Traffic Noise in Georgia: Sound Levels and Inequality

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Abstract: Using Lorenz-type curves, means tests, ordinary least squares, and locally weighted regressions (LWR), we examine the relative burdens of whites, blacks, and Hispanics in Georgia from road and air traffic noise. We find that whites bear less noise than either blacks or Hispanics and that blacks tend to experience more traffic noise than Hispanics. While every Metropolitan Statistical Area (MSA) showed that blacks experienced relatively more noise than average, such a result did not hold for Hispanics in roughly half of the MSAs. We find much heterogeneity across Census tracts using LWR. For most Census tracts, higher black and Hispanic population shares are associated with increased noise. However, 5.5 percent of the coefficients for blacks and 18.9 percent for Hispanics are negative, suggesting larger population shares are associated with less noise. The noise LWR marginal effects for black populations across most tracts in the state are consistent with diminishing marginal noise from additional black population, while those in Atlanta exhibit diminishing marginal noise for Hispanics. In many regions of the state where the potential for health-damaging noise exists, we find relatively high disproportionality in noise experienced by the black and Hispanic populations compared to the rest of the overall population. Our findings underscore the importance of using nonparametric estimation approaches to unveil spatial heterogeneity in applied urban and housing economics analyses.

JEL Codes: C25, Q53, R41

Key Words: traffic noise, Lorenz curves, nonparametric regressions

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Introduction

Much is unknown about the ultimate effects of traffic noise on nearby residents and whether certain demographic groups may bear the burden of the noise more disproportionately than other groups. In this paper we focus on this latter issue. Specifically, we examine both general road noise and aircraft-related noise for MSAs located in Georgia.[1] Using traffic noise measures in conjunction with various data at the Census tract-level, we consider noise levels across MSAs in Georgia and generate figures and statistical estimates to summarize the relationship between noise and the burdens borne by demographic groups. We also describe various relationships, including how some vary over space, more closely via regression analysis.

Over the last two decades a substantial research effort has been undertaken to identify the effects of noise on health.[2,3] A consistent finding is that the health of individuals exposed to excessive noise tends to be affected adversely. Children are especially at risk for negative effects.[4]

These potential health effects have generated increased attention in recent years. While a statistical analysis of environmental justice is clearly beyond our scope, some of the increased attention in this literature has occurred because environmental justice issues have become more prominent.[5] Three airport-noise studies are related directly to the current study – Ogneva-Himmelberger and Cooperman (2010), Sobotta et al. (2007), and Cohen and Coughlin (2012). Ogneva-Himmelberger and Cooperman (2010), using Boston's Logan International Airport, find that minority and lower-income populations are subjected to relatively higher noise levels than

[1] Kopsch (2016) found in a meta-analysis of housing prices and noise that the cost of an additional decibel of aircraft noise was more than an additional decibel of road noise.

[2] Swoboda et al. (2015) identified the following effects: 1) simple annoyance – Miedema and Oudshoorn (2001); Ouis (2001); Ohrstrom et al. (2007); de Kluizenaar et al. (2013); and Weinhold (2013); 2) sleep disturbance – Ouis (1999); Jakovljević et al. (2006); and Kim et al. (2012); 3) increasing risk for stroke – Sørensen et al. (2011); 4) hypertension – Jarup et al. (2008); and Bodin et al. (2009); 5) myocardial infarction – Babisch et al. (2005); and 6) overall quality of life – Shepherd et al. (2013).

[3] With respect to airport noise, Morrell et al. (1997) concluded that high-quality studies on these various health issues related to airport noise were lacking and, thus, definitive conclusions about adverse effects were not possible. However, more recent literature reviews reach stronger conclusions. Ising and Kruppa (2004) highlight that even during sleep the noise from aircraft may lead to the release of stress hormones increasing the risk of heart attacks. This conclusion is reinforced by Lefèvre et al. (2017) in their study of aircraft noise exposure in France.

[4] Hygge et al. (2002) find a link between noise and cognitive performance. Stansfeld and Matheson (2003) note that children exposed to chronic noise suffer detrimental effects on reading comprehension and long-term memory. Based on additional studies reported in Clark et al. (2006) and Stansfeld et al. (2005), this conclusion has been found for children in the Netherlands, United Kingdom, and Spain. A recent paper by Makles and Schneider (2016) highlights that noise may impair early childhood development and may ultimately have permanent effects on academic achievement and health.

[5] The U.S. Environmental Protection Agency defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." See https://www.epa.gov/environmentaljustice.

their counterparts. Sobotta et al. (2007) regress airport noise in Phoenix, expressed as a qualitative dependent variable, on various independent variables, including the percentage of neighborhood population that is Hispanic. They find that households in neighborhoods with a greater Hispanic population were subjected to higher noise levels than households in other neighborhoods. Following McMillen and McDonald (2004), Cohen and Coughlin (2012) estimate ordered probit locally weighted regressions (OPLWR) to explore the issue of spatial heterogeneity in the context of the determinants of airport noise in Atlanta.

Cohen and Coughlin (2012) find notable differences in parameter estimates for different houses in their sample with the OPLWR estimates. In particular, the sign on the coefficient for each explanatory variable contains some positive and some negative values. Also, compared to an ordered probit model, the mean of the magnitudes of the coefficients for some of the other explanatory variables is larger with the OPLWR model, while for other coefficients the mean is smaller. These differences between the OPLWR and ordered probit results imply that focusing exclusively on an ordered probit model for the determinants of noise can lead to biased estimates in our context due to ignored heterogeneity among individual houses in our sample. Overall, the heterogeneity over the relatively small area examined precluded any environmental-justice generalizations with respect to either the black or Hispanic populations.

Focusing on transportation noise in general, few studies have examined differences in exposure across demographic groups. Among these studies, more evidence has been produced on the association of noise and income differences than on the association of noise and ethnic differences.

Brainard et al. (2004) explored exposure to noise in Birmingham, UK. The connection between noise and various socioeconomic indicators was examined. No relationship was found between noise exposure and age. At most, only weak evidence was found for a relationship between noise exposure and ethnicity. Indian and Pakistani sub-groups tended to have lower exposure than the city average, while blacks tended to have higher exposure. Finally, evidence of a weak relationship between noise exposure and economic deprivation was found. Because of the strong association between ethnicity and deprivation, the authors could not identify the independent effects of these variables.

As part of a study examining various environmental indicators in the greater Rotterdam region known as the Rijnmond, Kruize et al. (2007a) examined exposure to traffic noise. They found increased noise exposure for those with lower incomes, but these differences across income categories were quite small. Somewhat surprisingly, they found higher air traffic noise exposure to be associated with higher incomes.

In a related study, Kruize et al. (2007b) examined equity in an area surrounding the Amsterdam Airport (Schiphol). Similar to Kruize et al. (2007a), various environmental indicators were used, but we restrict our focus to noise. Also, because of a lack of data on race, income was the key socioeconomic indicator. In addition to the distribution of environmental quality, the authors explored the interaction of market forces and government policy that produced equity. A key finding was that exposure to higher levels of traffic noise was similarly distributed across income categories; however, those with lower incomes tended to be exposed to relatively more traffic noise. This finding resulted from changes in the relative power of government regulation and market forces.

Finally, Havard et al. (2011) found that in Paris higher levels of noise in a neighborhood were associated with higher educational attainment and higher property values. In addition, more noise was associated with higher proportions on non-French citizens; however, when citizens were connected to their origin countries, they found that more noise was associated with higher proportions of citizens from advantaged countries.

A standard issue in this literature can be phrased as follows: Were a disproportionate percentage of minority residents already present at the time the environmental hazard was sited or did the disproportionate percentage occur as a result of location decisions after the hazard was sited? This question cannot be adequately answered in most cases without panel data.[6]

In the case of traffic noise throughout the state of Georgia, this issue is not of major concern. The vast majority of the locations of roads were determined many years ago. Of course, this issue is of importance for the construction of new roads and airport expansions/modifications.

Turning to our paper, we begin by providing some basic statistics at the Census tract-level for the housing market in Georgia. Next, we construct curves that are similar, but not identical, to Lorenz curves to generate a number of facts about traffic noise and the exposure of whites, blacks, and Hispanics to it. We follow with statistical analyses to examine a number of simple relationships between traffic noise and economic/demographic variables. Our additional analysis provides insights on the relationships between road noise and economic/demographic variables.

Data

In the context of our problem, we leverage the fact that we have some data covering multiple time periods. Our data come from two different sources; we merge the road/airport noise data with the Census data to create a dataset lending itself to analysis of how demographics are correlated with noise. We describe more details of our data below.

Specifically, we have obtained noise data for 2016-17 from the Bureau of Transportation Statistics (BTS). This dataset contains information on noise levels (measured in A-weighted 24-hour equivalent sound levels (LAEQ)) from both road and air traffic sources, and therefore it is quite comprehensive. The data are very close to being a continuous estimate of noise, therefore at virtually any point in geographic space (such as a centroid of a Census tract), it is generally possible to assign a noise level to this point. However, locations with noise levels below 35 dBA (A-weighed decibels) are not assigned noise values. While most of the other noise studies described above consider only road noise or airport noise, but not both, this dataset enables us to more accurately attribute sources of variation that are correlated with all types of noise.

[6] Depro et al. (2015) stress this challenge in an examination of air toxics in Los Angeles County. They find differences across groups in their willingness to pay for cleaner air.

Figure 1 shows these noise data aggregated to the average for Census tracts. For areas of Georgia below the 35 dBA reporting threshold, values of 0 were assigned. Thus, the average noise levels for most Census tracts are biased downward. Not surprisingly, the highest levels of traffic noise occur in the Atlanta area and in portions of other MSAs throughout the state. Traffic noise levels throughout most of the state are low.

Much of the remaining data we use come from the Census Bureau's American Community Survey data files, for 2016 and for 2011 – specifically the 2012-2016 and 2007-2011 5-year estimates. These data include tract-level variables on average house value, average rental rates, average house age, average number of rooms, average number of housing units, vacancy rates, population, and demographic information such as percent Hispanic, percent black, and average income. Note that we have chosen to ignore the percent Caucasian variable because black and white populations can include the Hispanic population, due to the fact that Hispanic is an ethnic group. That gives us reason for excluding the white percentage from our regressions, because the sum of the white percentage, the Hispanic percentage, and the black percentage could technically surpass 100%.

Descriptive Statistics

Table 1 presents the descriptive statistics for the Census tract-level data from the 1891 tracts in the state of Georgia for which we have values for all variables except median house value and median gross rent.[7] With the exception of the 2016-17 average noise data from BTS (described above), all of the data in our analyses are from the 2011 American Community Survey (ACS). The median house value averaged approximately $159,000 across Georgia's Census tracts, with a range of $20,500 to just under $1 million. The median gross rent is defined as the median dollar value of rent plus utilities. Gross rents range from $250 to over $1,900, with a median of $840. Median household income was slightly less than $50,000. The average house was about 29 years old, with 5.7 rooms, and the average number of housing units per tract was slightly less than 2100.

The average total population per tract was just under 5,000, with a range of 117 to approximately 20,000. The percent black variable was defined as the percent of individuals in a tract whose race is black alone, including both Hispanics and non-Hispanics. In the average tract, about one-third of the population was comprised of individuals who are black. However, the standard deviation was large (approximately 28 percent). The percent Hispanic variable was defined as the percent of individuals of any race who are Hispanic. The mean percentage Hispanic across all tracts was approximately 8 percent.

The vacancy rate was the percent of housing units that are vacant, excluding vacant migrant worker housing units, vacant vacation units, vacant rented units, and vacant sold units awaiting occupancy. The mean vacancy rate across tracts was 11.4 percent, with a standard deviation of approximately 7 percent. At least one tract had a vacancy rate that was as high as 77

[7] Median house value and median gross rent are interchanged in some regressions, so the descriptive statistics sample was chosen to capture all observations used in regression analyses.

percent, and some tracts had a 0 percent vacancy rate. Finally, the OLS regressions included an MSA dummy, which was a dummy variable equal to 1 if a tract is in an MSA and 0 if not.

