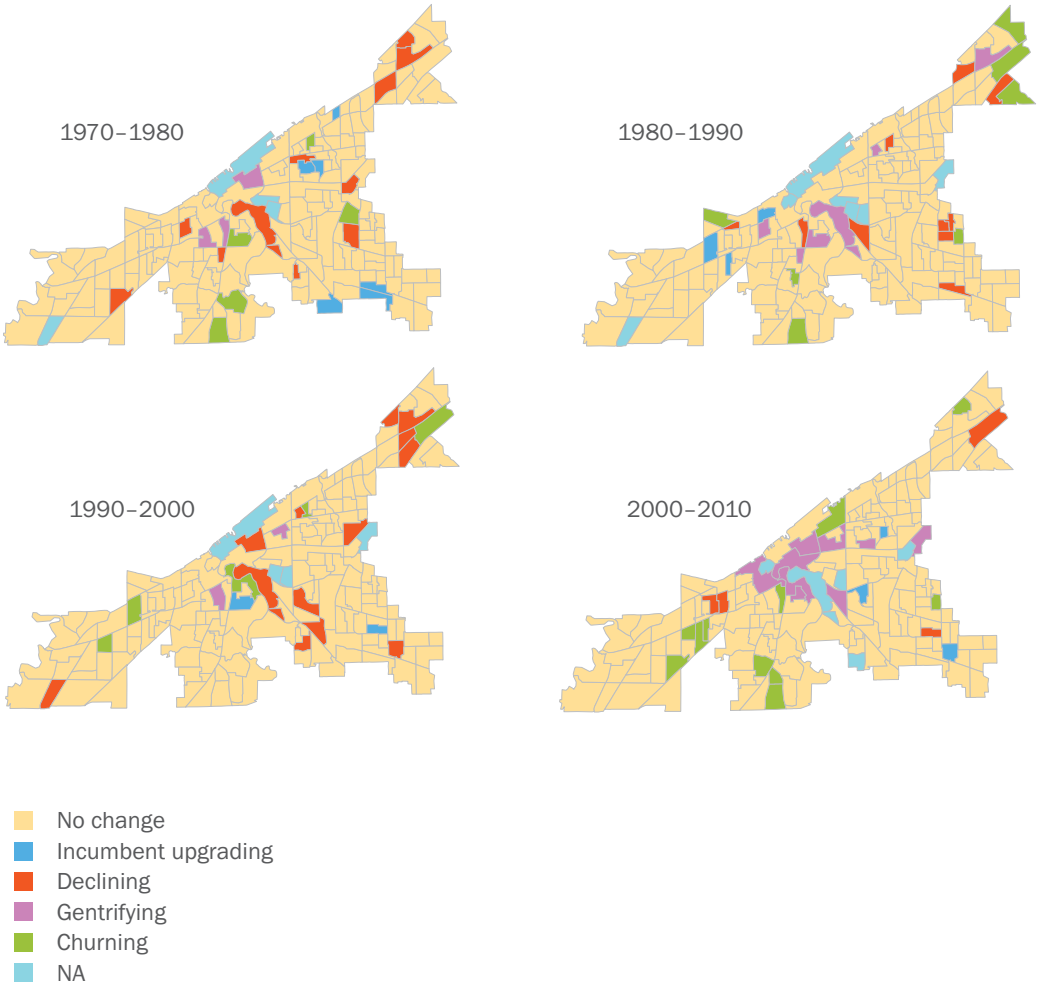
Figure 3-CLE. Neighborhood typologies in Cleveland, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Mapping the different types of neighborhood change reveals where most of the change experienced took place. Figure 4-CLE depicts maps of Cleveland's neighborhood change by decade. These maps reveal that most of the neighborhood change activity in Cleveland happened in neighborhoods near the urban core and neighborhoods on the fringes of the city. Most notable is the gentrification of urban-core neighborhoods during the 2000s.

Figure 4-CLE. Neighborhood change in Cleveland, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Summary

Overall, most neighborhoods in Cleveland retain the same character, income level, and home price level over time. However, some neighborhoods did change during the past 40 years, and the rate at which neighborhoods have changed has been markedly consistent. These changes have led to a compositional change in Cleveland's neighborhoods as the share of African American low-income neighborhoods has increased, while the share of white upper-middle-income owner-occupied neighborhoods has declined. Consistent with this finding, the most common type of neighborhood change found in Cleveland since 1970 has been a declining neighborhood. However, the 2000s saw increased levels of incumbent upgrading, churning, and gentrifying neighborhoods.

Columbus

The composition of Columbus neighborhoods in 2010 is presented below along with the change in this composition since 1970. Citywide neighborhood change rates by decade are also presented along with individual neighborhood change rates by typology. Finally, a series of maps is presented to spatially illustrate the neighborhood typology and neighborhood change from 1970 to 2010.

Neighborhood Typology

Five different types of neighborhoods, excluding outliers,[9] are found in Columbus from 1970 to 2010. Table 1-COL provides the 2010 mean value for a series of variables by neighborhood type and aids in developing the following descriptions of each type of neighborhood (see technical appendix for additional information). Please note that these descriptions are relative to the city of Columbus only and not to the entire metropolitan statistical area. Income designations follow the general guidelines of the following: "low income" equals 80 percent or less of city average household income (CAHI); "middle income" equals 80 to 130 percent of CAHI; and "high income" equals 130 percent or higher of CAHI.

- African American low income: majority African American, above-average share of households comprising a single female with children, above-average poverty rates, below-average home values and household income levels, below-average rates of college-degreed adults
- Low income: mixed racial composition, above-average share of single-family detached homes, below-average home values and household income levels, below-average rates of college-degreed adults
- White nonfamily low income: majority white residents, above-average share of nonfamily households, above-average share of rental housing comprising 5+ units, below-average home values and household income levels, above-average share of college-degreed adults, above-average rates of poverty, below-average resident tenure

9. Outliers are not placed into a neighborhood type because they have either missing data points or values that are +/- 5 standard deviations away from the mean, translating into the 0.0001 percentile or the 99.9999 percentile.

