# Assessing Racial Disparity in Property Assessment in Milwaukee, Wisconsin

Vinnie Palazeti and Brandon Ristoff
STAT 488
November 18, 2020

# Acknowledgements


- Professors
  - Dr. Swarnali Banerjee, Loyola University Chicago
- Client
  - Colin Williams, City of Milwaukee Tax Assessor’s Office

# Outline

1. Description of the Project
2. Background of Assessment Ratio
3. Data Visualizations
4. Geo Mapping
5. Pre-Regression Analysis
6. Correlations
7. Multiple Linear Mixed Models
8. Subpopulation Analysis
9. Conclusions

# Project Background

- “Identifying how market trends differentially impact communities of color and varying socioeconomic status”
- “Determining whether Milwaukee property assessments change disproportionally according to demographic factors”

# Property Assessments

- There has been history of some local governments taxing properties in predominantly black and/or low-income neighborhoods at a greater overall rate than properties in predominantly white and/or high-income neighborhoods
- Although they would be both assessed the same nominal property tax rate, black and/or low-income neighborhood properties would be over-assessed, which would lead to higher overall tax rates for them

Citations: Rothstein, Richard (2017). *The Color of the Law: A Forgotten History of How Our Government Segregated America*. New York / London: Liveright Publishing. pgs. 169-172

Baar, Kenneth. K. (1981). “Property Tax Assessment Discrimination Against Low-Income Neighborhoods.” *Urban Lawyer* 13(3): 333-406

Makovi, Michael, Is There Discrimination in Property Taxation? Evidence from Atlanta, Georgia, 2010-2016 (August 18, 2019). Available at SSRN: https://ssrn.com/abstract=3438838 or http://dx.doi.org/10.2139/ssrn.3438838

# The ATS Ratio

- The assessment-to-sale (ATS) ratio is the metric we are using to test this
- What the mean ATS ratio is not entirely important,  but the what deviations between the ATS ratios is the important part
- An easy way to think about this is when you have a higher ATS ratio, your taxes go up

Citation: Makovi, Michael, Is There Discrimination in Property Taxation? Evidence from Atlanta, Georgia, 2010-2016 (August 18, 2019).
Available at SSRN: https://ssrn.com/abstract=3438838 or http://dx.doi.org/10.2139/ssrn.3438838

# Data

- We were provided with the residential data for newly sold homes in 2018 and 2019 in Milwaukee, Wisconsin
- Number of Observations in Original Dataset: 8,572 observations
- We also imported Census Tract data from the American Community Survey (ACS)

# Data

## Milwaukee City Assessor's Office

- Sale Price
- Assessed Value
- Land Size
- Sale Date
- Building Type
- Year Built
- Quality
- Condition
- Kitchens & Baths

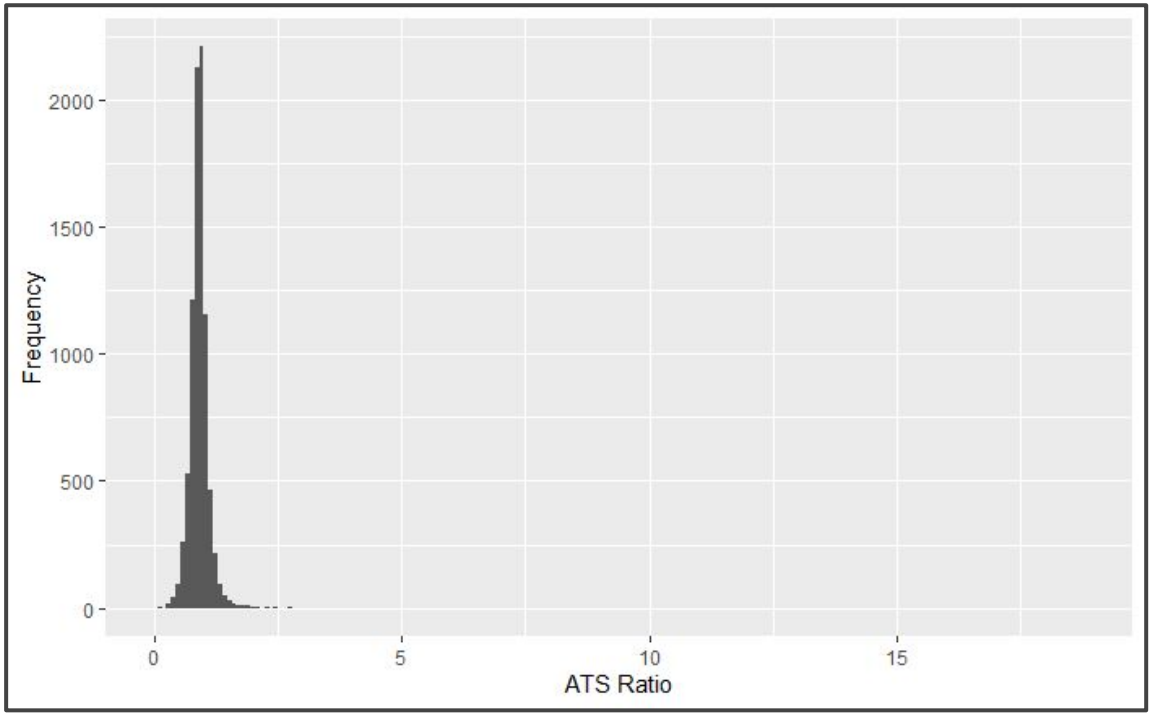
## American Community Survey

- Total Population
- Total Sub-Population
  - Hispanic
  - Non-Hispanic White
  - Black
- Median Income
- Income Below Poverty Rate
- Percent Renter