The average levels of noise across Census tracts for each MSA revealed that only Atlanta had areas that could be characterized as excessively noisy. The Albany, Athens, and Gainesville MSAs had no Census tracts that exceed 50 dBA using the LAEQ metric. A reading of 50 is roughly equivalent to a quiet office or a quiet outdoor urban daytime setting. Atlanta, however, had areas with readings above 50 dBA. Readings in the 60s are indicative of heavy traffic noise at a distance of 300 feet; this is also the level at which Sørensen et al. (2011) found notable increases in the risk of stroke. While average tract noise was relatively low for many areas, 94 percent of tracts in the state had at least one area with a noise level exceeding 60 dBA. The Federal Aviation Administration defines significantly disturbing noise as 65 dBA and above; 74 percent of tracts in the state had an area also exceeding that threshold. We used ArcGIS to derive the "average" noise per Census tract based on the daily average values in each of the noise "grids" within the boundaries of the tract. This average noise level in 2016-17 was approximately 12 dBA, while the variation was large relative to the mean (i.e., the standard deviation was 14.6 dBA). Among all of the tracts in Georgia for which demographic data were reported, the one with the highest amount of average noise – located in Atlanta – had 65 dBA, while the quietest tracts in the state had 0 dBA.

Empirical Analysis

Traffic Noise and Population Throughout Georgia

We begin by examining the distributions of noise and population across all Census tracts in Georgia. Key features of the distributions are summarized in Table 2 and represented in Figure 2. Table 2 shows that 18.9 percent of Georgia's population lives in the most noisy Census tracts (i.e., the first 20 percent). Roughly 10.8 percent of Georgia's white population lives in the most noisy Census tracts, while 24.2 percent of Georgia's black population and 22.4 percent of Georgia's Hispanic population resides in these Census tracts. Thus, a relatively smaller percentage of whites than either blacks or Hispanics experience the highest levels of noise.

When one examines the other end of the distribution (i.e., the least noisy 20 percent), one finds that 16.0 percent of Georgia's population lives in the least noisy census tracts. Roughly 21.2 percent of Georgia's white population resides in these Census tracts, while 10.4 percent of Georgia's black population and 9.3 percent of Georgia's Hispanic population lives in these Census tracts. Thus, a relatively larger percentage of whites than either blacks or Hispanics experience these lower levels of noise.

While Table 2 provides tail information, Figure 2 shows the entire distribution. The dashed line is the cumulative percentage of Georgia's population on the y-axis, while the noise percentile is on the x-axis. This line is not a 45-degree line, but in the present case it deviates only slightly. Using this reference line and the lines for white, black, and Hispanic populations, we can calculate a measure of the inequality of noise exposure. These figures and measures of inequality are similar, but not identical, to Lorenz curves and Gini coefficients. Our inequality coefficients can range from minus one to plus one, with zero being perfect equality. [8]

Three cases can arise for the relationship between the reference line and our inequality curve. First, the inequality curve for a specific group might lie entirely below the reference line. In this case the inequality coefficient is positive and is simply the areas between the two curves divided by the entire area below the reference line. Thus, as this coefficient approaches one, then the specific group experiences less and less noise in a relative sense.

Second, the inequality curve for a specific group might lie entirely above the reference line. In this case the inequality coefficient is negative and is the negative of the area between the two curves divided by the area above the reference line. As this coefficient approaches minus one, then the specific group experiences more and more noise in a relative sense.

Third, a portion of the inequality curve for a specific group might lie below the reference line and another portion might lie above. In this case the inequality coefficient might be either positive or negative as a positive value will be added to a negative value. The inequality coefficient is the area between the two curves when the inequality curve is below the reference line, appropriately weighted, divided by the associated area under the reference line minus the area between the two curves when the inequality curve is above the reference line divided by the associated area above the reference line, appropriately weighted. The weights reflect the percentage that the inequality curves are below and above the reference line.

With the preceding background on the inequality coefficient, let's return to Figure 2, which provides the distribution by noise level for the entire state. One sees that the inequality curve for the white population always lies below the reference line. The inequality coefficient in Table 3a is 0.14, indicating that whites tend to bear a relatively smaller share of noise than other groups. Meanwhile, the inequality curve for both the black and Hispanic populations lie above the reference line. The associated inequality coefficient is -0.19 for blacks and -0.13 for Hispanics.

Traffic Noise at the MSA Level

Next, we examine noise level and the distribution of noise for a number of MSAs in Georgia. The MSAs are those that are fully contained within the state's borders and are relatively large. As a result, a few MSAs are excluded. For example, Augusta, Columbus, and Chattanooga, are excluded because they are not completely within Georgia, while the Brunswick, Hinesville, and Rome MSAs are excluded for size reasons.

An examination of the Albany MSA reveals that the white and Hispanic populations bear a relatively smaller share of noise than the overall population in Albany. Meanwhile, the black population bears a relatively larger share. Figure 3 and Table 2 show that 16.3 percent of the Albany population resides in the most noisy (up to the 20th percentile) area. In this area, 3.8 percent of whites, 11.3 percent of Hispanics and 25.2 percent of blacks reside. The inequality

[8] See Boyce et al. (2016) for the use of other measures in the context of environmental inequality.

coefficients based on Figure 3 and highlighted in Table 3a reveal of level of 0.28 for whites, 0.12 for Hispanics, and -0.17 for blacks.

Turning to Atlanta, which tends to have higher levels of noise than other MSAs in Georgia, one sees in Figure 4 that the distribution of noise for whites and blacks is similar to that of Albany, but that the distribution for Hispanics tends to be closer to blacks than whites, which is not the case for Albany. [9] Table 2 shows that in the most noisy area, where 17.6 percent of Atlanta resides, the corresponding percentages for whites, Hispanics, and blacks are 7.1, 15.7, and 33.7. Meanwhile, in the least noisy area, where 22.0 percent of the population reside, the corresponding percentages for whites, Hispanics, and blacks are 31.5, 13.5, and 12.9. The inequality coefficients for whites, Hispanics, and blacks, shown in Table 3, are 0.21, -0.09, and -0.22. Thus, one finds that whites experience disproportionately less noise than the population overall, while blacks and, to a lesser extent, Hispanics experience disproportionately more noise.

Moving on to Athens, which similar to Atlanta tends to be a relatively noisy MSA, one sees in Figure 5 a pattern for the distribution of noise for whites and blacks that is similar, but slightly less pronounced, to the previously examined MSAs. The line associated with the white population lies below the reference line, while the line associated with the black population lies above the reference line. Meanwhile, the line associated with the Hispanic population is below the reference line for higher levels of noise and above the reference line for lower levels of noise. Table 2 shows that in the most noisy area, with 21.0 percent of the population in Athens, the corresponding percentages for whites, Hispanics, and blacks are 18.6, 16.8, and 26.8. Meanwhile, in the least noisy area, with 25.0 percent of the population in Athens, the corresponding percentages for whites, Hispanics, and blacks are 30.0, 16.4, and 15.0. The inequality coefficients for whites, Hispanics, and blacks, shown in Table 3, are 0.07, 0.01, and -0.15. Thus, one finds that whites experience disproportionately less noise than the population overall, while blacks experience disproportionately more noise. The Hispanic population experiences noise similar to the overall population.

Turning to Dalton, one sees in Figure 6 a similar pattern for blacks and Hispanics, with both curves above the reference line. Meanwhile, as is standard, the line associated with the white population lies below the reference line. Table 2 shows that in the most noisy area, with 20.3 percent of the population in Dalton, the corresponding percentages for whites, Hispanics, and blacks are 19.5, 20.5, and 27.9. Meanwhile, in the least noisy area, with 19.8 percent of the population in Dalton, the corresponding percentages for whites, Hispanics, and blacks are 27.7, 7.6, and 9.2. The inequality coefficients for whites, Hispanics, and blacks, shown in Table 3, are 0.11, -0.19, and -0.25. Thus, one finds that whites experience disproportionately less noise than the population overall, while blacks and Hispanics experience disproportionately more noise.

For Gainesville, the patterns in Figure 7 are slightly nuanced for the black and Hispanic populations, while the inequality line for the white population exhibits its standard location below the reference line. For the higher levels of noise, the line associated with the Hispanic population lies above that of the black population. In fact, the line associated with the black

[9] A health-related traffic noise study that is focused on Fulton County, Atlanta is Kim et al. (2012).

population is very close to the reference line. Then, for the least noisy area, the pattern reverses with the line associated with the black population being above that of the Hispanic population. Table 2 shows that in the most noisy area, with 20.8 percent of the population in Gainesville, the corresponding percentages for whites, Hispanics, and blacks are 7.5, 41.4, and 25.7. Meanwhile, in the least noisy area, with 18.2 percent of the population in Gainesville, the corresponding percentages for whites, Hispanics, and blacks are 22.6, 15.7, and 5.5. The inequality coefficients for whites, Hispanics, and blacks, shown in Table 3, are 0.14, -0.18, and -0.13. Thus, one finds that whites experience disproportionately less noise than the population overall, while Hispanics and, to a slightly lesser extent, blacks experience disproportionately more noise.

Moving on to Macon, Figure 8 shows, as is standard, the line associated with the white population lies below the reference line. Meanwhile, the line associated with the black population lies above the reference and the line associated with the Hispanic population coincides with the line associated with the white population for the most noisy areas, but then lies above the reference line for the less noisy areas. Table 2 shows that in the most noisy area, with 11.2 percent of Macon's population, the corresponding percentages for whites, Hispanics, and blacks are 6.3, 5.9, and 16.0. Meanwhile, in the least noisy area, with 25.3 percent of the population in Macon, the corresponding percentages for whites, Hispanics, and blacks are 31.7, 10.8, and 20.9. The inequality coefficients for whites, Hispanics, and blacks, shown in Table 3, are 0.18, -0.13, and -0.12. Thus, one finds that whites experience disproportionately less noise than the population overall, while blacks and Hispanics experience disproportionately more noise.

For Savannah, Figure 9 shows that while whites experience disproportionately less noise than the overall population and blacks experience disproportionately more noise than the overall population, the difference is small. Meanwhile, Hispanics fall between the white and black experiences. Table 2 shows that in the most noisy area, with 17.4 percent of Savannah's population, the corresponding percentages for whites, Hispanics, and blacks are 19.3, 22.9, and 14.3. Note that the white population is experiencing relatively more noise than the black population. Meanwhile, in the least noisy area, with 23.5 percent of the population in Savannah, the corresponding percentages for whites, Hispanics, and blacks are 32.4, 22.7, and 12.5. The inequality coefficients for whites, Hispanics, and blacks, shown in Table 3, are 0.06, 0.02, and -0.10. Similar to Athens, the Hispanic population in Savannah experiences noise similar to the overall population.

Turning to Valdosta, Figure 10 shows that the distribution of population by noise level is similar for whites and Hispanics, while blacks have a pattern that is similar to its pattern in most other MSAs. Table 2 shows that in the most noisy area, with 13.2 percent of Valdosta's population, the corresponding percentages for whites, Hispanics, and blacks are 9.0, 14.2, and 18.8. Meanwhile, in the least noisy area, with 17.5 percent of the population in Valdosta, the corresponding percentages for whites, Hispanics, and blacks are 18.7, 22.7, and 14.9. The inequality coefficients for whites, Hispanics, and blacks, shown in Table 3, are 0.12, 0.08, and -0.17. Thus, one finds that whites and Hispanics experience disproportionately less noise than the population overall, while blacks experience disproportionately more noise.