- White middle income: majority white residents, above-average share of college-degreed adults, above-average home values and average household income levels
- White high income: majority white residents, above-average share of households comprising married couples with children, above-average share of owner-occupied single-family detached homes, above-average home values and household income levels, below-average rates of poverty, above-average resident tenure

It is important to note that the typology created for a neighborhood simply describes the dominant trends in that neighborhood and does not mean that every individual living in the neighborhood will share these dominant characteristics.[10]

10. See the "Framework for Neighborhood Change" section above for additional information.

Table 1-COL. 2010 averages for selected variables by neighborhood type

2010 Averages	African American low income	Low income	White non-family low income	White middle income	White high income	City average
Population	3,083	3,705	4,052	4,422	4,886	3,926
% White	25.3	69.4	74.2	70.7	78.1	59.9
% African American	70.2	23.7	11.4	20.4	15.3	32.9
% Owner occupied	36.8	47.2	10.7	35.3	68.1	42.5
% Rental	41.8	36.9	72.3	51.2	23.9	42.1
% Vacant	21.5	15.9	17.0	13.5	8.1	15.4
% Households married with kids	9.0	11.8	3.5	13.0	19.5	12.2
% Households single female with kids	20.8	15.0	2.8	8.1	6.6	11.9
% Nonfamily households	40.2	39.8	81.9	52.9	37.5	46.5
% Single-family dettached	56.1	64.4	11.6	31.6	70.4	50.5
5+ units	18.7	15.7	64.1	33.5	14.3	25.5
Average home value ($)	99,866	97,706	122,265	177,485	182,782	138,548
Household income ($)	36,593	39,944	33,570	58,847	74,982	51,071
% Poverty	35.0	27.7	52.5	16.0	8.5	24.6
% No GED	16.3	19.3	7.0	5.3	4.8	10.6
% Some college	22.6	17.9	18.2	20.4	20.8	20.5
% Bachelor's degree	13.2	10.0	51.0	43.0	41.6	29.8
% Same house 5 years ago	78.3	76.9	49.9	76.3	86.7	76.7

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Neighborhood Composition

Table 2-COL lists the share of city census tracts according to the neighborhood typology in 2010, the share difference from 1970 to 2010, and the share difference from 2000 to 2010. In 2010, African American low-income neighborhoods account for 26.7 percent of Columbus's neighborhoods, followed by white high-income neighborhoods, white middle-income neighborhoods, and low-income neighborhoods at 23.3 percent, 21.8 percent, and 16.5 percent, respectively. White nonfamily low-income neighborhoods account for just 6.3 percent of Columbus's census tracts. Surprisingly, various types of low-income neighborhoods collectively account for almost 50 percent of 2010 census tracts found in Columbus.

Table 2-COL. Share of city neighborhoods by neighborhood type, 2010

Cluster description	2010	1970 to 2010	2000 to 2010
African American low income	26.7	8.3	1.9
Low income	16.5	–10.2	0.5
White nonfamily low income	6.3	0.0	–2.4
White middle income	21.8	7.3	–4.9
White high income	23.3	–8.3	0.5
Outlier	5.3	2.9	4.4

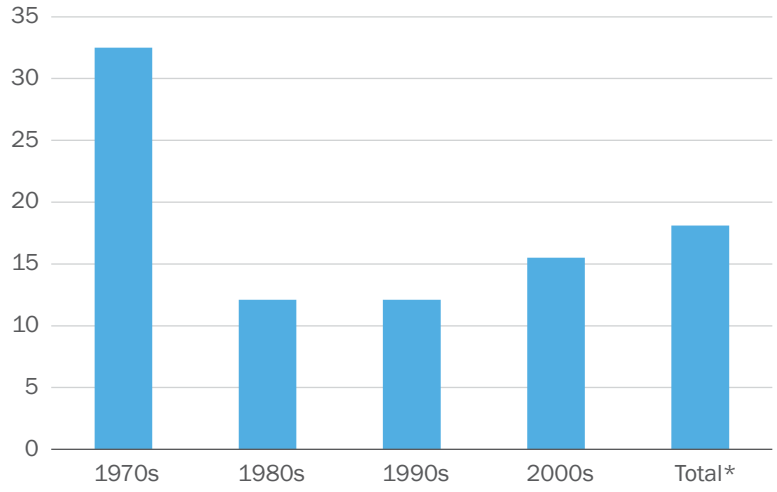
Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Switching to changes in Columbus's composition of neighborhoods from 1970 to 2010, only two neighborhood types saw their shares increase. African American low-income neighborhoods increased 8.3 percentage points, while white middle-income neighborhoods increased 7.3 percentage points. The share of African American low-income neighborhoods experienced most of its increase from 1970 to 2000, with only 1.9 percentage points of 8.3 percentage points total added after 2000, whereas the share of white middle-income neighborhoods declined during the 2000s. Conversely, white high-income and low-income neighborhoods saw steep declines in shares prior to 2000.

Neighborhood Change

Neighborhood change can be better understood by looking at how frequently a transition between neighborhood types occurs. Figure 1-COL charts by decade the overall neighborhood change rate for Columbus. The 1970s had the highest rate of neighborhood change, with 32.5 percent of neighborhoods transitioning to another neighborhood type. The 1980s and 1990s saw neighborhood change slow to just 12.1 percent prior to its picking up to 15.5 percent in the 2000s. Overall, Columbus neighborhoods remain the same 81.9 percent of the time during the 40-year span included in this study.

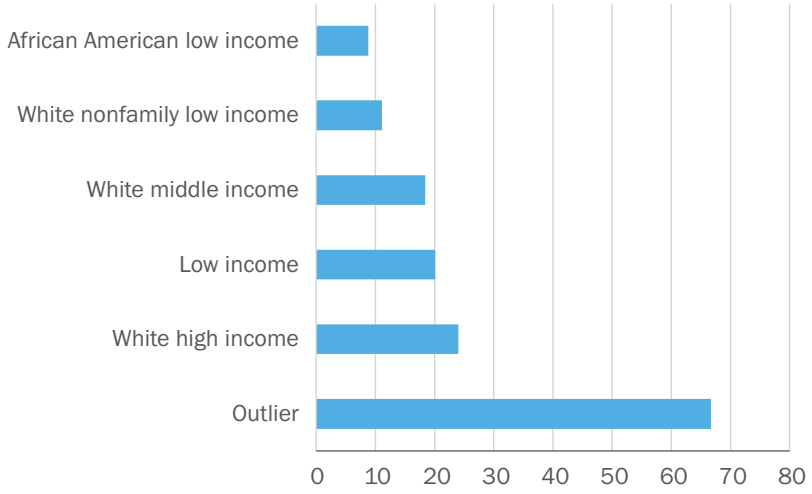
Figure 1-COL. Neighborhood change rate by decade, 1970–2010



*Total refers to the aggregate neighborhood change for all four decades.
Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

As indicated above, across all decades, most neighborhoods do not change. But breaking down the neighborhood change rates into transitions from one type of neighborhood to another allows one to observe some additional nuances and shows that not all neighborhood types change at the same rate. Figure 2-COL presents the rate at which neighborhoods change from one decade to the next for the period of 1970 to 2010. African American low-income neighborhoods tend to change the least, with 8.8 percent of African American low-income neighborhoods transitioning to another neighborhood type in the following decade. White nonfamily low-income neighborhoods also see very little change, changing 11.1 percent of the time in the following decade. Conversely, white high-income neighborhoods changed the most frequently, changing to another neighborhood type 24.0 percent of the time.

Figure 2-COL. Neighborhood change rates by neighborhood type, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Further classifying each neighborhood transition into the different types of neighborhood change provides additional insight. Table 3-COL presents a breakdown of all neighborhood transitions by neighborhood change type. During the four decades, declining has been the most common type of neighborhood change experienced in Columbus. More recently, as residential development has encroached into traditionally nonresidential areas, NA neighborhood change accounts for the largest share of neighborhood change.