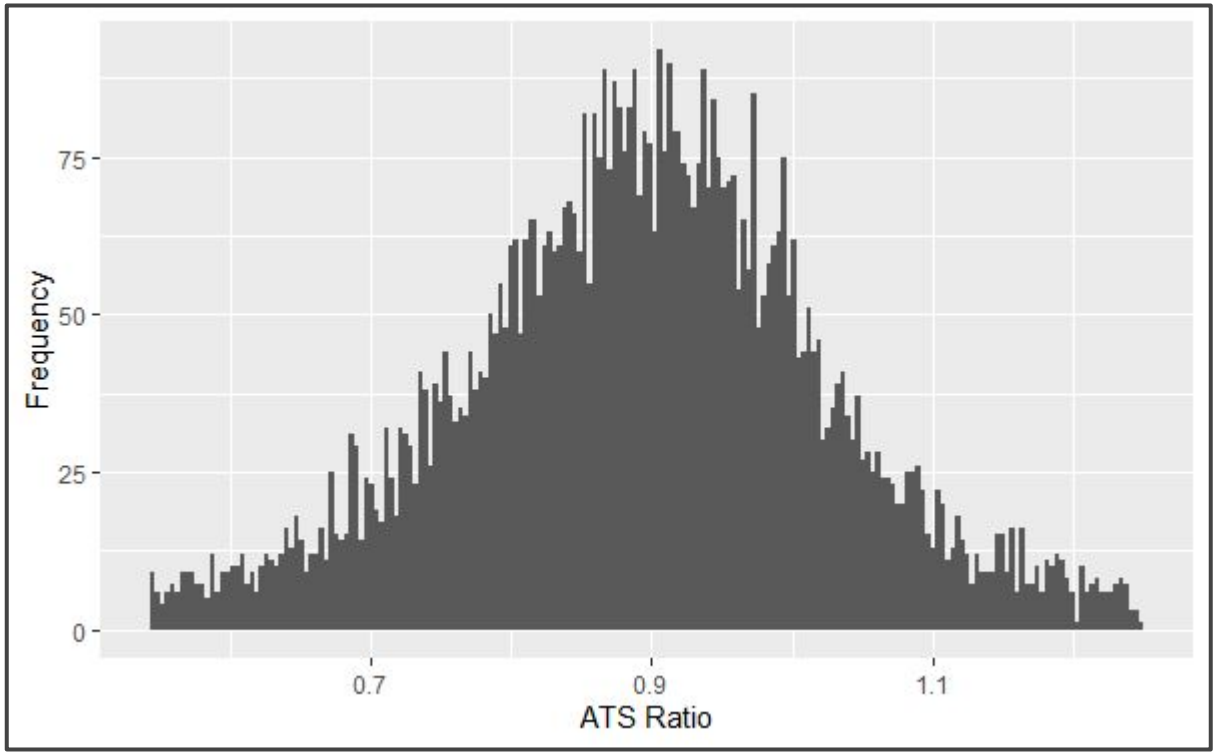
# Cleaning

- We looked to previous work (Makvoi (2019)) to help us consider what observations to filter out (as well as input from Colin)
  - We filtered out implausible values (those below $20,000 and those above $10 million)
  - We also filtered out implausible assessed-to-sale ratios (outside the 1.5xIQR range)
  - We removed observations that were in non-residential zones
  - We removed observations with more than one building on the property
  - We only kept single-family homes in the dataset
- Final Number of Observations after Cleaning: 5,813 observations