The final MSA that we examine, Warner Robins, has a distribution of population by noise level that is quite similar for all groups. This is shown in Figure 11. Table 2 shows that in the most noisy area, with 21.1 percent of the population in Warner Robins, the corresponding percentages for whites, Hispanics, and blacks are 20.1, 15.9, and 24.2. Meanwhile, in the least noisy area, with 20.9 percent of the population in Warner Robins, the corresponding percentages for whites, Hispanics, and blacks are 22.0, 15.3, and 19.3. The inequality coefficients for whites, Hispanics, and blacks, shown in Table 3, are 0.05, -0.01, and -0.09. Similar to Athens and Savannah, the Hispanic population in Warner Robins experiences noise similar to the overall population.

Overall, across all MSAs that we examined, whites bore smaller shares of noise than blacks. Generally speaking, but not without exception, Hispanics bore noise level shares between whites and blacks.

Generally speaking, our inequality coefficients are suggestive of whether a specific population is exposed to more or less than the average noise levels in an MSA or state. For example, all the white inequality coefficients in Table 3a are positive and all the average noise levels for the white population are less than the average for the total population in table 3b. Similarly, all the black inequality coefficients are negative and the average noise levels for the black population are more than the average for the total population. An exception to this generality exists for the Hispanic population in Savannah; the inequality coefficient is slightly positive, while the average noise level experienced by Hispanics slightly exceeds the average noise level in this region. Such a possibility can only arise in a case in which the distribution of noise for a group is at times below and at other times above the distribution for the region's entire population. See Figure 10 to see this case for Savannah.

Means Tests

We perform two sets of differences in means tests to reinforce our suggestive results. One set is focused on mean noise differences between a group and the overall state /MSA population, while the other set is focused on mean noise differences between groups. As shown in Table 3c, for the state as a whole and for each MSA the average noise exposure for the white population is less than the total population and the average noise exposure for the black population exceeds the total population. All these differences are statistically significant. Meanwhile, the results for Hispanics are mixed. For the state as a whole and for Atlanta, Dalton, Gainesville, and Macon the average noise exposure for the Hispanic population exceeds the total population, while the reverse is the case for Albany. For four MSAs (Athens, Savannah, Valdosta, and Warner Robins), the results reveal no statistically significant differences.

Turning to the differences between groups, the means tests show that whites experience less noise than blacks for Georgia as a whole and for each MSA. With one exception, a similar conclusion holds for a comparison of whites and Hispanics. The exception is that there is no statistically significant difference for Warner Robins. For the comparison of blacks and Hispanics, generally speaking, blacks experience more noise than Hispanics. The exceptions are for Gainesville, where blacks experience less noise than Hispanics, and for Warner Robins, where there is no statistically significant difference.

Methodology Underlying Regression Analysis

Fotheringham, et al. (1998) and Fotheringham, et al. (2002) provide general background on LWR. Consider a regression model that is estimated locally, around each point in the dataset, called a "target point" (in our case, the target point is a centroid of a particular Census tract). More specifically, LWR can be thought of as a version of weighted least squares, where such a regression is carried out at each target point. This allows for there to be different parameter estimates at each target point, which is a way to allow for nonlinearities in the relationships between the explanatory variables and the dependent variable. This technique is sometimes referred to as a kernel smoothing estimation approach. If in fact the true model is one where all parameter estimates are the same (i.e., if OLS is the true model), then the parameter estimates across all target points will be equal for a given explanatory variable, implying that OLS could be a special case of LWR.

Since LWR is a version of weighted least squares, an important consideration is how to define the weights. McMillen and Redfearn (2010) have noted that in general, the estimation results are quite robust to the choice of kernel weights. A common choice is the Gaussian kernel. The results are typically quite sensitive to the bandwidth selection, on the other hand. There are some canned routines that select the optimal bandwidth, using a given kernel weights structure, as in the GWR routine in Stata (which is the approach we use in our estimations).

More formally, the LWR estimator for a given target point, *i*, can be written as follows:

$$\widehat{\beta_i} = (X'PX)^{-1}X'PY,$$

where $P \equiv w_{ij}'w_{ij}$,

$$w_{ij} = \left(\frac{1}{\sqrt{2\pi}}\right)e^{-(\frac{d_{ij}}{b})^2},$$

b is the bandwidth and d_{ij} is the Euclidean distance between points i and j.

We considered the following set of statistical models. We used LWR, with cross-validation used to generate the appropriate bandwidth, to regress 2017 total noise (i.e., airport and road noise, expressed as a continuous variable) in a Census tract, against 2011 Census tract house value, 2011 vacancy rates (to control for supply factors), 2011 average house age, 2011 average number of housing units, 2011 average number of rooms in housing units, 2011 population, and 2011 Census tract demographics (i.e., percent black, percent Hispanic, and income). Lagged independent variables partially mitigate endogeneity concerns. In order to assess whether there was a symmetric relationship between renters and noise as compared with owners and noise, we swapped 2011 Census tract house value with 2011 Census tract gross rent in our second specification. Our final specification included both house value and gross rent.[10] The results of these LWR estimations are presented in Table 4, and maps of the percent black and percent Hispanic coefficient estimates are in Figures 12 and 13.

OLS, Fixed Effects, and Locally Weighted Regressions Results

Our presentation of the results consists of the following. First, we examine the OLS and fixed effects regression estimates in Table 4. Then, we discuss the results from LWR that are summarized in Table 5. Finally, we present our LWR results in several maps to glean insights regarding the spatial heterogeneity of the relationships between different demographic variables and the levels of noise.

In the OLS and fixed effects regressions in Table 4, we present results for 6 different specifications: Specifications 1-3 are identical to the three specifications discussed above for LWR, except that a dummy indicating whether or not a tract is within an MSA has been added. Similarly, specifications 4-6 are identical to the three specifications discussed above, except that MSA fixed effects have been added with a base group of tracts not in MSAs. Since the results are generally quite similar across specifications, we focus on the results for the fixed effects regressions with both the median house value and median rental price included.

The elasticities of noise with respect to price, for both the rental and sales variables, were in the range of 0.64 to 0.77, are highly statistically significant, and very close in magnitude across specifications. This result may seem surprising since it implies that higher priced residential real estate was in noisier areas. However, it was also likely that higher priced real estate was in more urban areas (e.g., Atlanta), which were noisier. Focusing on the last column of Table 4, the elasticity of noise with respect to house age was approximately 0.5 and was highly significant, implying that older houses were in areas with more noise. The coefficients on the vacancy rate and on the household income elasticity were insignificant in all of the OLS and FE specifications that include only house value but do not include the rental value, while these coefficients were statistically significant in several of the rental price only specifications. While the overall population size was generally uncorrelated with noise, the coefficients on the percentages of black or Hispanic population were significant, and quite similar to each other in magnitude. Minorities tended to live in Census tracts with more road and airport noise, and on average, the correlations between percentages of population that are minorities were quite similar across both blacks and Hispanics.

This similarity in the coefficient estimates for black and Hispanic populations, together with the fact that noise levels vary dramatically in Atlanta relative to other parts of Georgia, raises the possibility of heterogeneity in the marginal effects across geographic space. The LWR estimates in Table 5, along with the maps in Figures 12 and 13, enabled us to address this question. Across all tracts, the LWR coefficient estimates for percent black and percent Hispanic have some positive and some negative values. This implies possibilities of both negative and

[10] All variables not in percent form are transformed to logs for regressions.

positive relationships between the percent minority populations in neighborhoods and the associated noise exposure.

For the three reported specifications, there was a substantial amount of variation in the coefficient estimates for the percent Hispanic variable, while somewhat less variation in the percent black variable. The mean of coefficients for the percent black variable was slightly more positive than the mean of the coefficients for the percent Hispanic variable. For example, for LWR model that includes both the log of median house value and gross rent as explanatory variables (Model 3 results in Table 5), the mean of the LWR coefficient estimates for the black percentage and the Hispanic percentage variables were quite close, 0.017 and 0.014, respectively. Noteworthy is the difference in the ranges. The range of the coefficient estimates for percentage Hispanic was between -0.093 and 0.090, with a standard deviation of 0.020. On the other hand, the range of coefficient estimates for the black percentage was narrower, with a low of -0.025 to a high of 0.070 and a standard deviation of 0.010. These descriptive statistics imply that the relationship between noise and the Hispanic population depends notably on the geographic location within Georgia. Meanwhile, the relationship between noise and black population exhibits relatively less variation across the state.

We can also observe some of this heterogeneity in Figures 12a, 12b, 13a, and 13b. These maps are based on the LWR coefficient estimates using model 3. Figures 12a and 12b are maps of the percent black population and black LWR coefficients, respectively; and Figures 13a and 13b are maps of the percent Hispanic population and percent Hispanic LWR coefficients, respectively.

We find that 108 of the 1,967 (5.5 percent) percent black coefficients are negative. Among those negative coefficients, about 75 percent have a magnitude less than 0.002. Compared to the magnitudes of the positive coefficients, 0.002 is miniscule. In terms of qualitative magnitude, a coefficient of -0.002 should imply that, for every percentage point increase in percent black, average noise only declines by 0.2 percent.

For the percent Hispanic coefficients, the situation was a bit different (371 of the 1,967 coefficients were negative, or 18.9 percent), but we have found situations to be a lot more equal for Hispanics across all of our analyses in this paper. Looking at the magnitudes of the negative coefficients, about 25 percent of them have magnitudes larger than 0.02, compared to 50 percent of the positive coefficients. Thus, only about 92 of the 1,967 coefficients have values less than -0.02, while 764 of the 1,967 coefficients have values greater than 0.02

In terms of general trends in Figures 12a, 12b, 13a, and 13b, there was a negative correlation between the percent black coefficients and the black population. Specifically, using the coefficient estimates and the Census tract population shares, we find a negative correlation coefficient of -0.27 that is statistically significant for blacks. In other words, the negative (marginal) effects of increased population share tend to diminish. For Hispanics, we find no statistically significant relationship – thus, the negative (marginal) effects of increased population share tend to be unchanged. When we examine specific MSAs, only for Atlanta do we find that the marginal effects of increased population share tend to diminish and are statistically significant for both blacks and Hispanics. In fact, for all other MSAs we find no statistically significant relationship for Hispanics. For blacks, we find that Dalton, Macon, and Valdosta exhibit results similar to those in Atlanta.

In contrast to the black population, the Atlanta MSA has much more heterogeneity in the Hispanic coefficients. For the coefficients we map – the percent black and percent Hispanic coefficients – the correlation coefficient is 0.3884. While this is positive, it is not exceedingly strong. This positive but moderate correlation can be observed anecdotally in the maps. In many areas the black and Hispanic coefficient estimates appear to move together, but there are some areas where they move in opposite directions to each other.

In the Atlanta MSA, the eastern and western parts of the MSA appear to have had the greatest density of percentage black population. But in examining the LWR coefficient estimates in the Atlanta MSA, the city of Atlanta appears to be somewhat of an oasis compared with surrounding areas in the MSA, with relatively small coefficients on the black percent variable.

The northwest corner of the Atlanta MSA had several of the highest Hispanic percentages in the state, and also had some of the lowest coefficients in the MSA. Thus, there is some evidence of diminishing marginal effects of Hispanic population on noise in the noisiest region of Georgia.

Looking specifically at percent black and percent Hispanic coefficients relative to average noise in the Census tracts, the latter being displayed in Figure 1, the majority of coefficients with the most severe negative implications for disproportionate noise distribution are in rural areas with the least noise. However, noisier areas in many of Georgia's smaller MSAs and in the outskirts of the Atlanta MSA do have coefficients with moderately severe implications. The Albany, Athens, and Macon MSAs together contained 12 of the state's 45 non-Atlanta Census tracts with average noise higher than 30 decibels, as well as some of the most severe percent Hispanic coefficients in the state. The area around the Hartsfield-Jackson airport south of Atlanta is far and away the noisiest area in the state, with average noise above 30 decibels several miles away from the airport in all directions. Coefficients on percent black are almost all above the 60th percentile of coefficients in that 30 decibel-plus area. The situation is not as severe for the percent Hispanic coefficients, but many are still above the median coefficient. As previously discussed, 30 decibels, is a relatively low amount of noise, but a 30 dBA average across an entire Census tract is indicative of very high daily average noise levels within notably sized subregions of the Census tract. In the region around Hartsfield-Jackson airport, for example, many Census tracts have large shares of their total area with *daily averages* exceeding the 60-decibel threshold above which Sørensen et al. (2011) found notable increases in the risk of stroke. Therefore, in many areas where the potential for health-damaging noise exists, our coefficient estimates imply that noise is disproportionately heard by the black population and the Hispanic population to a relatively high degree.