Table 3-COL: Neighborhood change breakdown in Columbus, 1970–2010

Type of neighborhood change	1970s	1980s	1990s	2000s
Incumbent upgrading	4.5	28.0	16.0	18.8
Declining	49.3	40.0	48.0	31.3
Churning	11.9	4.0	20.0	9.4
Gentrifying	28.4	28.0	4.0	6.3
NA	6.0	0.0	12.0	34.4
Neighborhood change rate	32.5	12.1	12.1	15.3

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Table 4-COL lists the 12 most common neighborhood changes found in Columbus, the decades in which those changes took place, and the types of neighborhood change. It is apparent that declining neighborhoods in Columbus were prevalent prior to 2000. It is also apparent that the 1970s were a time of much change for Columbus's neighborhoods.

Table 4-COL. Most frequent neighborhood change combinations in Columbus, 1970–2010

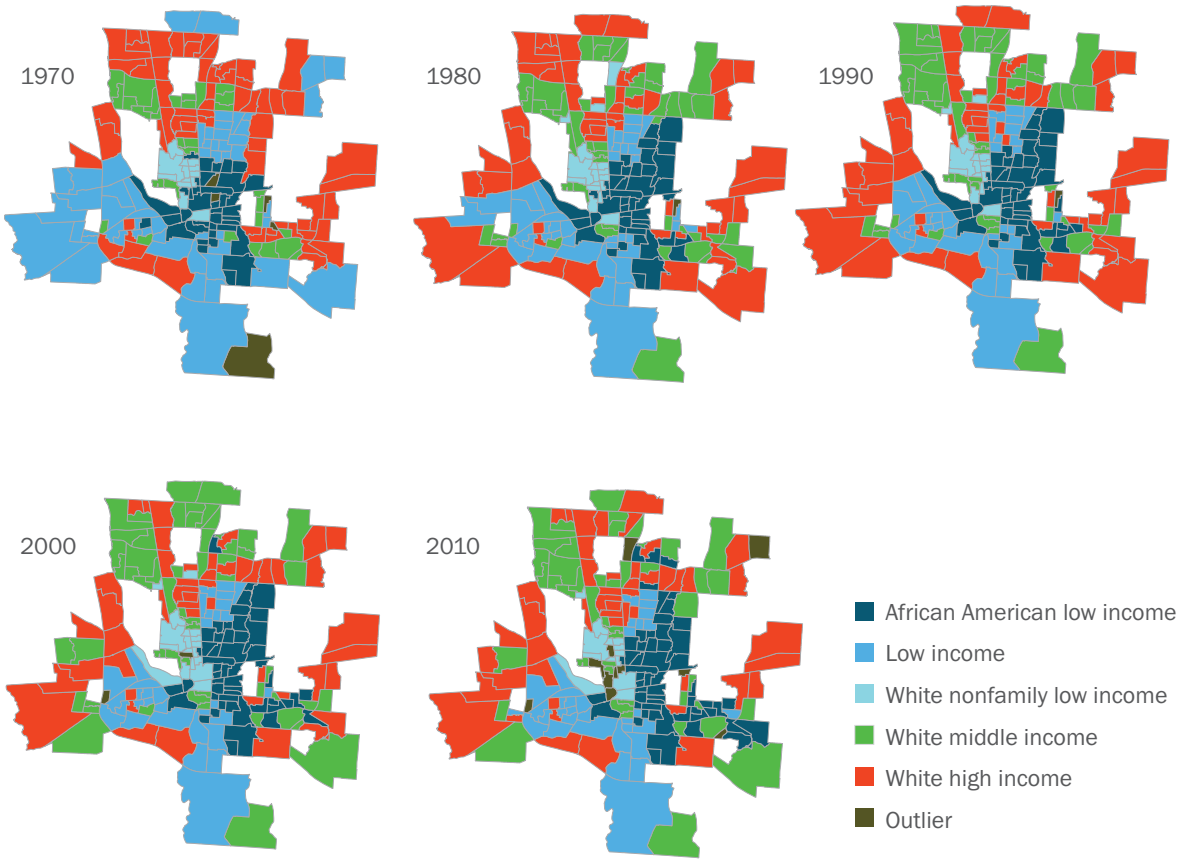
Initial neighborhood type	New neighborhood type	Decade	Transition	Count
White high income	White middle income	1970s	Declining	19
Low income	White high income	1970s	Gentrifying	12
White high income	White middle income	1980s	Declining	6
White high income	White middle income	1990s	Declining	6
White high income	African American low income	1970s	Declining	5
Low income	White high income	1980s	Gentrifying	5
White middle income	White high income	2000s	Incumbent upgrading	5
Low income	White middle income	1970s	Gentrifying	4
Low income	African American low income	1970s	Churning	4
White middle income	White high income	1980s	Incumbent upgrade	4
White middle income	White high income	1990s	Incumbent upgrade	4
White high income	African American low income	1990s	Declining	4

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Mapping Neighborhoods and Neighborhood Change

The following series of maps illustrates the spatial aspect of neighborhood change within Columbus. Figure 3-COL depicts Columbus's neighborhood typology by decade. First, the decrease in low-income neighborhoods is evident throughout the southern half of Columbus and in the northeast corner as the number of white middle-income neighborhoods increased. Second, movement of white high-income neighborhoods took place throughout the city. Third, the increase in white middle-income neighborhoods is noteworthy throughout Columbus. Fourth, changing neighborhood types near the urban core are evident during the 2000s.