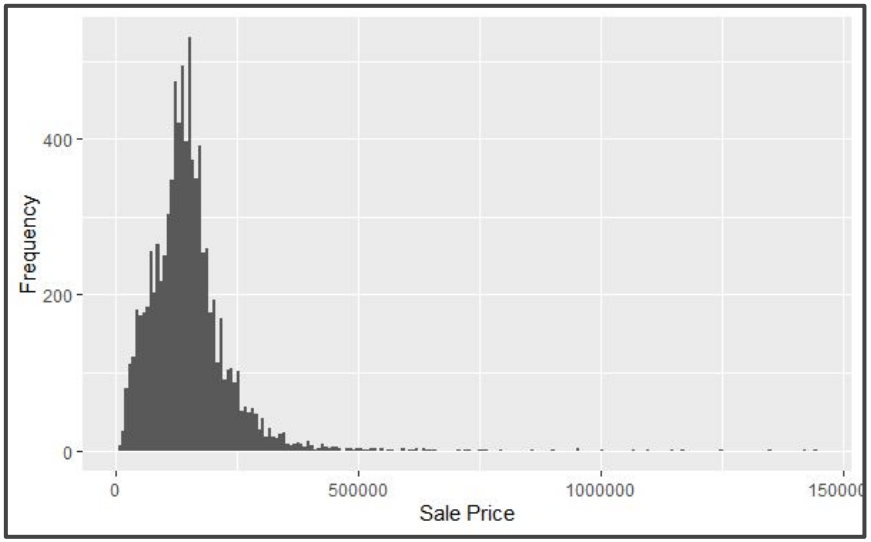
# Data Visualization - ATS Ratio

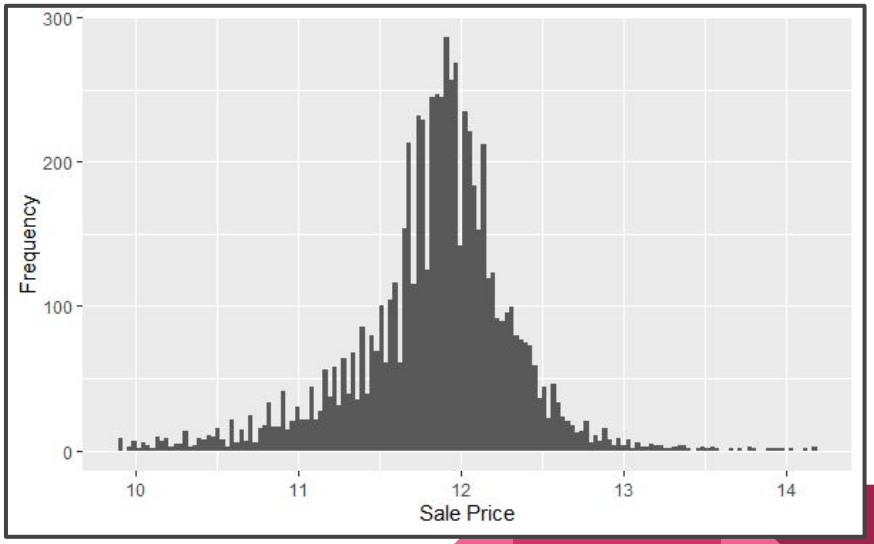


# Data Visualization - ATS Ratio

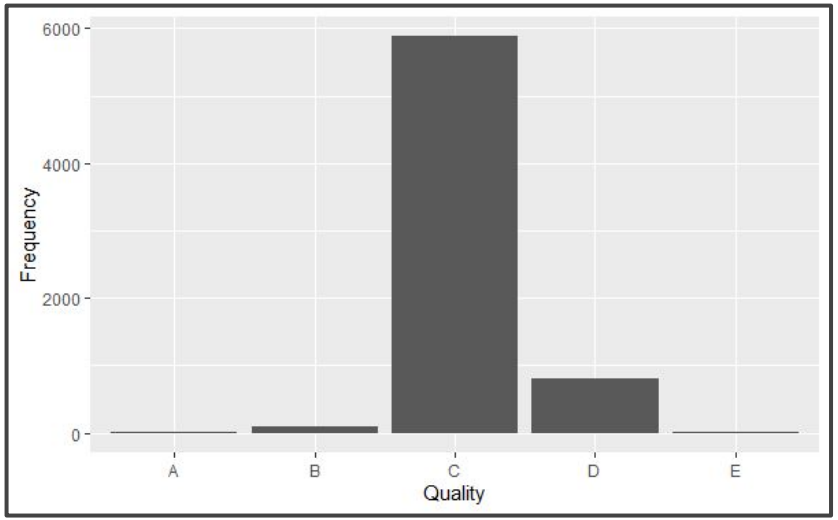


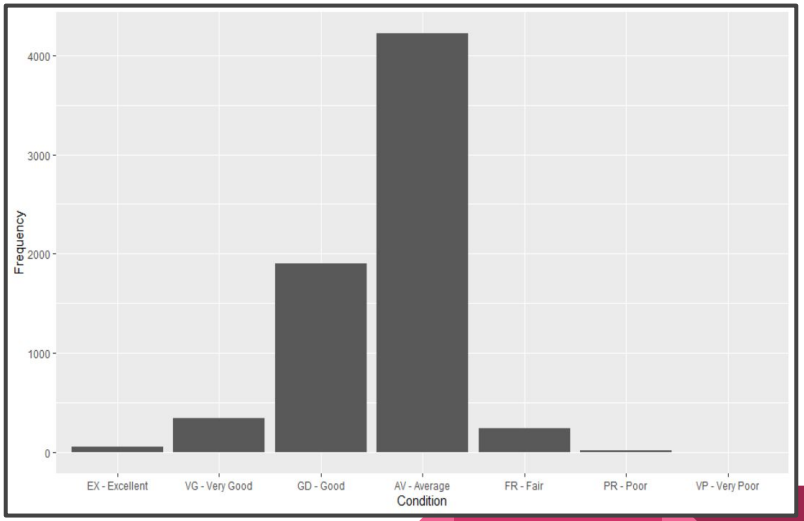
# Data Visualization- Sales Price Histogram