Conclusion

From various geographic perspectives, we examined whether Hispanics and blacks in Georgia bear relatively larger noise burdens from road and air traffic noise than whites.

Combining traffic noise data from the Bureau of Transportation Statistics with various economic/demographic variables, we constructed Lorenz-type curves and estimated OLS and locally weighted regressions to provide basic information about the levels and distribution of noise. Excluding parts of Atlanta, noise levels in average Census tracts were not at levels that likely cause health problems. However, the vast majority of Census tracts contained an area with health-damaging noise levels. Lorenz-type curves reinforced by means tests for MSAs indicated that whites had borne smaller shares of noise than blacks. No straightforward generalization could be made for Hispanic populations. In some MSAs, the Hispanic population share of noise mirrored the share borne by whites, while, in other locations, its share was closer to the share borne by blacks. Then, there were times when it mirrored neither and could have been either less or more than the shares borne by whites and blacks. As a general statement, Hispanics were exposed to noise level shares that fell between whites and blacks.

With noise as the dependent variables in OLS regressions controlling for many other factors, the coefficients on the percentages of both black and Hispanic populations were similar in magnitude and significant. Using LWR, we found substantial variation in the coefficient estimates for the percent Hispanic variable across the state and relatively less variation in the percent black variable. In other words, the range of the coefficient estimates was wider for Hispanics than for blacks. For the Atlanta MSA only, we found a negative correlation between Hispanic population and the LWR coefficient on Hispanic population, while, throughout the state, we found a positive correlation between Hispanic population and the associated coefficients. The marginal effects for the black population percentages tend to decrease across geographic space as population increases. Such a negative relationship appears to be sensible because noise cannot increase indefinitely as population increases; usually, one would expect there to be upper bounds to noise, even in areas with extremely high minority population concentrations.

We emphasize that our findings do not necessarily imply causality or explicit noise discrimination. Instead, we simply find that the Hispanic and black populations tend to be concentrated in relatively noisy areas, with the exceptions being locations where noise is less of an issue or where there are amenities that outweigh the negative effects of noise (e.g. small towns, particularly on the coast). Given that these measures are averages, we can reasonably expect the peak noise (both in terms of time and space) to get rather loud in places with at least moderate average noise levels. In these areas where noise actually matters, particularly in some outlying areas of Atlanta (including the Hartsfield-Jackson airport), the relationship between percent black or Hispanic and noise is positive, and generally moderate to moderate-high relative to other areas. In locations where noise is significant enough to result in possible health effects, there is a disproportionate distribution of noise onto the two minority groups of interest. Relative to areas where noise is likely not damaging to health, the disproportionate distribution is moderate to moderate-high; the less noisy areas tend to contain the extremes of the coefficient distribution. Comparing the two minority groups, the degree of disproportionality tends to be worse for the black population than the Hispanic population.

Finally, these findings that we uncover using LWR underscore the potential usefulness of LWR in unmasking the spatial heterogeneity that exists in many urban settings. OLS techniques are not able to bring out this rich spatial variation in the marginal effects on noise of additional population among various demographic groups. The LWR approach has been, and should continue to be, an important empirical technique in many applied urban and housing economics settings.

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Table 1 - Descriptive Statistics, Census Tract-Level Data for Georgia, USA

Variables	Mean	Standard Deviation	Min	Max
Average Noise (2016-17)	12.6	14.6	0	65
2011 Median House Value	158836	93489.9	20500	992100
2011 Median Gross Rent*	840	266.4	249	1917
2011 Median HH Income	49192	21814.6	5426	188870
2011 Average House Age	28.9	12.4	6	71
2011 Number of Housing Units	2095.1	931.2	54	7092
2011 Median Rooms/Unit	5.7	1.0	3	9
2011 Population	4926	2420	117	19529
2011 Percent Black	32.6	28.4	0	100
2011 Percent Hispanic	8.1	11.2	0	90
2011 Vacancy Rate	11.4	7.3	0	77
2011 MSA Dummy	0.7	0.5	0	1
Number of Observations	1891			

Source: Bureau of Transportation Statistics and Census Bureau

Table 2 - Percent of Population in Most and Least Noisy Census Tracts, 2016

Area	Group	20% Most Noisy	20% Least Noisy
Georgia	Black	24.2%	10.4%
	Hispanic	22.4%	9.3%
	White	10.8%	21.2%
	Total	18.9%	16.0%
Albany	Black	25.2%	14.5%
	Hispanic	11.3%	25.0%
	White	3.8%	29.2%
	Total	16.3%	20.2%
Atlanta	Black	33.7%	12.9%
	Hispanic	15.7%	13.5%
	White	7.1%	31.5%
	Total	17.6%	22.0%
Athens	Black	26.8%	15.0%
	Hispanic	16.8%	16.4%
	White	18.6%	30.0%
	Total	21.0%	25.0%
Dalton	Black	27.9%	9.2%
	Hispanic	20.5%	7.6%
	White	19.5%	27.7%
	Total	20.3%	19.8%
Gainesville	Black	25.7%	5.5%
	Hispanic	41.4%	15.7%
	White	7.5%	22.6%
	Total	20.8%	18.2%
Macon	Black	16.0%	20.9%
	Hispanic	5.9%	10.8%
	White	6.3%	31.7%
	Total	11.2%	25.3%
Savannah	Black	14.3%	12.5%
	Hispanic	22.9%	22.7%
	White	19.3%	32.4%
	Total	17.4%	23.5%
Valdosta	Black	18.8%	14.9%
	Hispanic	14.2%	22.7%
	White	9.0%	18.7%
	Total	13.2%	17.5%
Warner Robins	Black	24.2%	19.3%
	Hispanic	15.9%	15.3%
	White	20.1%	22.0%
	Total	21.1%	20.9%

Source: Census Bureau, Bureau of Transportation Statistics, and author's calculations

Table 3a - Inequality Coefficient

	Coefficient		
Area	White	Hispanic	Black
Georgia	0.14	-0.13	-0.19
Albany	0.28	0.12	-0.17
Atlanta	0.21	-0.09	-0.22
Athens	0.07	0.01	-0.15
Dalton	0.11	-0.19	-0.25
Gainesville	0.14	-0.18	-0.13
Macon	0.18	-0.13	-0.12
Savannah	0.06	0.02	-0.10
Valdosta	0.12	0.08	-0.17
Warner Robins	0.05	-0.01	-0.09

Source: Census Bureau, Bureau of Transportation Statistics, and author's calculations

Table 3b – Average Noise by Population Group

	Average Decibel Level			
Area	Total	White	Black	Hispanic
Georgia	12.39	8.62	18.00	14.42
Albany	13.67	8.17	17.41	11.44
Atlanta	17.21	11.76	24.59	18.45
Athens	16.31	15.13	19.02	15.71
Dalton	6.82	6.07	8.71	7.93
Gainesville	11.82	8.70	14.23	16.19
Macon	9.41	7.47	11.14	10.36
Savannah	14.53	13.64	15.78	14.64
Valdosta	10.49	8.55	13.18	10.00
Warner Robins	8.18	7.90	8.71	8.30

Source: Census Bureau, Bureau of Transportation Statistics, and author's calculations

Table 3c – Differences in Means Hypothesis Tests

	Differences from Total			Differences between Groups		
Area	White - Total	Black - Total	Hispanic - Total	White - Black	White - Hispanic	Black - Hispanic
Georgia	-3.772***	5.608***	2.034***	-9.380***	-5.806***	3.574***
	(0.009)	(0.011)	(0.010)	(0.010)	(0.009)	(0.012)
Albany	-5.511***	3.749***	-2.297***	-9.259***	-3.213***	6.046***
	(0.505)	(0.588)	(0.550)	(0.518)	(0.4740	(0.564)
Atlanta	-5.451***	7.380***	1.239***	-12.831***	-6.690***	6.141***
	(0.012)	(0.016)	(0.014)	(0.014)	(0.011)	(0.016)
Athens	-1.178**	2.710***	-0.594	-3.888***	-0.584	3.304***
	(0.554)	(0.547)	(0.524)	(0.545)	(0.531)	(0.524)
Dalton	-0.754*	1.892***	1.107***	-2.646***	-1.861***	0.785*
	(0.393)	(0.420)	(0.387)	(0.418)	(0.385)	(0.412)
Gainesville	-3.114***	2.415***	4.377***	-5.529***	-7.491***	-1.962**
	(0.660)	(0.805)	(0.808)	(0.659)	(0.663)	(0.861)
Macon	-1.944***	1.730***	0.946***	-3.674***	-2.889***	0.785***
	(0.188)	(0.208)	(0.188)	(0.173)	(0.195)	(0.195)
Savannah	-0.888***	1.246***	0.114	-2.134***	-1.002***	1.132***
	(0.210)	(0.191)	(0.202)	(0.200)	(0.210)	(0.191)
Valdosta	-1.943***	2.686***	-0.491	-4.629***	-1.453***	3.177***
	(0.493)	(0.537)	(0.557)	(0.508)	(0.529)	(0.569)
Warner Robins	-0.283	0.530*	0.119	-0.813***	-0.402	0.411
	(0.270)	(0.272)	(0.267)	(0.271)	(0.265)	(0.267)

Source: Census Bureau, Bureau of Transportation Statistics, and author's calculations
***(p<0.01); **(p<0.05); *(p<0.10)

Table 4 - Regression Results
Ordinary Least Squares & Fixed Effects

p-values in bold

Dependent variable: log(noise)	**OLS**	**OLS**	**OLS**	**FE**	**FE**	**FE**
log(median house value)	.690***	-	0.637***	0.654***	-	0.636***
	(0.000)	-	**(0.0000)**	**(0.000)**	-	**(0.000)**
log(median gross rent)	-	0.773***	0.6363***	-	0.672***	0.639***
	-	**(0.000)**	**(0.000)**	-	**(0.000)**	**(0.000)**
log(household inc)	0.161	0.282***	-0.031	0.160	0.273**	-0.001
	(0.105)	**(0.008)**	**(0.753)**	**(0.111)**	**(0.012)**	**(0.993)**
log(house age)	0.450***	0.439***	0.497***	0.453***	0.457***	0.488***
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
log(housing units)	0.143	0.584***	0.208*	0.139	0.574***	0.184
	(0.238)	**(0.003)**	**(0.098)**	**(0.263)**	**(0.002)**	**(0.155)**
log(number of rooms)	-1.700***	-1.888***	-1.747***	-1.681***	-1.856***	-1.747***
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
log(population)	0.016	-0.398**	-0.047	0.017	-0.404**	-0.024
	(0.893)	**(0.032)**	**(0.693)**	**(0.890)**	**(0.025)**	**(0.841)**
black percent	0.017***	0.014***	0.015***	0.016***	0.014***	0.016***
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Hispanic percent	0.017***	0.015***	0.0152***	0.018***	0.015***	0.017***
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
vacancy rate	-0.003	-0.010**	-0.003	-0.004	-0.013***	-0.002
	(0.424)	**(0.019)**	**(0.450)**	**(0.373)**	**(0.007)**	**(0.637)**
MSA dummy	1.115***	1.117***	0.966***	-	-	-
	(0.000)	**(0.000)**	**(0.000)**	-	-	-
constant	**-9.199*****	**-6.820*****	**-10.645*****	**-8.780*****	**-6.038*****	**-10.979*****
log(house age)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
R-squared	0.576	0.540	0.591	0.584	0.552	0.598
Log Likelihood	**-2259.6**	**-2353.9**	**-2186.3**	**-2169.8**	**-2330.4**	**-2169.8**
N	1870	1869	1848	1848	1869	1848

Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations
***(p<0.01); **(p<0.05); *(p<0.10)

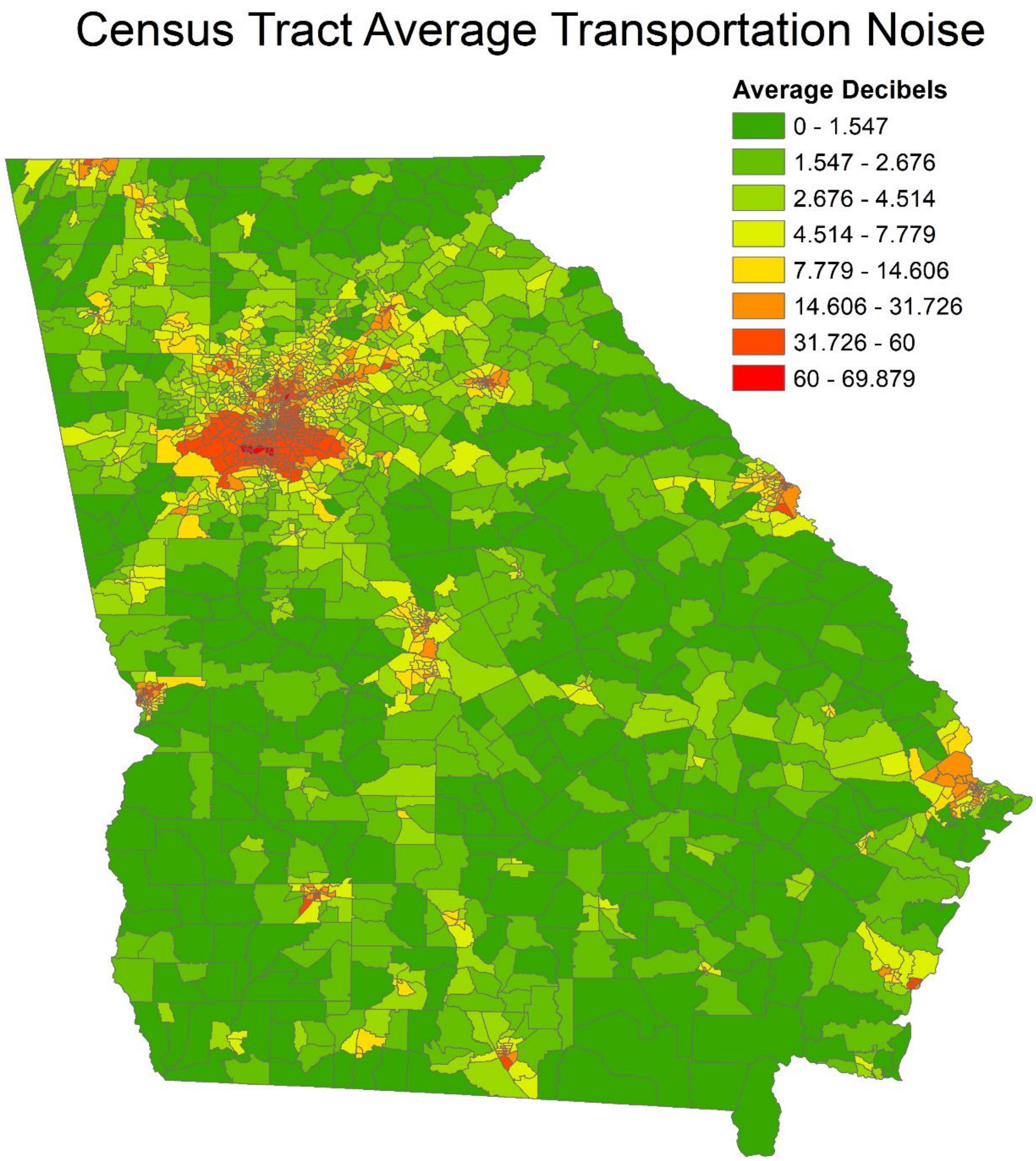
Table 5 - Locally Weighted Regressions Coefficient Results

Dependent Variable: log(noise)

	Model 1					Model 2					Model 3				
	mean	**median**	**st dev**	**min**	**max**	**mean**	**median**	**st dev**	**min**	**max**	**mean**	**median**	**st dev**	**min**	**max**
log(median house value)	0.7215	0.6518	0.4720	-1.7849	2.9011	-	-	-	-	-	0.6787	0.6452	0.4465	-3.2161	2.4659
log(median gross rent)	-	-	-	-	-	0.6403	0.4170	0.7970	-0.8662	2.8949	0.6893	0.4814	0.7329	-0.8690	3.8200
log(household income)	0.0654	0.1700	0.5491	-1.6678	3.7284	0.2880	0.5457	0.6733	-2.4247	5.0264	-0.1102	0.1158	0.5925	-2.2096	4.0818
log(house age)	0.4980	0.4430	0.4149	-1.5897	2.4112	0.4771	0.4445	0.3307	-1.2932	2.2649	0.5064	0.4461	0.3823	-1.6144	2.2102
log(housing units)	0.2802	0.3353	0.9077	-3.4298	6.9305	0.6063	0.3000	1.0188	-1.3785	5.6064	0.3090	0.3202	0.9032	-3.2540	7.1082
log(number of rooms)	-1.8101	-1.4094	1.9516	-14.4142	6.9410	-1.8180	-1.9351	1.9855	-14.7759	6.3883	-1.8135	-1.4646	2.0204	-15.5350	9.8701
log(population)	-0.1720	-0.3243	0.8155	-4.374	3.2786	-0.4857	-0.3158	0.9241	-4.5413	1.9362	-0.2266	-0.3273	0.8168	-4.8948	3.1641
black percent	0.0182	0.0191	0.0097	-0.0218	0.0700	0.0164	0.0164	0.0100	-0.0171	0.0748	0.0173	0.0186	0.0098	-0.0253	0.0698
Hispanic percent	0.0171	0.0180	0.0197	-0.0520	0.1073	0.0104	0.0130	0.0222	-0.1151	0.0928	0.0142	0.0173	0.0204	-0.0930	0.0903
vacancy rate	-0.0185	-0.0171	0.0225	-0.1230	0.0392	-0.0195	-0.0169	0.0202	-0.1075	0.0796	-0.0136	-0.0147	0.0170	-0.0936	0.0433
constant	-6.9522	-6.4613	8.4401	-42.0080	23.5079	-4.6663	-3.6312	7.2047	-43.1340	13.0478	-8.9145	-8.3494	7.4846	-41.3652	16.8334

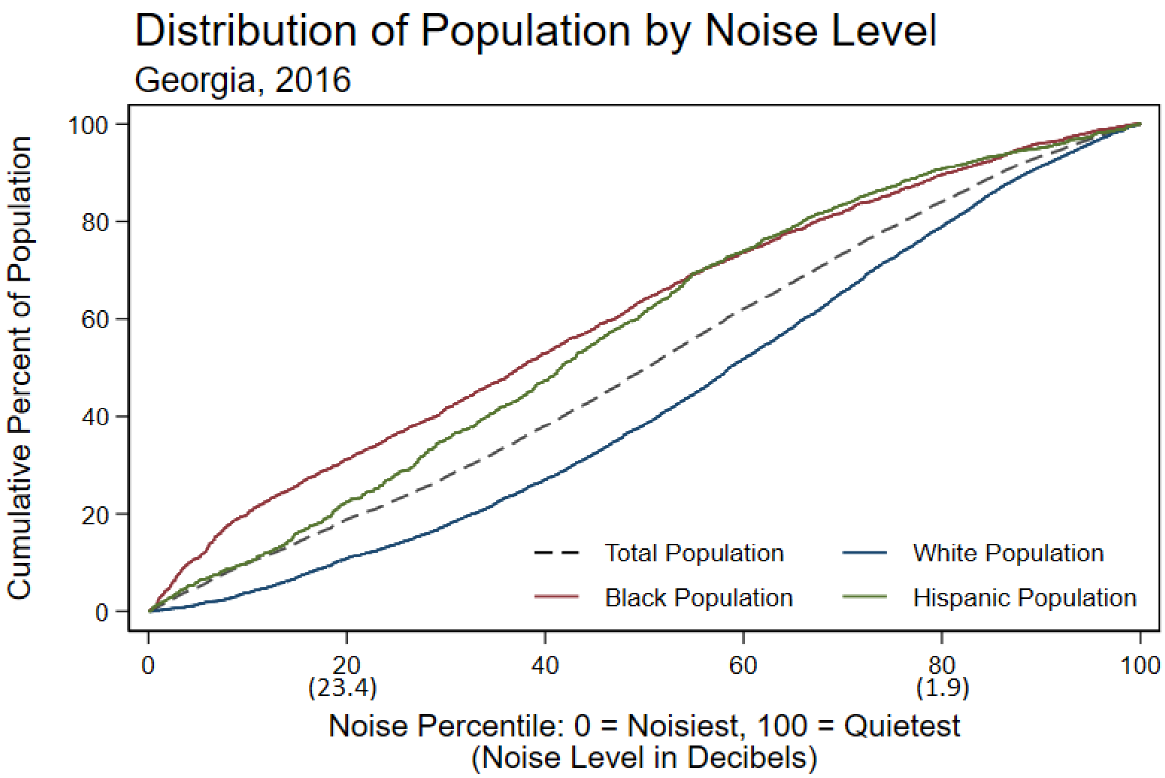
Note: Based on locally weighted regressions run in all 1,967 of Georgia's Census tracts.
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations.

Figure 1



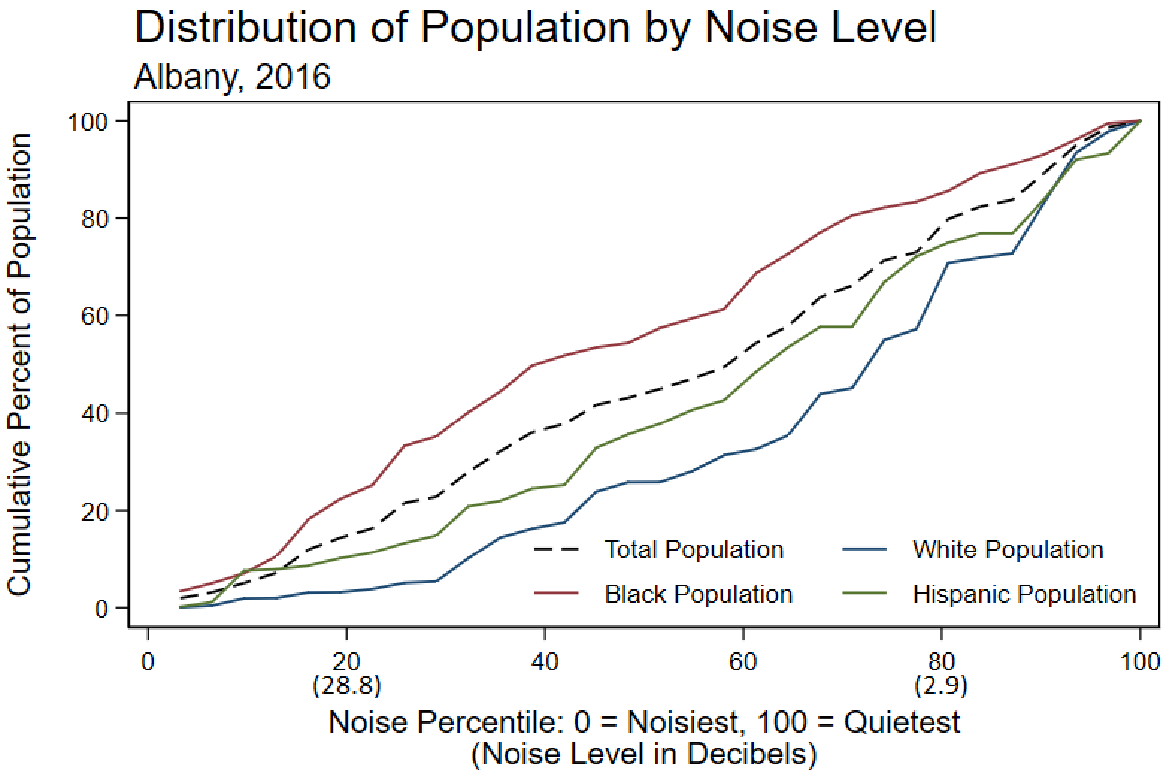
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations.