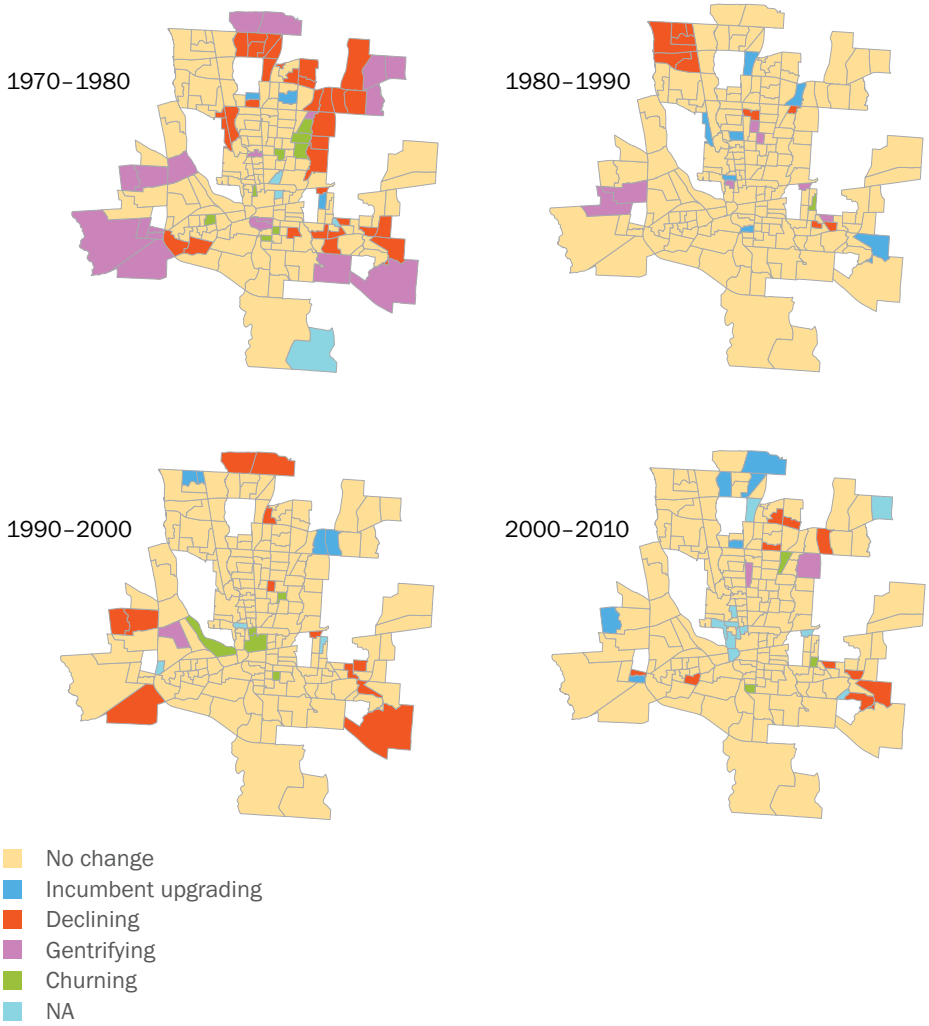
Figure 3-COL. Neighborhood typologies in Columbus, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Mapping the different types of neighborhood change reveals where most of the change experienced took place. Figure 4-COL depicts maps of Columbus's neighborhood change by decade. The maps reveal that most of the neighborhood change activity in the earlier parts of the study period took place on the periphery of the city. Conversely, neighborhoods near the urban core experienced more changes during the 1990s and 2000s.

Figure 4-COL. Neighborhood change in Columbus, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Summary

Overall, most neighborhoods in Columbus retain the same character, income, and home price levels over time. However, some neighborhoods did change during the past 40 years, and the rate at which neighborhoods have been changing has slowed markedly since 1970. The slowing rate of neighborhood change likely is related to Columbus's high level of annexation activity during the early part of the study period. Regardless, these changes at the neighborhood level have led to a compositional change in Columbus's neighborhoods as the shares of low-income and white high-income neighborhoods have declined since 1970, while the share of white middle-income neighborhoods has increased.

Pittsburgh

The composition of Pittsburgh neighborhoods in 2010 is presented below along with the change in this composition since 1970. Citywide neighborhood change rates by decade are also presented along with individual neighborhood change rates by typology. Finally, a series of maps is presented to spatially illustrate the neighborhood typology and neighborhood change from 1970 to 2010.

Neighborhood Typology

Ten different types of neighborhoods, excluding outliers,[11] are found in Pittsburgh from 1970 to 2010. Table 1-PIT provides the 2010 mean value for a series of variables by neighborhood type and aids in developing the following descriptions of each type of neighborhood (see technical appendix for additional information). Please note that these descriptions are relative to the city of Pittsburgh only and not to the entire metropolitan statistical area. Income designations follow the general guidelines of the following: "low income" equals 80 percent or less of city average household income (CAHI); "middle income" equals 80 to 130 percent of CAHI; and "high income" equals 130 percent or higher of CAHI.

- African American low income: predominately African American, above-average share of households comprising a single female with children, above-average share of doubles and 3- to 4-unit housing, above-average poverty rates, below-average home values and household income levels, above-average resident tenure
- African American low income rental: majority African American, above-average share of rental housing comprising 5+ units, above-average poverty rates, below-average home values and household income levels
- Low income: mixed racial composition, above-average share of households comprising a single female with children, below-average home values and household income levels

11. Outliers are not placed into a neighborhood type because they have either missing data points or values that are +/- 5 standard deviations away from the mean, translating into the 0.0001 percentile or the 99.9999 percentile.

- White lower-middle income: majority white, above-average share of single-family detached housing, slightly below-average home values and household income levels
- Nonfamily middle income: mixed racial composition, above-average share of nonfamily households, above-average share of doubles and 3- to 4-unit housing, average home values and household income levels
- White family middle income: predominately white, above-average share of owner-occupied single-family detached housing, average home values and household income levels, above-average resident tenure
- White nonfamily middle income: majority white, above-average share of nonfamily households, above-average share of doubles and 3- to 4-unit housing, average home values and household income levels, above-average share of college-degreed adults
- Nonfamily upper-middle income: mixed racial composition, above-average share of nonfamily households, above-average share of rental housing comprising 5+ units, above-average household income levels and well-above-average home values, above-average share of college-degreed adults, below-average resident tenure
- White nonfamily high income: majority white, above-average share of nonfamily households, above-average share of rental housing comprising 5+ units, well-above-average household income levels and average home values, well-above-average share of college-degreed adults, below-average resident tenure
- White family high income: predominately white, above-average share of families with children, above-average share of owner-occupied single-family detached housing, above-average home values and household income levels, above-average share of college-degreed adults

It is important to note that the typology created for a neighborhood simply describes the dominant trends in that neighborhood and does not mean that every individual in the neighborhood will share these dominant characteristics.

Table 1-PIT. 2010 averages for selected variables by neighborhood type

2010 Averages	African American low income	African American low income rental	Low income	White lower-middle income	Nonfamily middle income	White family middle income	White nonfamily middle income	Nonfamily upper-middle income	White non-family high income	White family high income	City average
Population	857	1,817	2,129	2,574	2,446	2,433	2,562	3,059	2,958	3,159	2,273
% White	6.0	18.3	31.2	80.7	73.9	84.1	76.9	68.1	74.4	83.6	63.4
% African American	93.5	78.9	66.6	16.6	21.3	13.3	16.9	10.7	8.2	6.4	31.8
% Owner occupied	37.8	20.0	41.8	49.7	34.3	70.6	39.0	31.1	27.5	65.5	44.3
% Rental	35.0	54.5	33.4	34.8	45.9	20.9	50.9	52.9	63.2	25.8	39.0
% Vacant	27.3	25.6	24.8	15.5	19.8	8.5	10.1	16.0	9.3	8.7	16.7
% Households married with kids	4.2	3.1	6.4	9.3	4.8	12.4	5.9	1.1	7.2	19.9	7.9
% Households single female with kids	30.0	15.4	19.4	8.5	7.9	6.4	3.2	0.3	1.4	4.4	10.0
% Nonfamily households	25.5	58.8	43.2	48.3	65.0	41.1	68.1	83.4	72.3	42.8	53.0
% Single-family detached	29.0	21.6	54.6	61.2	26.3	76.7	25.7	1.5	18.4	59.6	47.0
5+ Units	16.3	38.4	15.0	8.1	17.6	6.0	25.2	95.1	59.1	8.4	21.2
Average home value ($)	93,665	75,496	57,438	78,980	101,818	95,469	169,941	208,351	287,924	305,608	118,544
Household income ($)	33,690	31,055	37,318	45,519	43,009	55,733	58,299	62,019	77,533	116,964	50,249
% Poverty	45.3	35.5	28.3	18.5	33.5	10.0	17.0	35.3	18.2	8.2	23.6
% No GED	7.2	11.4	11.8	12.0	9.2	7.6	5.1	5.4	3.0	2.7	9.0
% Some college	25.5	20.9	22.4	16.3	15.3	19.3	14.7	17.5	7.8	11.7	17.8
% Bachelor's degree	17.2	20.4	15.0	18.7	27.8	26.9	49.8	48.1	73.5	72.6	30.6
% Same house 5 years ago	90.0	78.9	85.4	86.9	74.4	88.7	76.7	47.8	64.9	81.7	79.0