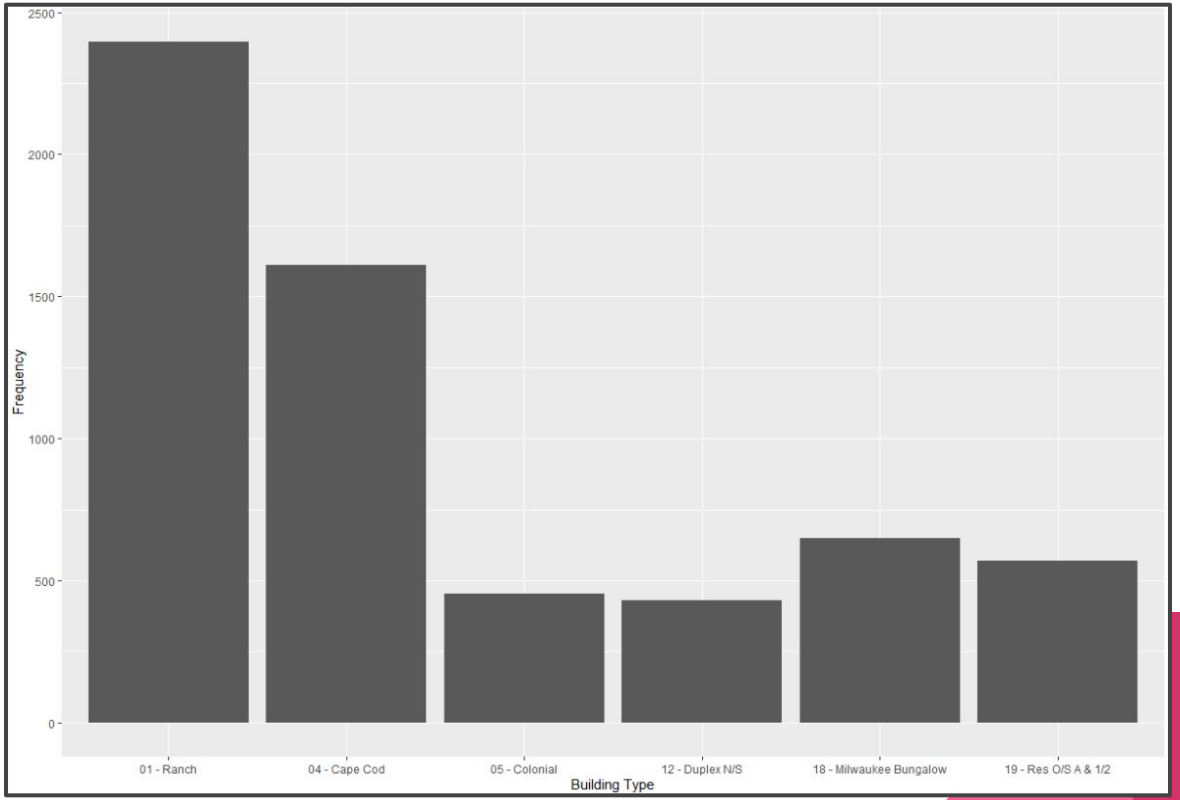



# Data Visualization- Quality and Condition

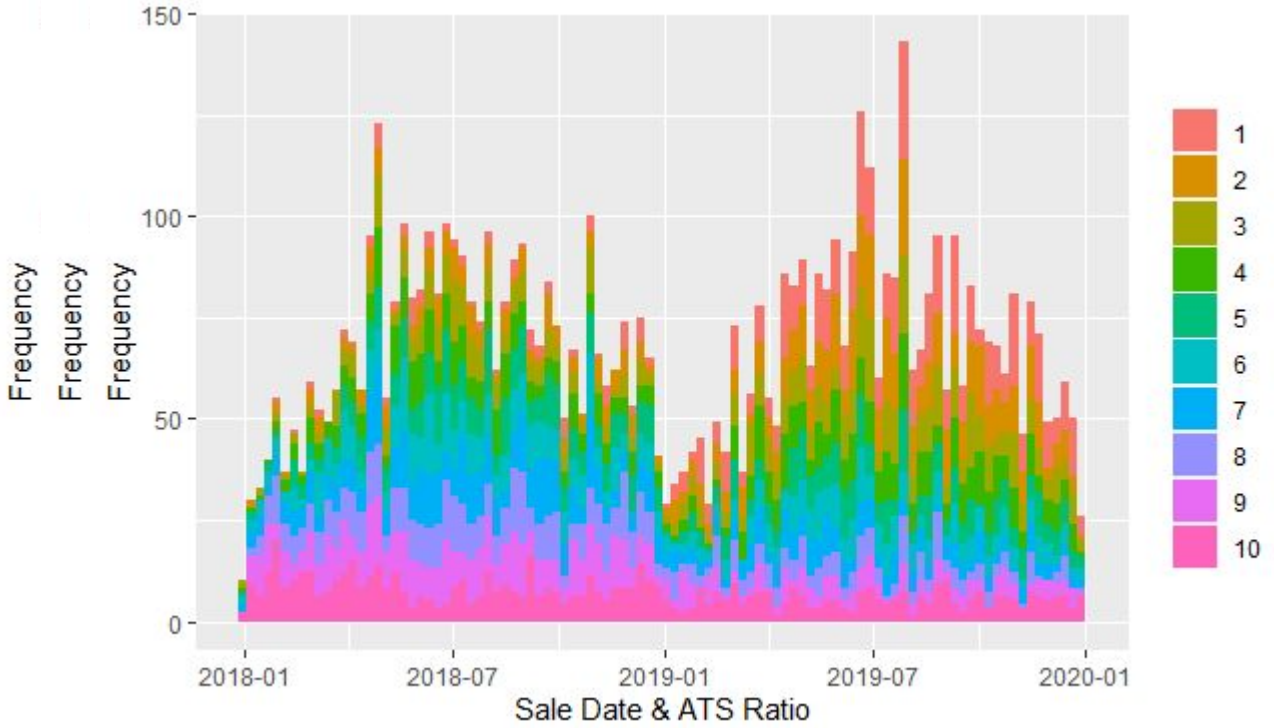


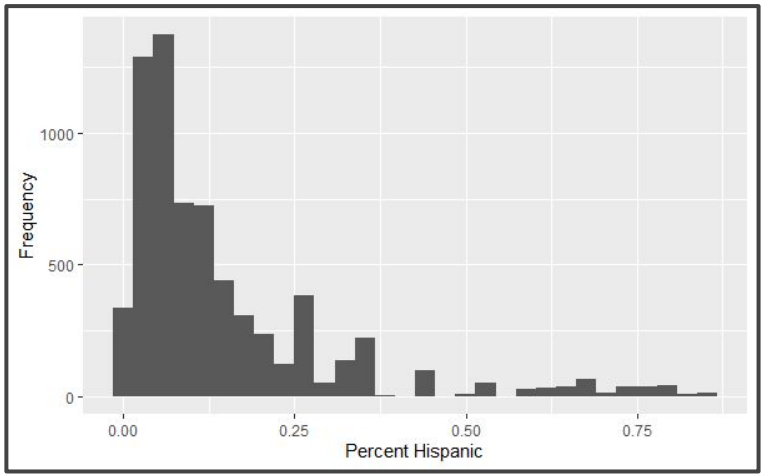
# Data Visualization- Building Type

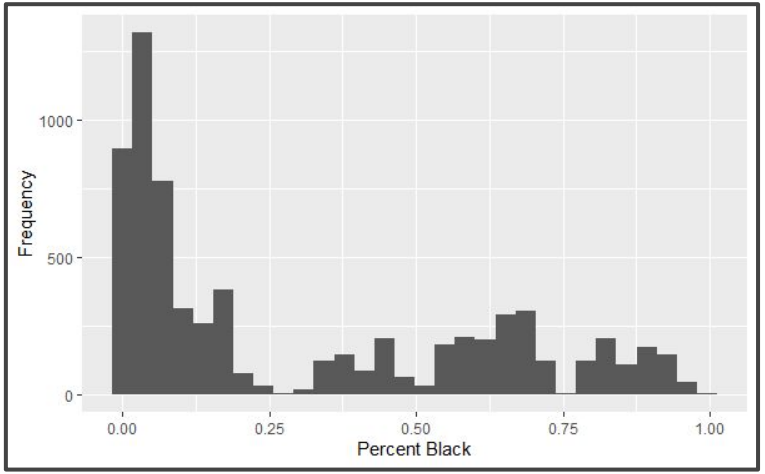


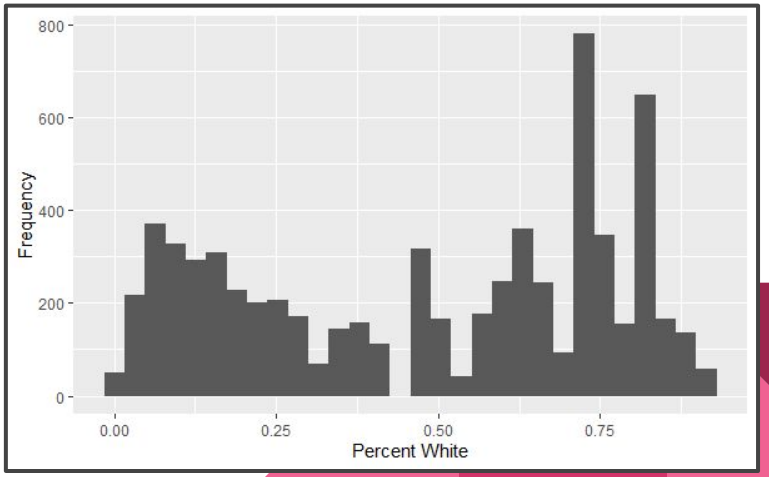
# Data Visualization- Sales Date



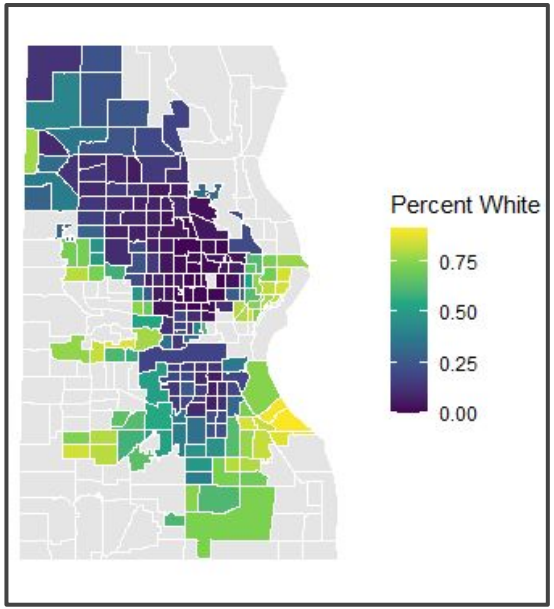
# Population Distributions

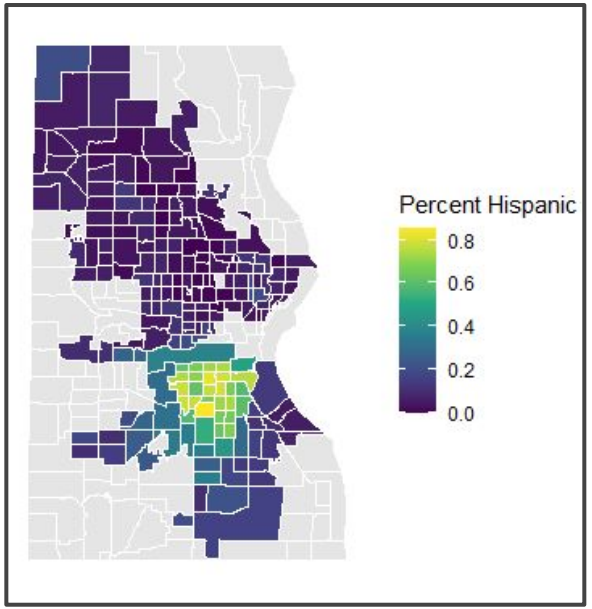


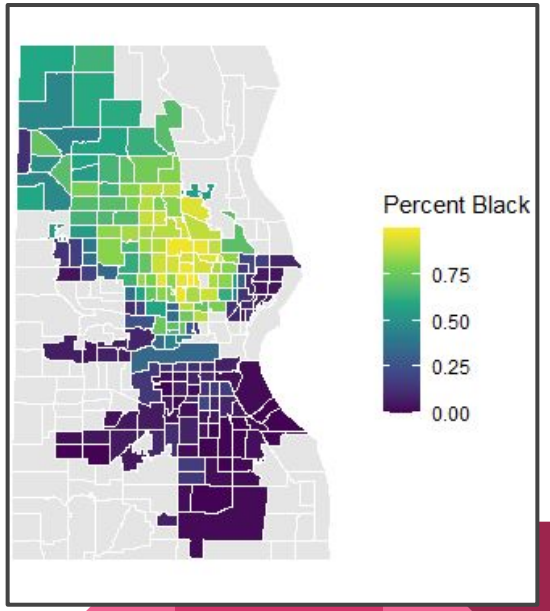



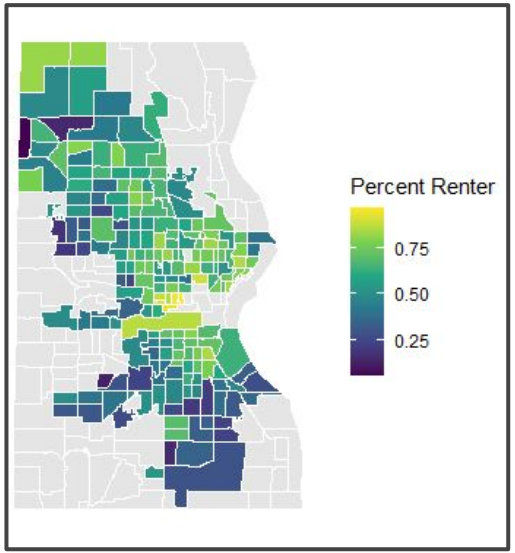
# Geo Mapping- Census Tract Racial Demographics

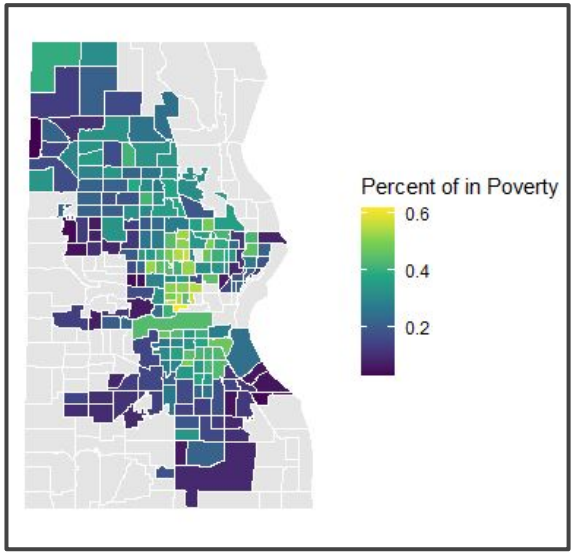


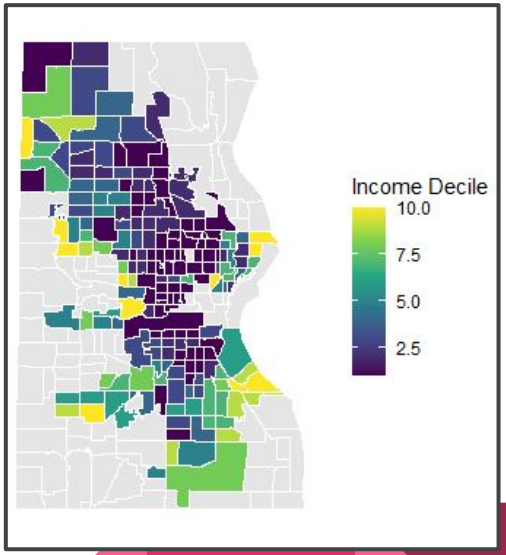