Figure 2



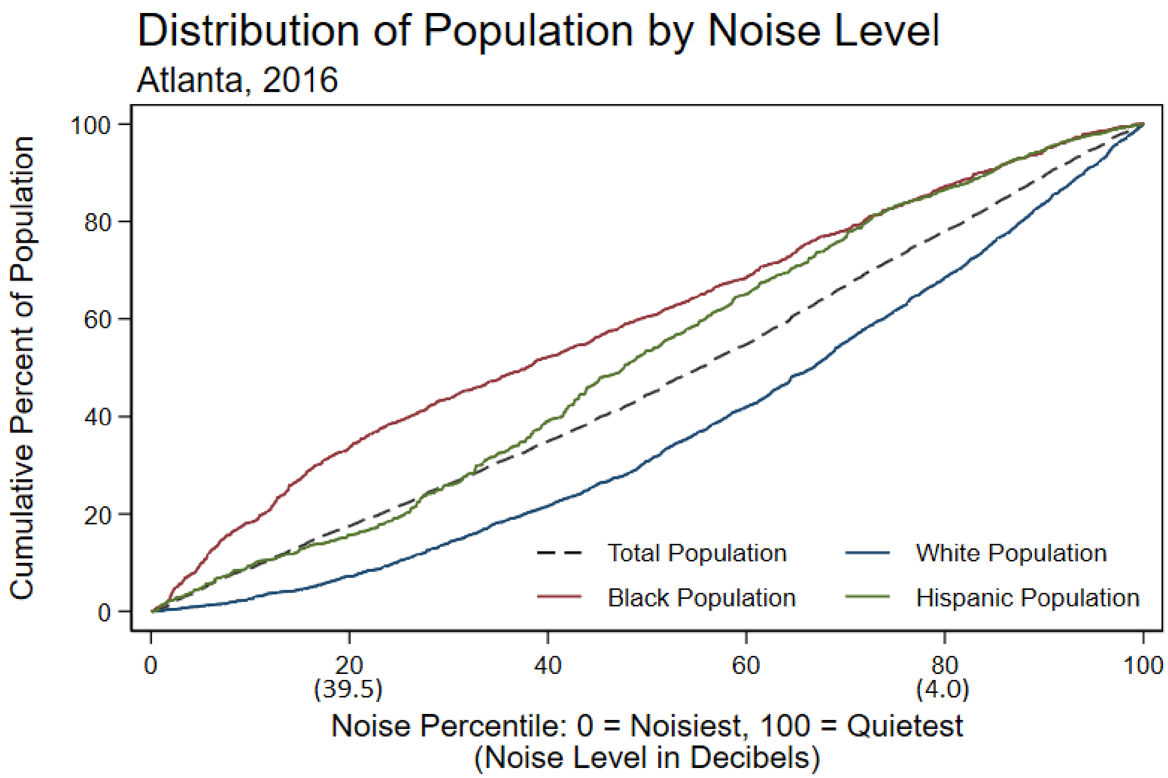
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations

Figure 3



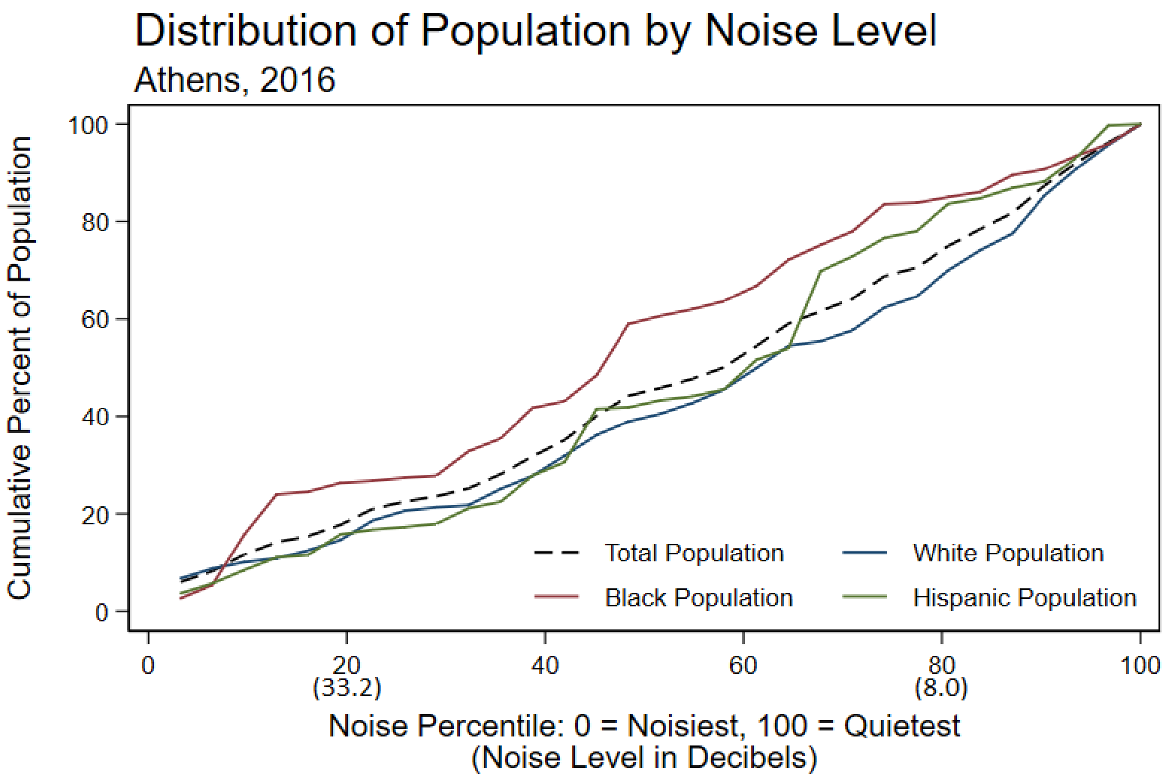
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations

Figure 4



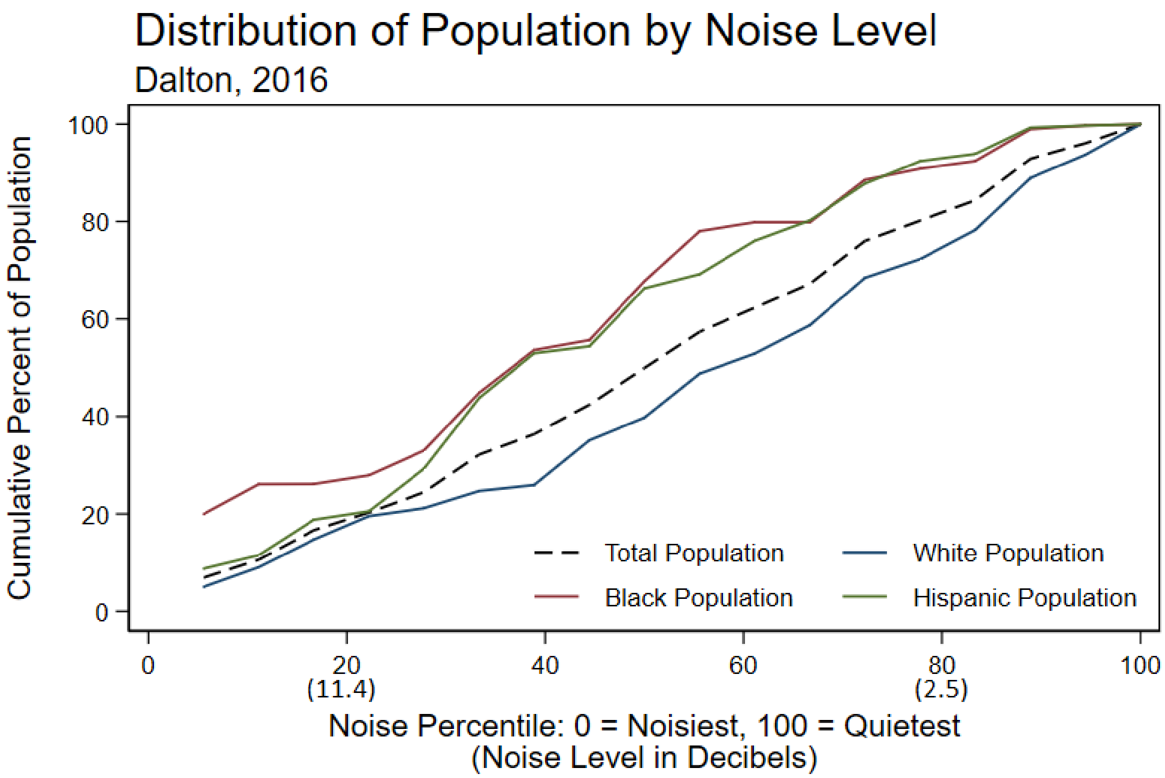
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations

Figure 5



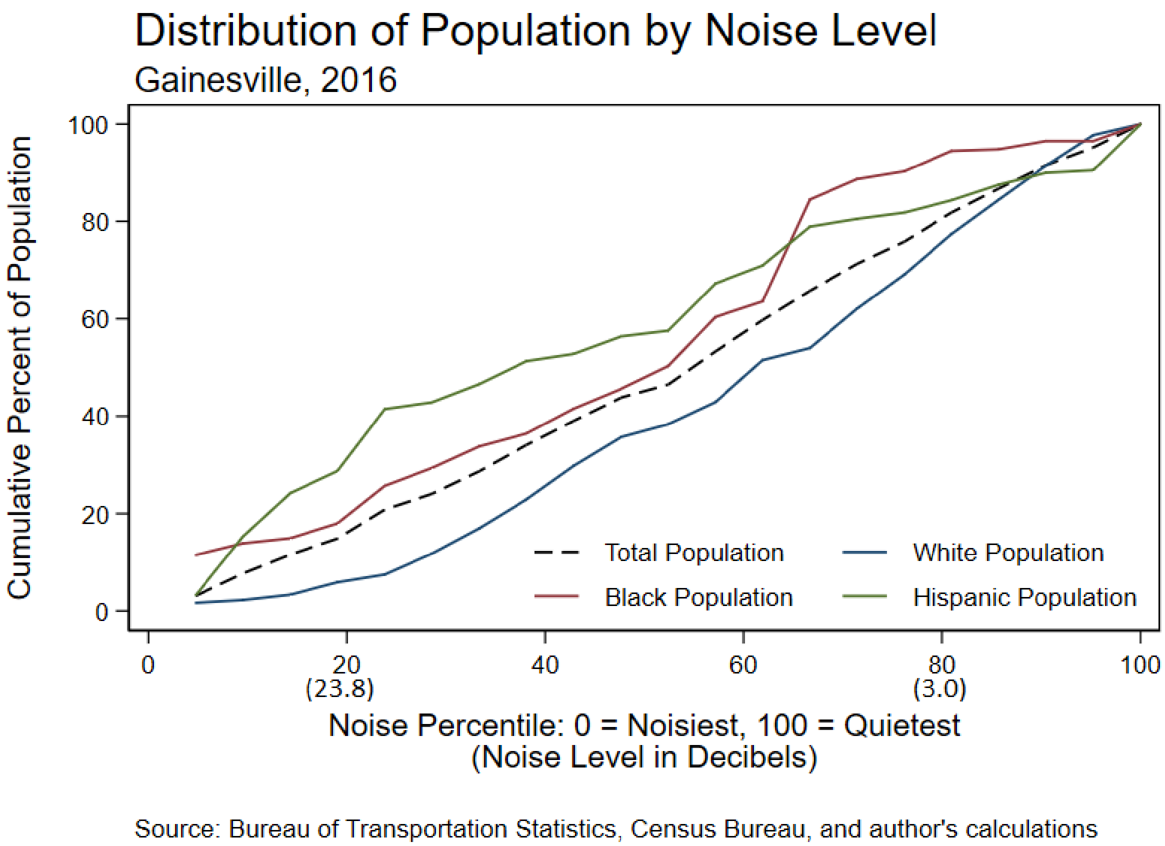
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations

Figure 6



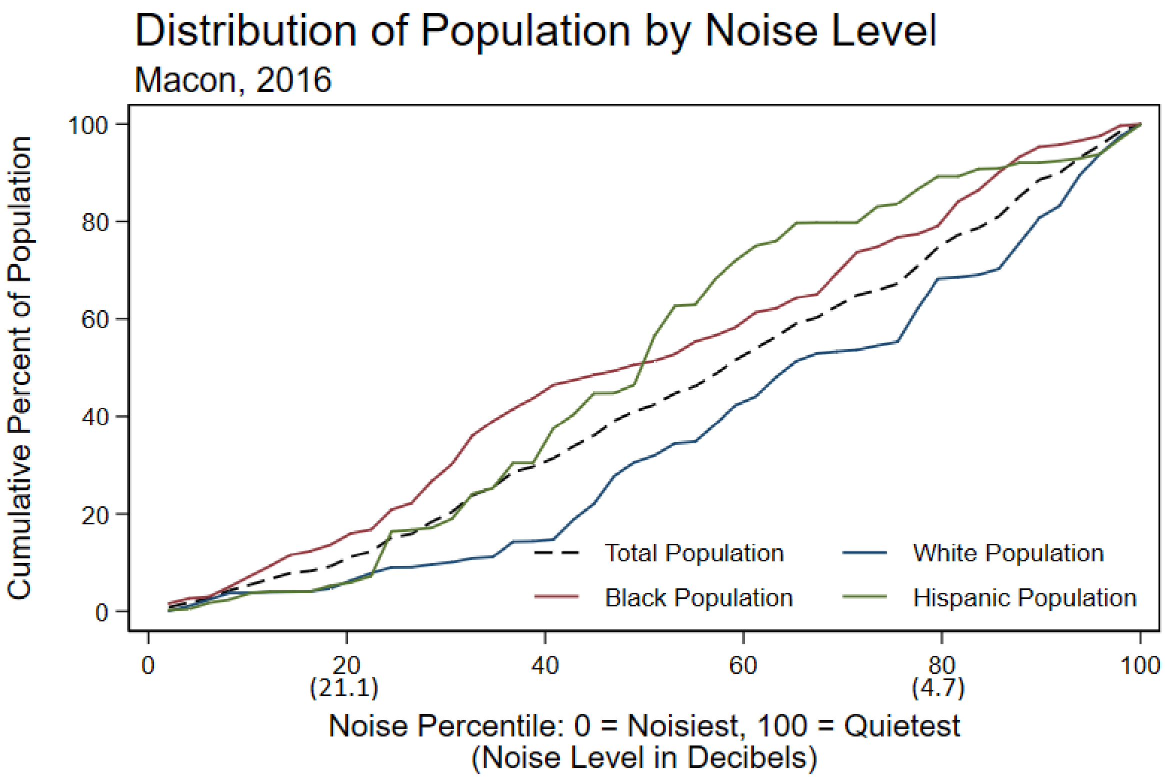
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations

Figure 7



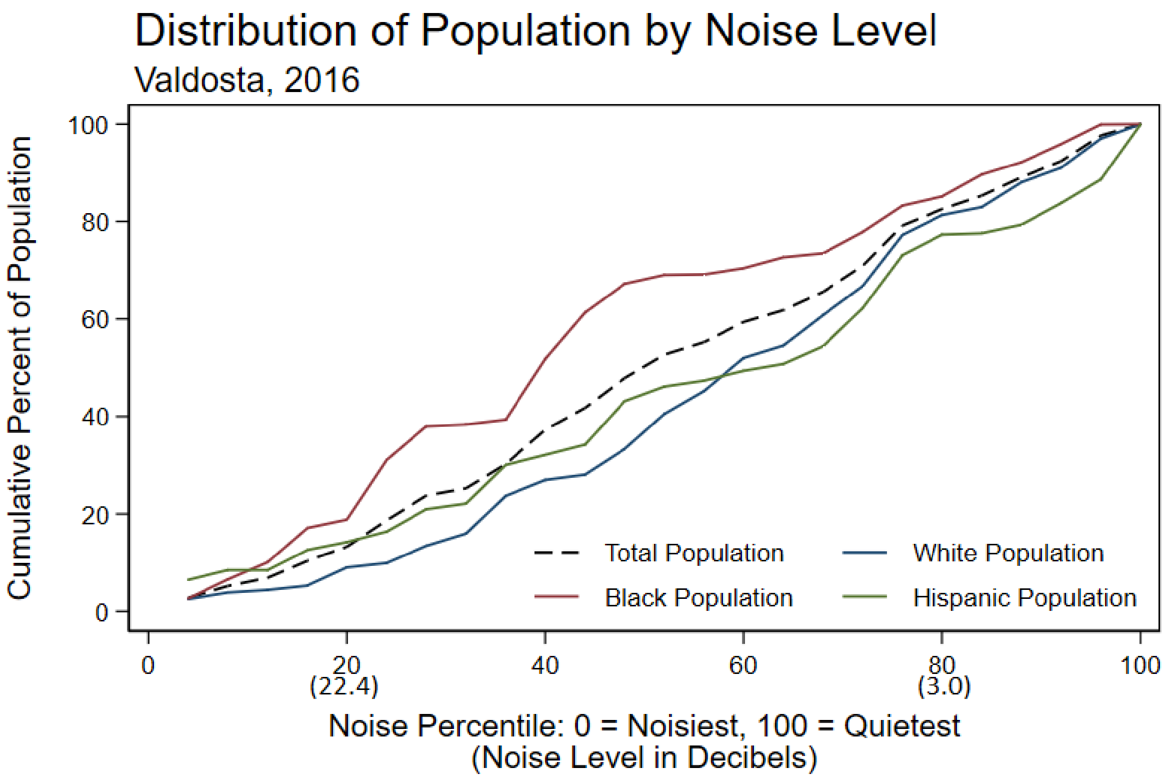
Distribution of Population by Noise Level
Gainesville, 2016
Cumulative Percent of Population
100
80
60
40
20
0
Total Population
White Population
Black Population
Hispanic Population
0
20
(23.8)
40
60
80
(3.0)
100
Noise Percentile: 0 = Noisiest, 100 = Quietest
(Noise Level in Decibels)
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations

Figure 8



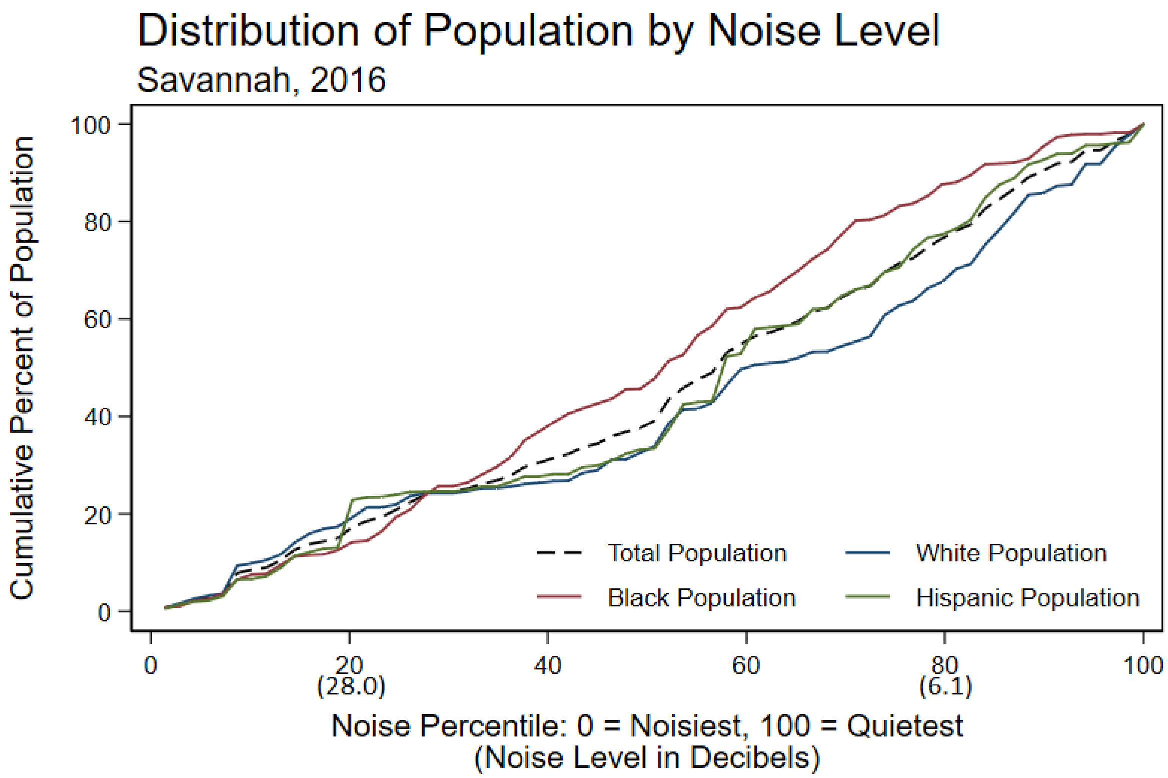
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations

Figure 9



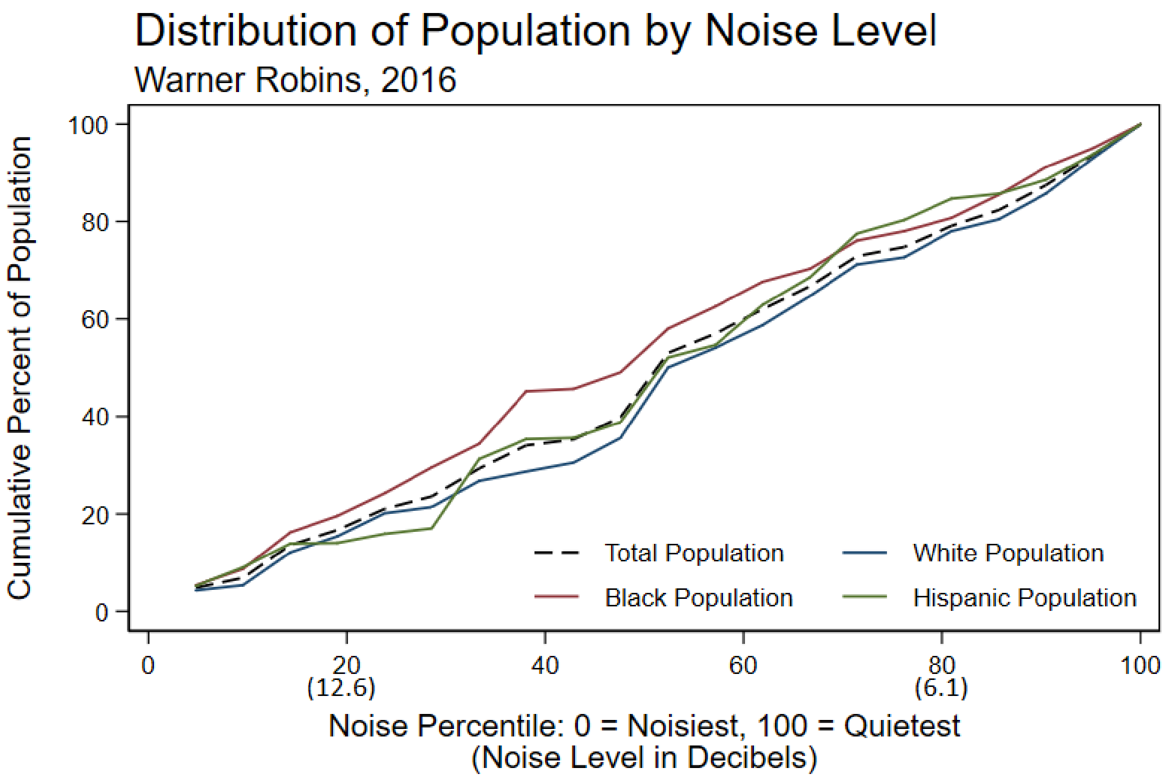
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations