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Neighborhood Composition

Table 2-PIT lists the share of city census tracts according to the neighborhood typology in 2010, the share difference from 1970 to 2010, and the share difference from 2000 to 2010. In 2010, low-income neighborhoods account for 19.1 percent of Pittsburgh's neighborhoods followed by white family middle-income neighborhoods, nonfamily middle-income neighborhoods, and white lower-middle income neighborhoods at 18.4 percent, 13.2 percent, and 11.0 percent, respectively.

Table 2-PIT. Share of city neighborhoods by neighborhood type, 2010

Cluster description	2010	1970 to 2010	2000 to 2010
African American low income	0.7	–3.7	–2.2
African American low income rental	8.1	–5.1	0.7
Low income	19.1	14.0	1.5
White lower-middle income	11.0	–5.1	1.5
Nonfamily middle income	13.2	–0.7	0.7
White family middle income	18.4	–5.1	–5.1
White nonfamily middle income	5.1	–4.4	–1.5
Nonfamily upper-middle income	1.5	–2.2	–2.2
White nonfamily high income	8.1	4.4	2.2
White family high income	5.1	–0.7	–1.5
Outlier	9.6	8.8	5.9

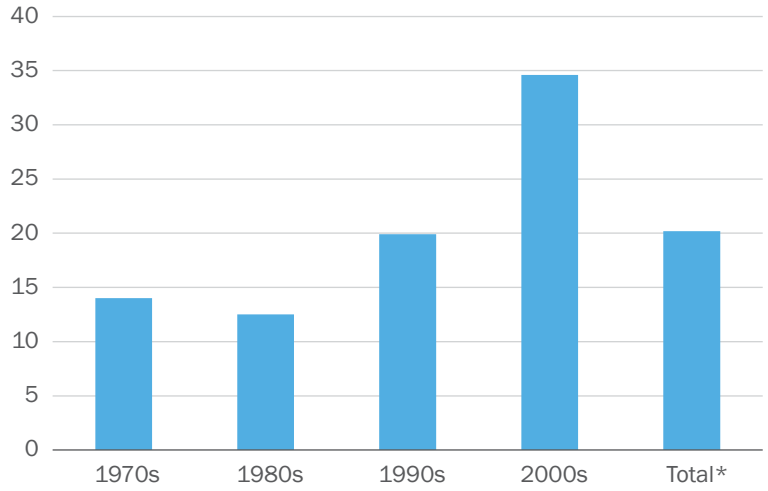
Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Switching to changes in Pittsburgh's composition of neighborhoods from 1970 to 2010, only two neighborhood types saw their shares increase. Low-income neighborhoods increased 14.0 percentage points, while white nonfamily high-income neighborhoods increased 4.4 percentage points. The share of low-income neighborhoods experienced most of its increase from 1970 to 2000, with only 1.5 percentage points of 14.0 percentage points added between 2000 and 2010, whereas the share of white nonfamily high-income neighborhoods saw half of its 4.4 percentage point increase during the 2000s. Conversely, several neighborhoods (African American low-income rental, white lower-middle income, and white family middle income) had declines in excess of 5.0 percentage points from 1970 to 2010. African American low-income rental neighborhoods and white lower-middle-income neighborhoods had most of their declines prior to 2000, while white family middle-income neighborhoods experienced their entire decline during the 2000s.

Neighborhood Change

Neighborhood change can be better understood by looking at how frequently transitions between neighborhood types occur. Figure 1-PIT charts by decade the overall neighborhood change rate for Pittsburgh. The neighborhood change rate is the share of neighborhoods that start the decade as one type of neighborhood and end the decade as another. The 2000s had the highest rate of neighborhood change at 34.6 percent of neighborhoods, followed by 19.9 percent in the 1990s. The 1980s marked the lowest rate of neighborhood change at 12.5 percent. Overall, Pittsburgh neighborhoods remain the same 80.0 percent of the time during the 40-year span included in this study.

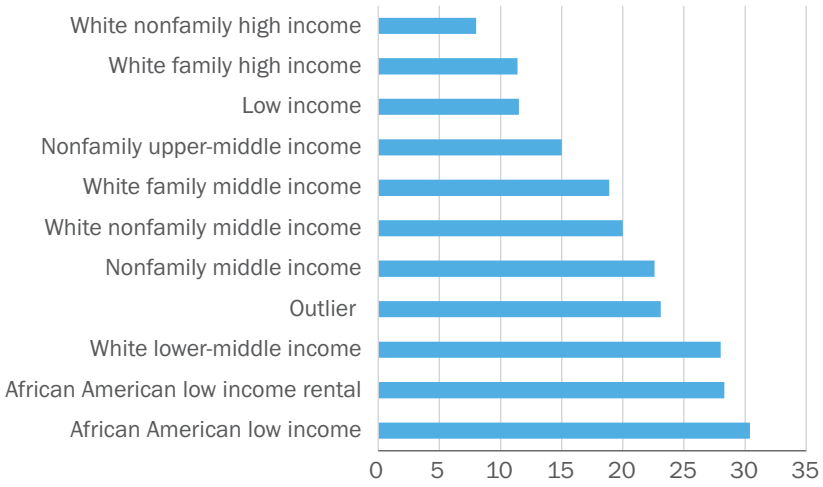
Figure 1-PIT. Neighborhood change rate by decade, 1970–2010



*Total refers to the aggregate neighborhood change for all four decades.
Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

As indicated above, across all decades, most neighborhoods do not change. But breaking down the neighborhood change rates into transitions from one type of neighborhood to another allows one to observe additional nuances and shows that not all neighborhood types change at the same rate. Figure 2-PIT presents the rate at which neighborhoods change from one decade to the next for the period of 1970 to 2010. White nonfamily high-income neighborhoods tend to change the least at 8.0 percent. Low-income and white high-income neighborhoods also see very little change, remaining the same type of neighborhood approximately 88 percent of the time in the following decade. African American low-income rental, African American low-income, and white lower-middle-income neighborhoods change the most frequently, roughly 30 percent of the time.

Figure 2-PIT. Neighborhood change rates by neighborhood type, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Further classifying each neighborhood transition into the different types of neighborhood change provides additional insight. Table 3-PIT presents a breakdown of all neighborhood transitions by neighborhood change type. During the four decades, churning has been by far the most common type of neighborhood change experienced in Pittsburgh. Declining is the second most common type of neighborhood change in each decade. Notably, the 2000s saw an increase in the share of neighborhood changes considered gentrifying.