# Geo Mapping- Census Tract Socio-Economic Demographics

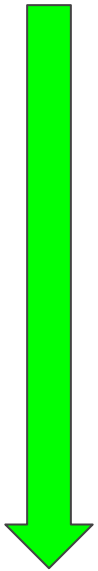


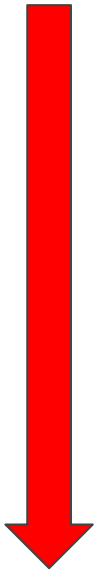



# Median ATS Ratio By Percent Population Deciles

| Black | White | Hispanic |
|---|---|---|
| 1. 0.9149 | 1. 0.8748 | 1. 0.8847 |
| 2. 0.8968 | 2. 0.8695 | 2. 0.9012 |
| 3. 0.8892 | 3. 0.8695 | 3. 0.8992 |
| 4. 0.9038 | 4. 0.8872 | 4. 0.9016 |
| 5. 0.8876 | 5. 0.8948 | 5. 0.8835 |
| 6. 0.9069 | 6. 0.9087 | 6. 0.8988 |
| 7. 0.9014 | 7. 0.9016 | 7. 0.8914 |
| 8. 0.8869 | 8. 0.8999 | 8. 0.9059 |
| 9. 0.8713 | 9. 0.9078 | 9. 0.9073 |
| 10. 0.8695 | 10. 0.9063 | 10. 0.8748 |