Figure 10



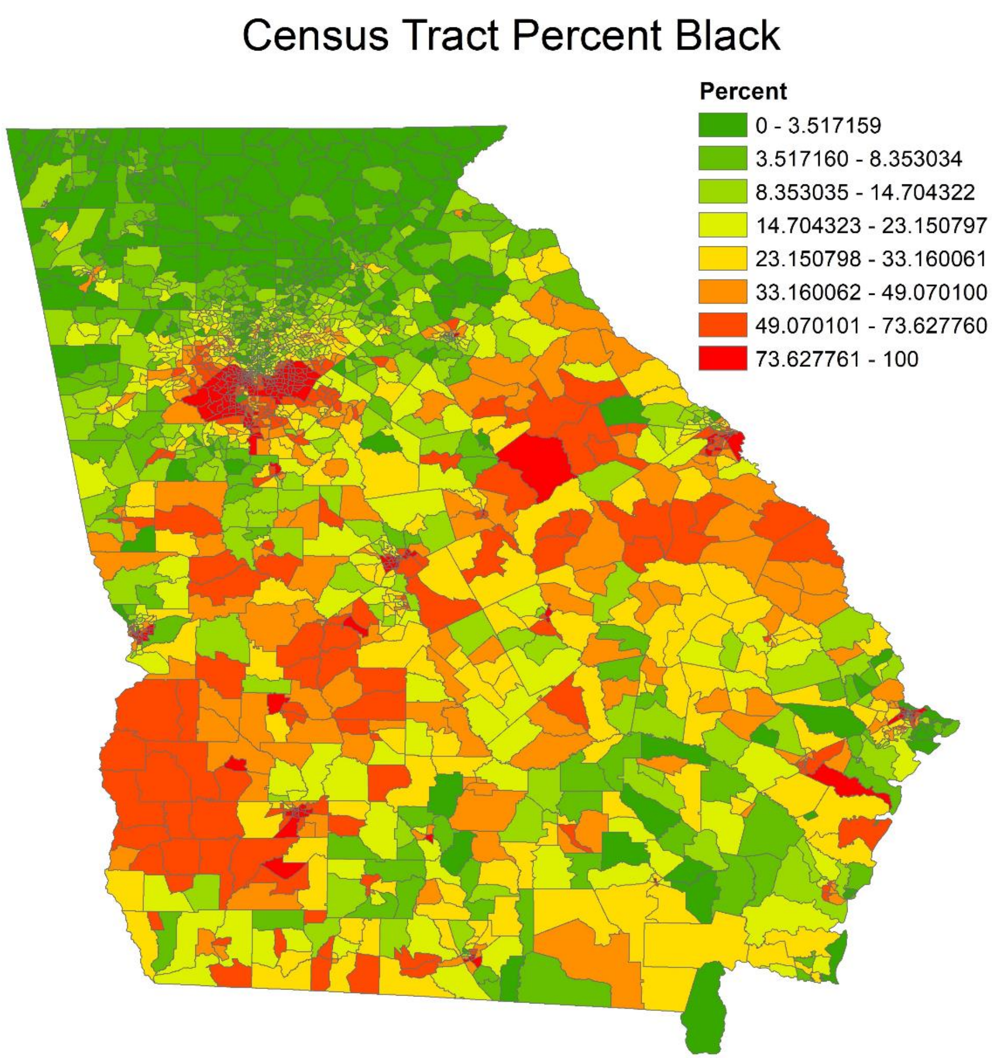
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations

Figure 11



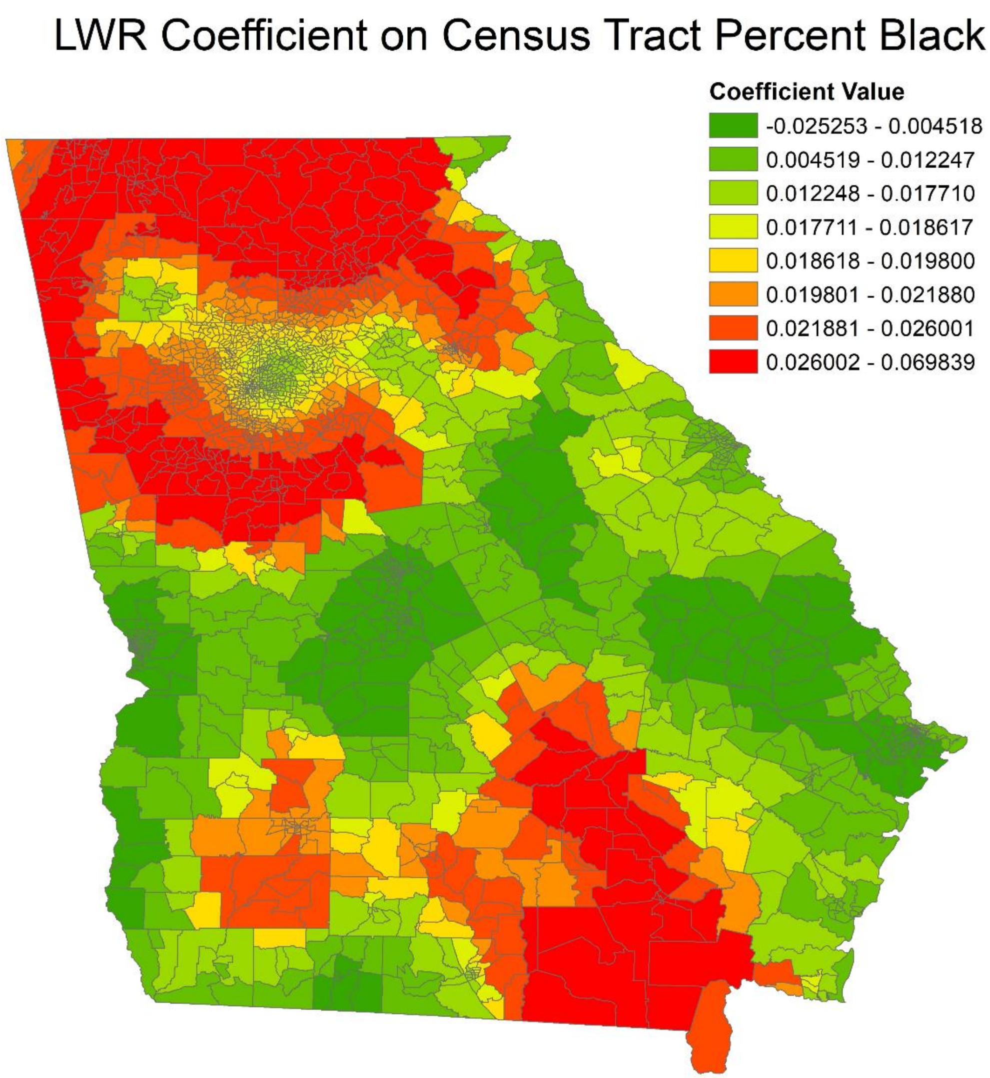
Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations

Figure 12a



Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations.

Figure 12b



Source: Bureau of Transportation Statistics, Census Bureau, and author's calculations

Figure 13a

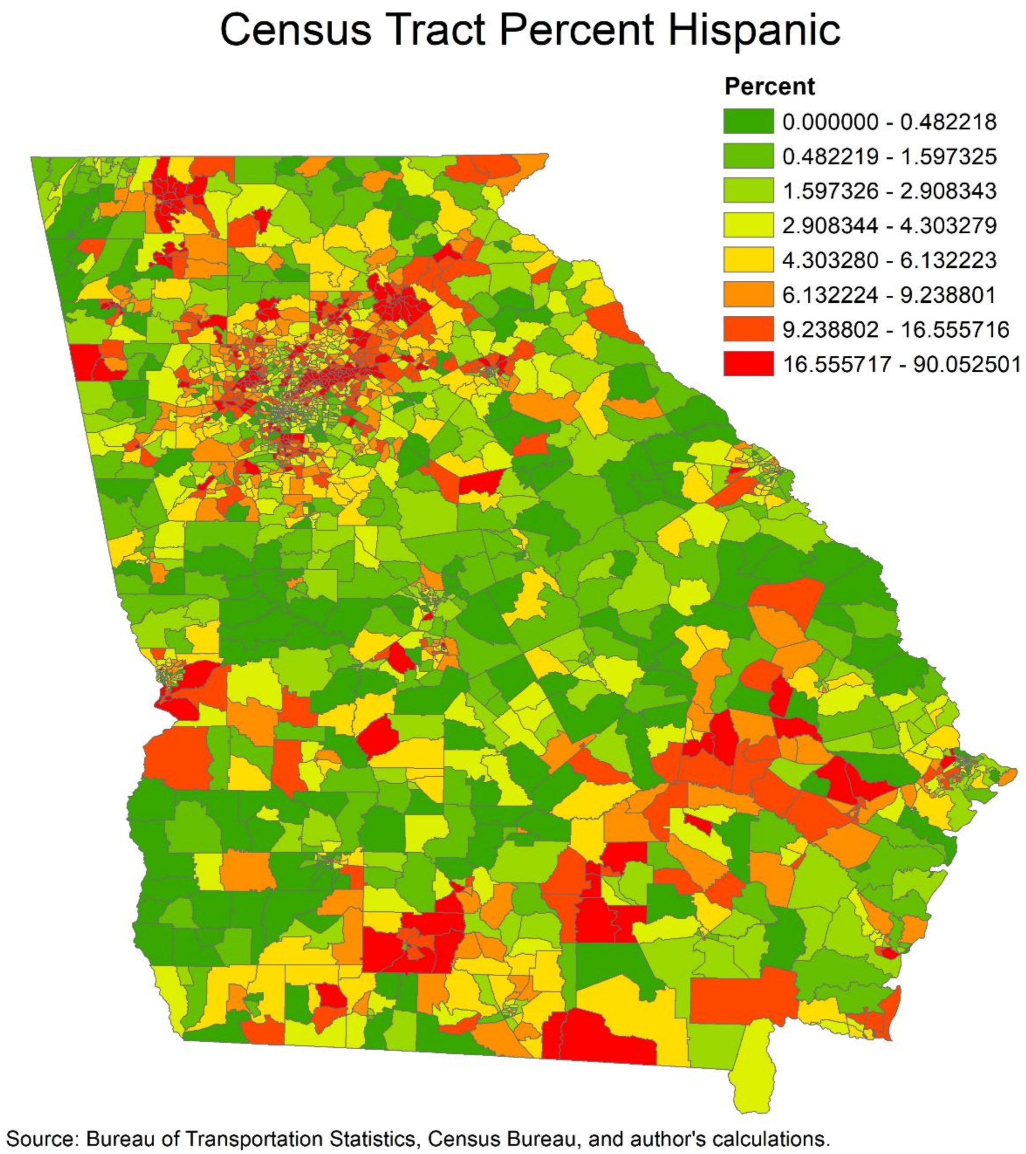


Figure 13b