Table 3-PIT. Neighborhood change breakdown in Pittsburgh, 1970–2010

Type of neighborhood change	1970s	1980s	1990s	2000s
Incumbent upgrading	5.3	11.8	3.7	2.1
Declining	21.1	11.8	7.4	10.6
Churning	57.9	64.7	74.1	48.9
Gentrifying	5.3	5.9	3.7	12.8
NA	10.5	5.9	11.1	25.5
Neighborhood change rate	14.0	12.5	19.9	34.6

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Table 4-PIT lists the nine most common neighborhood changes found in Pittsburgh, the decades in which those changes took place, and the types of neighborhood change. It is clear that the most common neighborhood changes fall into the churning category. This chart also highlights that most of the 34.6 percent rate of neighborhood change in Pittsburgh during the 2000s was churning of similar neighborhoods rather than gentrifying neighborhoods.

Table 4-PIT. Most frequent neighborhood change combinations in Pittsburgh, 1970–2010

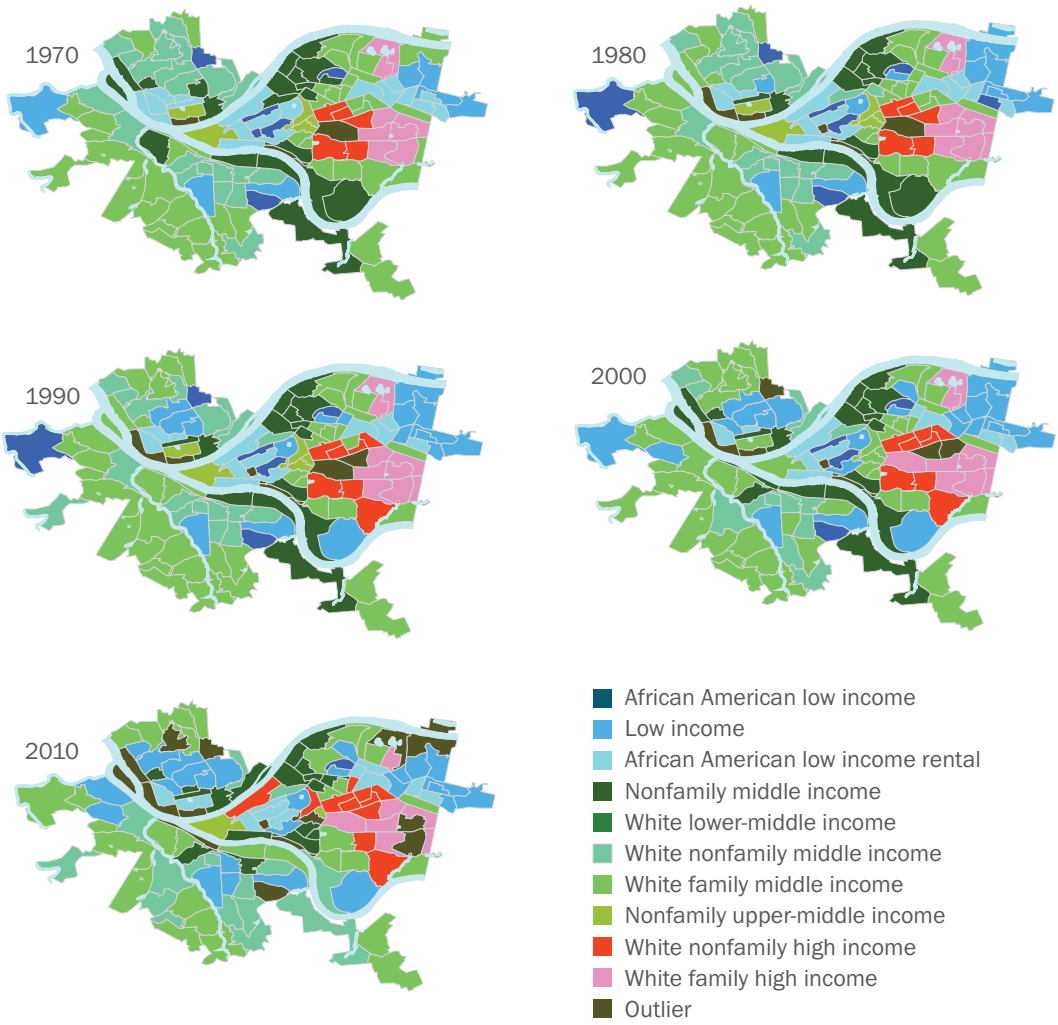
Initial neighborhood type	New neighborhood type	Decade	Transition	Count
White lower-middle income	White family middle income	1990s	Churning	6
White family middle income	White lower-middle income	2000s	Churning	6
African American low income rental	Low income	1990s	Churning	4
Nonfamily middle income	White family middle income	1970s	Churning	3
White lower-middle income	White family middle income	1980s	Churning	3
White family middle income	Nonfamily middle income	1990s	Churning	3
White family middle income	White lower-middle income	1990s	Churning	3
White family middle income	Low income	2000s	Declining	3
White nonfamily middle income	Nonfamily middle income	2000s	Churning	3

Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Mapping Neighborhoods and Neighborhood Change

The following series of maps illustrates the spatial aspect of neighborhood change within Pittsburgh. Figure 3-PIT depicts Pittsburgh's neighborhood typology by decade. First, the increase in low-income neighborhoods is evident throughout the city from 1970 to 2010. Second, additional white nonfamily high-income neighborhoods emerged on the east side of the city. Third, the decline of African American low-income rental and African American low-income neighborhoods is striking. These neighborhoods racially integrate during the period and mostly transition to low-income neighborhoods.