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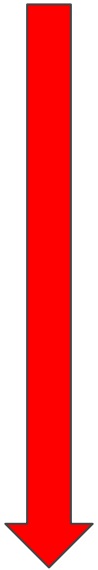
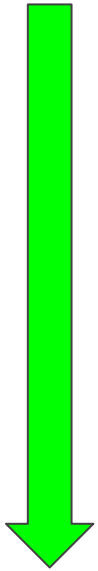
# Median ATS Ratio by Socio-Economic Demographics

| Income Decile | | Sales Decile | | Renter Decile | |
|---|---|---|---|---|---|
| 1. | 0.8830 | 1. | 0.9535 | 1. | 0.8914 |
| 2. | 0.8709 | 2. | 0.9487 | 2. | 0.9011 |
| 3. | 0.8730 | 3. | 0.8965 | 3. | 0.9114 |
| 4. | 0.8937 | 4. | 0.9034 | 4. | 0.8992 |
| 5. | 0.8951 | 5. | 0.9092 | 5. | 0.9111 |
| 6. | 0.8935 | 6. | 0.8959 | 6. | 0.8909 |
| 7. | 0.9059 | 7. | 0.8831 | 7. | 0.8828 |
| 8. | 0.9028 | 8. | 0.8756 | 8. | 0.8806 |
| 9. | 0.9077 | 9. | 0.8605 | 9. | 0.8679 |
| 10. | 0.9068 | 10. | 0.8748 | 10. | 0.9006 |





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# Mann Kendall Trend Test- Test for Monotonic Trend

**Black Population Deciles**
$\tau$ = -0.6
p-value = 0.02

**White Population Deciles**
$\tau$ = 0.6
p-value = 0.02

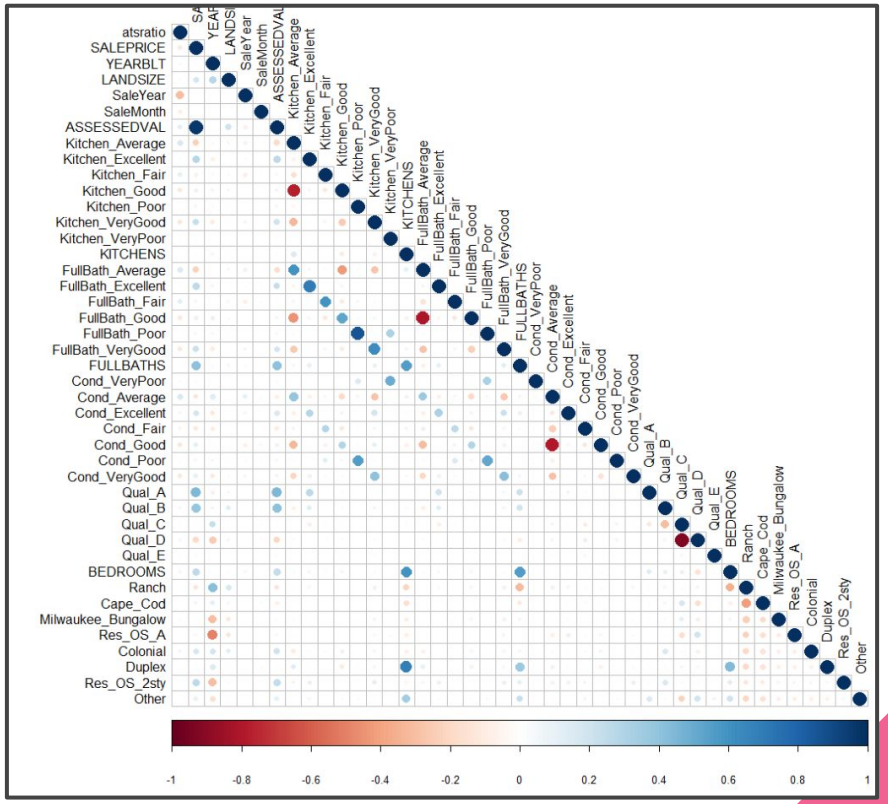
**Hispanic Population Deciles**
$\tau$ = 0.067
p-value = 0.86

**Income Deciles**
$\tau$ = 0.73
p-value = 0.004

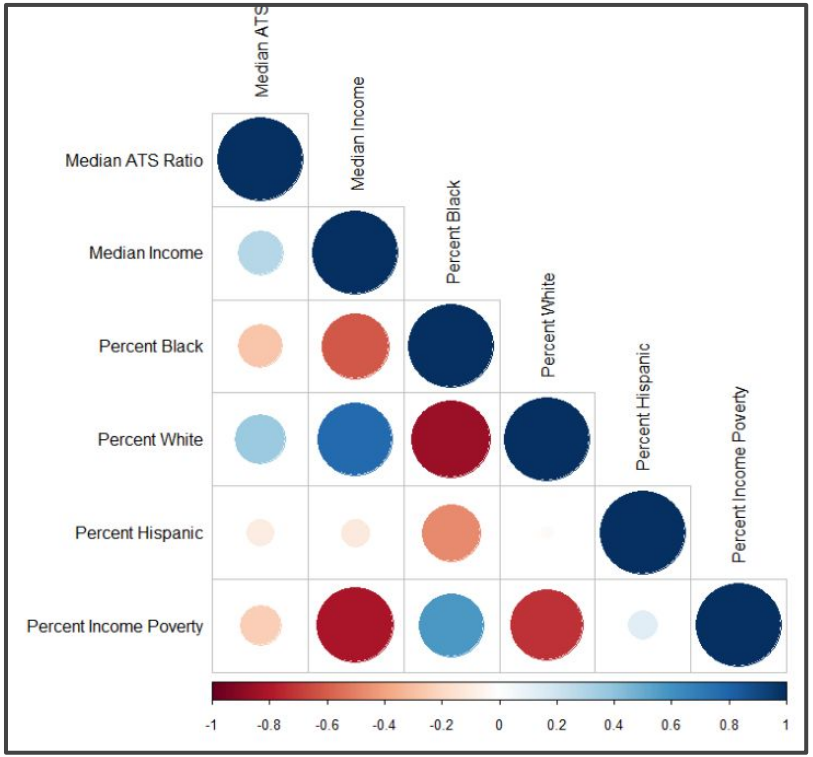
**Sale Price Deciles**
$\tau$ = -0.822
p-value = 0.001

**Renter Population Deciles**
$\tau$ = -0.422
p-value = 0.11

# Observation Level Correlations

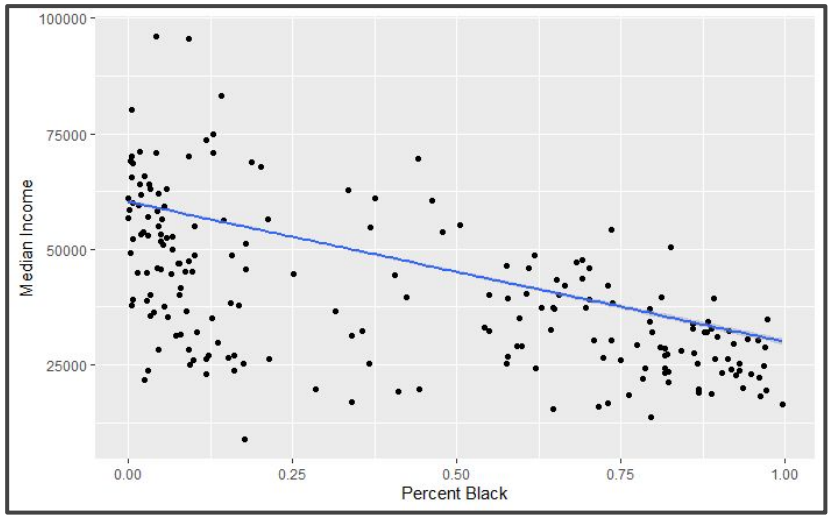


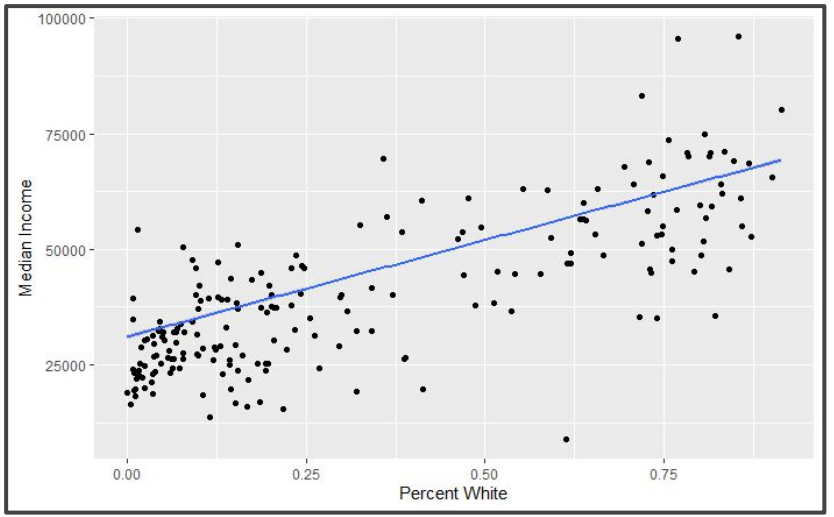
# Tract Level Correlations




- Positive Correlations
  - Median Income and Percent White
- Negative Correlations
  - Percent White and Percent Black
  - Percent in Poverty and Median Income
  - Percent White and Percent Income Poverty
  - Percent Black and Median Income

# Linear Regression as Visualization



# Multiple Linear Mixed Model

$$Y_{ij} = \beta_0 + \beta_1 X_i + u_j + \sum_{i=1}^{p_i} \gamma_i V_i + \epsilon_{ij}$$

$$u_j \sim \mathcal{N}(0, \sigma_0^2) \qquad \epsilon_{ij} \sim \mathcal{N}(0, \sigma^2)$$

# Variables, Random Effect, and Covariates

**Covariates**

Observation Level

- Quality
- Condition
- Kitchens
- Bathrooms
- Primary Wall
- Differences from Median Tract Aspects

Tract Level

- Median Land Size
- Median Income
- Median Tract Sale Price

**Random Effect**

Spatial Level

- Census Tract

**Variables of Interest**

Percent Black Population

Percent Hispanic Population

**Note**

We will be scaling/centering the coefficients

# ATS Ratio or Assessment Value?

Interesting findings about ratio as dependent variable

> height squared as an independent variable. The reason for this difference is that the coefficient in equation (6) is measuring the joint effect of varying age and height squared (an interaction) whereas the coefficient obtained from the linear regression model given by equation (1) measures the effect of age after adjusting for height squared. Equation (5) predicts that the population with the smaller average height

Kronmal 1993 tells us that our interpretation of coefficients with ATS as the outcome are actually the joint effect of the coefficient & sale price (denominator)

# Two Structures

Dependent Variables: ATS Ratio & Log Assessment Value

Linear & Mixed Effect Models

Simple Set Up

<u>Tract Level</u>

- Median Income
- Median Land Size
- Median Sale Price

Specific Set Up

<u>Tract Level Differences</u>

- Median Income
- Percent Increase/Decrease in Land Size
- Percent Increase/Decrease in Sale Price

# Inference

- All numerical variables are centered & scaled.
- Therefore, a one unit change translate to a one standard deviation change
- Because our coefficients are normally less than 1 they can be interpreted as:
    - “% of a standard deviation change in the response”

# Overview of Percent Black Population Effects

Table 1: Hierarchical Linear Model

Dependent Variable: ATS Ratio

| | Parameter | Simple | Specific |
|---|---|---|---|
| Percent Black | $\beta$ | $-0.1218^{***}$ | $-0.4642^{***}$ |
| | $\sigma^2$ | 0.04271 | 0.0587 |
| Percent Hispanic | $\beta$ | $-0.1198^{***}$ | $-0.1839^{***}$ |
| | $\sigma^2$ | 0.02684 | 0.03498 |
| | $ICC$ | 0.0510 | 0.2037 |

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

# Inference of ATS Ratio Models

One Standard Deviation of our ATS Ratio variable is: 0.1323

Mixed Effect Models

Simple

$B_1 = -0.122$

A coefficient of -0.122 indicates that a one standard deviation increase in percent black is associated with a 0.122 standard deviation decrease in the assessment ratio. This is 12% of a standard deviation. The standard deviation of the assessment ratio is about 0.13, so 12% of that is 0.016 or 1.16%. A neighborhood with a one standard deviation increase in the percent of black people is subject to about a 1.16% decrease in their taxable property values