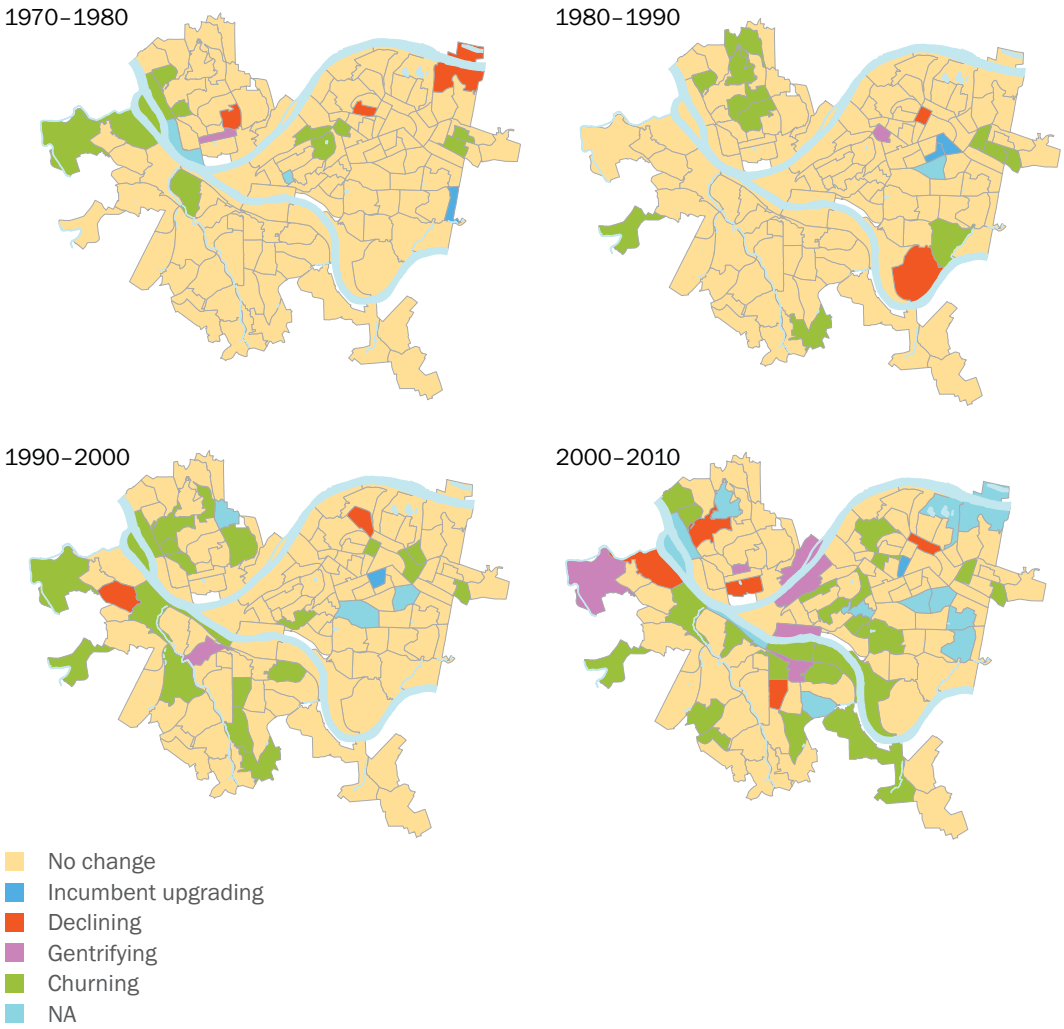
Figure 3-PIT. Neighborhood typologies in Pittsburgh, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Mapping the different types of neighborhood change reveals where most of the change experienced took place. Figure 4-PIT depicts maps of Pittsburgh's neighborhood change by decade. The maps reveal that during the early part of the study period, neighborhood changes were typically found in the western portions of the city, while neighborhood change became citywide during the 2000s. Interestingly, neighborhoods along the river system experienced higher levels of change than did other parts of the city.

Figure 4-PIT. Neighborhood change in Pittsburgh, 1970–2010



Source: Author's calculations based on data from the Neighborhood Change Database, Geolytics.

Summary

Overall, most neighborhoods in Pittsburgh retain the same character, income, and home price levels over time. However, some neighborhoods did change during the past 40 years, and the rate at which neighborhoods have been changing has increased markedly during the 2000s. The most common type of neighborhood change found in Pittsburgh since 1970 has been churning. These changes have led to a compositional change in Pittsburgh's neighborhoods in which the character of a neighborhood is altered but the income and home price levels remain similar.

Technical Appendix

This technical appendix covers data, data manipulation, and the use of cluster and discriminant analysis to create, validate, and describe each neighborhood typology. The steps described in this section were completed four separate times in SPSS to produce four distinct neighborhood typologies, one for each city. A few examples from the creation of Cleveland's neighborhood typology will be used throughout this section to aid with the description of the steps involved. For further information related to using cluster and discriminant analysis for developing a typology, please consult Hill, Brennan, and Wolman (1998). This process mirrors methods presented in that text.

Data and Data Manipulation

The data used in this analysis come from the Neighborhood Change Database (NCDB) produced by Geolytics. The NCDB comprises US census variables at the census tract level for 1970, 1980, 1990, 2000, and 2010. Data come from the long-form census data, the 2010 Summary File 1, and the 2010 American Community Survey (ACS). This type of analysis is possible only because the NCDB has normalized census tract boundaries across all years such that all data are consistent with 2010 census tract boundaries. This normalization means that it is possible to compare the same geographic space consistently over time.

Prior to creating a typology, some data manipulation is required to prepare the data for cluster and discriminant analysis. After the set of variables is chosen, data are limited to census tracts in each central city. All variables are then standardized in each year, producing a z-score. Originally, the dataset is organized such that the year is part of a variable, making standardizing each variable by year a relatively easy task. However, to prepare the data for the next steps, they must be reorganized such that every year's data are now in a single variable rather than five separate variables. Tables 1A and 1B illustrate this step with Cleveland census tracts. Table 1A demonstrates how the data are originally organized, while table 1B demonstrates how the data need to be reorganized in order to move forward with the analysis. Reorganizing and pooling the data in this manner allows one to create the typology from all years and allows for the ability to track neighborhood changes over time. Another crucial step in this process is to address the outliers in the data. This step is taken to ensure that extreme values do not influence the typology creation process. All data with a z-score of +/- 5 are dropped from the typology creation process, and they are considered "outliers" in each typology.

Table 1A.

GEO2010	stdwhite1970	stdwhite1980	stdwhite1990	stdwhite2000	stdwhite2010
39035101101	0.81	0.95	0.65	0.53	0.45
39035101102	0.81	0.95	1.07	1.28	1.40
39035101200	0.79	0.87	0.63	0.88	0.90

Table 1B.

GEO2010	year	stdwhite
39035101101	1970	0.81
39035101101	1980	0.95
39035101101	1990	0.65
39035101101	2000	0.53
39035101101	2010	0.45
39035101102	1970	0.81
39035101102	1980	0.95
39035101102	1990	1.07
39035101102	2000	1.28
39035101102	2010	1.4
39035101200	1970	0.79
39035101200	1980	0.87
39035101200	1990	0.63
39035101200	2000	0.88
39035101200	2010	0.9

Cluster Analysis

Once the dataset is properly formatted, agglomerative hierarchical cluster analysis is used to find the correct number of clusters or neighborhood types and make those assignments. Agglomerative hierarchical cluster analysis is used because the number of neighborhood types is not known and because the process produces an output that helps to determine the proper number of clusters. This process systematically runs through all of the potential cluster options starting with each of Cleveland's 177 census tracts as its own cluster until all 177 census tracts appear in one cluster. Additional options chosen for the cluster analysis include assigning different ways to link clusters statistically and determining what should be used to measure the differences among the cluster solutions. The Ward's linkage method is used to link clusters, and squared Euclidean distance is used to measure the difference between cluster solutions such that "groups are constructed by minimizing the variance of squared Euclidean distances for each variable" (Hill, Brennan, and Wolman, 1998).

Table 2. Abbreviated agglomeration schedule for Cleveland

Stage	Clusters in solution	Agglomeration coefficient	First derivative	Second derivative
845	20	5293.009	1.5	–1.3
846	19	5377.525	1.6	9.9
847	18	5463.135	1.6	-0.3
848	17	5552.300	1.6	2.5
849	16	5652.231	1.8	10.3
850	15	5761.651	1.9	7.6
851	14	5874.697	2.0	1.4
852	**13**	**6019.384**	**2.5**	**25.5**
853	12	6164.643	2.4	–2.0
854	11	6334.321	2.8	14.1
855	10	6512.123	2.8	2.0
856	9	6704.700	3.0	5.4
857	**8**	**7008.013**	**4.5**	**53.0**
858	7	7402.871	5.6	24.5
859	6	7845.845	6.0	6.2
860	5	8385.087	6.9	14.9
861	**4**	**9254.332**	**10.4**	**50.8**
862	**3**	**10750.935**	**16.2**	**56.0**
863	2	12548.487	16.7	3.4
864	**1**	**15610.036**	**24.4**	**45.9**

SPSS produces an output from the hierarchical cluster process, called an agglomeration schedule. This schedule is used to determine the proper number of clusters. Table 2 is an abbreviated portion of the agglomeration schedule output for Cleveland. According to Hill, Brennan, and Wolman (1998): "The decision rule for selecting the candidate cluster solutions is [as follows]: when there is a 'marked' increase in the agglomeration coefficient, the previous stage of the cluster solution is the candidate solution. A 'marked' increase in the value of the SPSS-produced agglomeration coefficient between two stages indicates heterogeneous clusters are being combined." To distinguish what determines a "marked" increase, the first and second derivatives of the agglomeration coefficient are consulted. "Marked" increases are indicated by bolded lettering in table 2 and suggest clusters of 2, 4, 5, 9, and 14 groupings. This step is where some judgment and local knowledge is required such that the "resulting cluster solution has face validity" (Hill, Brennan, and Wolman, 1998). A typology with two and even four types of neighborhoods seems to be too few options for neighborhoods in Cleveland, and, conversely, 14 types of neighborhoods seems just as unlikely, so those are not considered.

To distinguish between a cluster solution with five neighborhood types versus nine neighborhood types requires some additional work. Both cluster solutions are compared by looking at the "hit ratio" computed during discriminant analysis. A hit ratio in this exercise is the percent of census tracts that have been correctly classified into a cluster based on a set of variables. Essentially, the choice between the five- and nine-cluster solution is made in terms of which one has the higher hit ratio. At this point, both cluster solutions are adopted and used to run separate discriminant analyses to produce the needed metric for comparison (more on the role of discriminant analysis follows in the next section). With hit ratios of 91.1 percent and 91.4 percent, respectively, the two solutions are interchangeable. However, the nine-cluster solution is chosen for Cleveland, as it allows for a more nuanced discussion of neighborhood change.

Discriminant Analysis

Discriminant analysis is used to validate statistically and to describe the nine-cluster solution. Specifically, canonical linear discriminant analysis is used to produce several useful outputs for validating and interpreting cluster solutions. In addition to the hit ratio described above, it is essential to examine the discriminant functions. Table 3 presents the discriminant function output table for Cleveland's nine-cluster solution. First, the column labeled "F-stat" indicates that all of our discriminant functions are significantly different from each other. Second, discriminant functions with eigenvalues near or above 1 indicate that those discriminant functions explain a good share of the variation and should be used to describe each grouping. This finding is confirmed by both variance explanation columns, as the first discriminant function explains almost 50 percent of the variation in cluster groupings. The first four discriminant functions collectively explain 95 percent of the variation in Cleveland's cluster groupings and are going to be used to describe each grouping.

Function	Eigenvalue	Variance explained	Cumulative variance explained	F-stat
1	8.0553	0.491	0.491	54.765
2	3.61577	0.2204	0.7114	38.615
3	2.89563	0.1765	0.888	28.099
4	0.932404	0.0568	0.9448	16.607
5	0.47854	0.0292	0.974	11.384
6	0.244691	0.0149	0.9889	7.8225
7	0.143658	0.0088	0.9976	5.4125
8	0.038643	0.0024	1	2.5088

Table 3. Discriminant function output table

The next step is to determine which of our standardized variables and discriminant functions align. Table 4 contains Cleveland's canonical structure (canonical loading or discriminant loadings) that represents correlations between standardized variables and the discriminant functions. Discriminant function 1 is positively correlated with the share of white residents in a neighborhood and negatively correlated with the share of African American residents and the share of households comprising a single female with children. Higher shares of single detached housing, owner-occupied homes, married couples with children, rates of tenure in the home, home values, household income, and GED rates are positively correlated with discriminant function 2, while negatively correlated with the poverty rate. Discriminant function 3 is positively correlated with the share of doubles and 3- to 4-unit housing and the high school dropout rate. Conversely, the shares of 5-plus-unit housing and adults with some college are negatively correlated with discriminant function 3. Discriminant function 4 is positively correlated with the share of adults with a bachelor's degree and negatively correlated with the share of adults without a high school diploma.

Function 1	**Correlation**
% African American	–0.88
% White	0.84
% of households that are single female with children	–0.40
Function 2	**Correlation**
% of units that are single-family detached	0.78
% of units that are owner occupied	0.75
% of population in poverty	–0.47
% of households that are married families with children	0.43
% of people living in the same house as they did 5 years ago	0.37
Average household income ($)	0.36
% of adults with only a high school diploma/GED	0.32
Average owner-occupied home value ($)	0.29
Function 3	**Correlation**
% units that are doubles	0.60
% of units that are 5+ units	–0.51
% of units that are 3 to 4 units	0.42
% of adults with some college	–0.29
% of high-school-aged youths not in high school	0.25
Function 4	**Correlation**
% of adults with a bachelor's degree	0.60
% of adults without a GED	–0.35

Table 4. Canonical structure

Once variables have been associated with discriminant functions, the next step is to develop labels for Cleveland's typology of neighborhoods. Table 5 contains the group means by discriminant function for each cluster. These highlighted functions have significance levels above 90 percent and indicate that these clusters are statistically different according to that particular discriminant function. Significant functions are used to label each neighborhood grouping. For example, clusters 2, 4, 7, and 8 are positively correlated with and significant to discriminant function 1, a circumstance which translates into their being primarily white neighborhoods, whereas clusters 3, 6, and 9 are negatively correlated and significant, indicating that they are primarily African American. Clusters 1 and 5 do not receive a label related to discriminant function 1. This process is repeated for each discriminant function until all labels are developed fully.

Table 5. Group means by discriminant function

Cluster	Function1	Function2	Function3	Function4
1	1.20	–3.80***	–1.23	0.11
2	3.62***	–4.32***	–4.29***	3.26***
3	–3.95***	–3.01***	–1.47	–2.23**
4	1.92*	–0.06	2.14**	–0.34
5	1.26	–1.50	2.61***	0.03
6	–3.21***	0.71	0.39	0.66
7	2.33	0.32	–0.03	0.36
8	3.86***	2.07	–1.81	–0.89
9	–1.78*	3.58***	–2.82***	–0.18

Note: * indicates 90% confidence interval (1.65), ** indicates 95% confidence interval (1.96), and *** indicates 99% confidence interval (2.57).

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