# Inference of ATS Ratio Models

One Standard Deviation of our ATS Ratio variable is: 0.1323

Mixed Effect Models

Simple

$B_1 = -0.4642$

A coefficient of -0.4642 indicates that a one standard deviation increase in percent black is associated with a 0.4642 standard deviation decrease in the assessment ratio. This is 46% of a standard deviation. The standard deviation of the assessment ratio is about 0.13, so 46% of that is 0.0614 or 6.14%. A neighborhood with a one standard deviation increase in the percent of black people is subject to about a 6.14% decrease in their taxable property values

# Overview of Percent Black Population Effects

Table 2: Hierarchical Linear Model

Dependent Variable: Log Assessment Value

| | Parameter | Simple | Specific |
|---|---|---|---|
| Percent Black | $\beta$ | $-0.1500^{***}$ | $-0.1518^{***}$ |
| | $\sigma^2$ | 0.01871 | 0.0196 |
| Percent Hispanic | $\beta$ | $-0.0580^{***}$ | $-0.0553^{***}$ |
| | $\sigma^2$ | 0.0112 | 0.0116 |
| | $ICC$ | 0.2144 | 0.2293 |

$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

# Inference on Assessment Value Models

One Standard Deviation of our Log Assessment Value variable is: 0.487 = $71,545

Mixed Effect Models

Simple

$B_1$ = -0.150

A coefficient of -0.150 indicates that a one standard deviation increase in percent black is associated with a 0.150 standard deviation decrease in the Log Assessment Value. This is 15% of a standard deviation. The standard deviation of the assessment ratio is about 0.487, so 15% of that is 0.0731 or 7.31%. A neighborhood with a one standard deviation increase in the percent of black people is subject to about a 7.31% decrease in their Log Assessment Value

# Inference on Assessment Value Models

One Standard Deviation of our Log Assessment Value variable is:
0.487 = $71,545

Mixed Effect Models

Specific
$B_1$ = -0.152

A coefficient of -0.1518 indicates that a one standard deviation increase in percent black is associated with a 0.1518 standard deviation decrease in the Log Assessment Value. This is 15.2% of a standard deviation. The standard deviation of the assessment ratio is about 0.487, so 15.2% of that is 0.0739 or 7.4%. A neighborhood with a one standard deviation increase in the percent of black people is subject to about a 7.4% decrease in their Log Assessment Value

# Conclusion

- We find in both the simple & specific mixed models that Percent Black population negative impacts both the ATS Ratio and the Assessed Value of homes.
- Percent Hispanic population also negative impacts both the ATS Ratio and the Assessed Value of homes, but the regression coefficient is much smaller. It has a negligible impact.

# LASSO Procedure

We used the LASSO penalized regression as a variable selection technique

Specifically, we used Grouped LASSO to account for our categorical variables with multiple levels

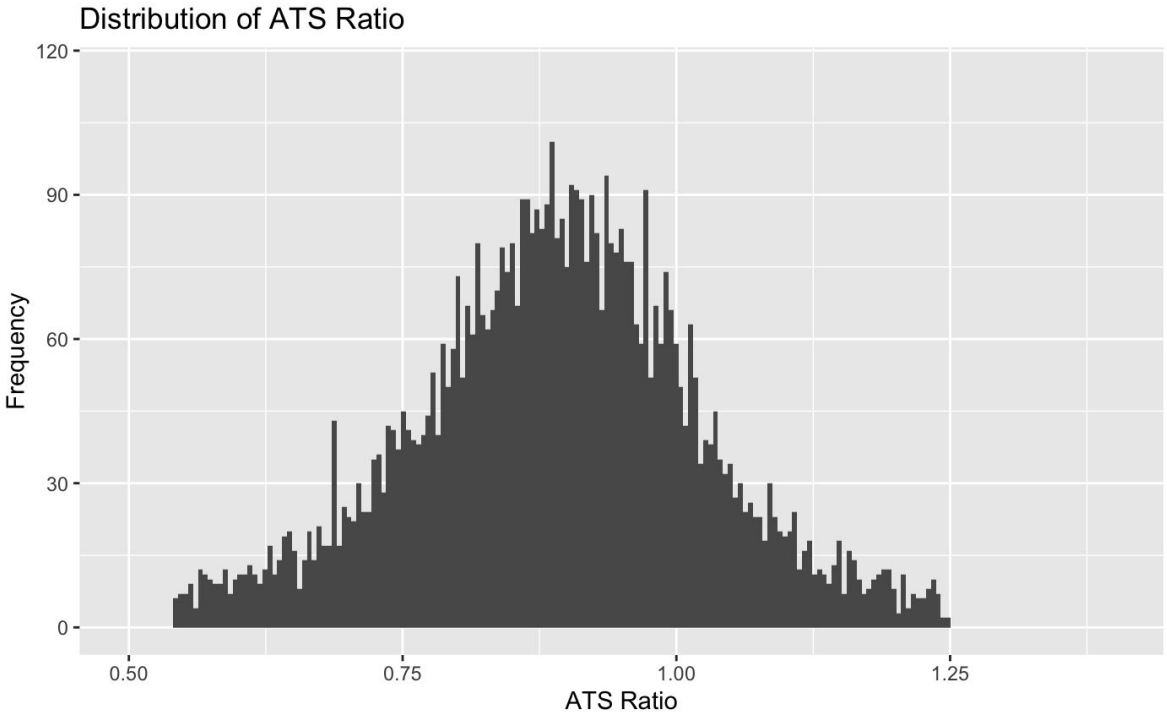
This procedure did not reduce any of our variables to 0, other than # of Kitchens

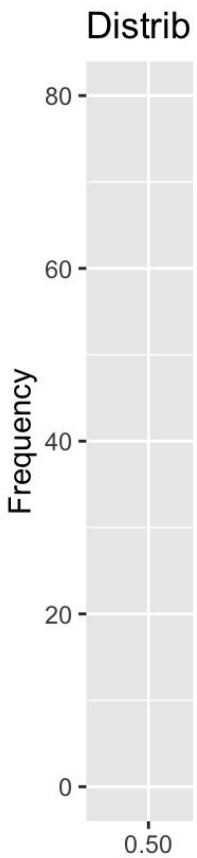
This result is consistent with our Variance Inflation Factors reported for each model

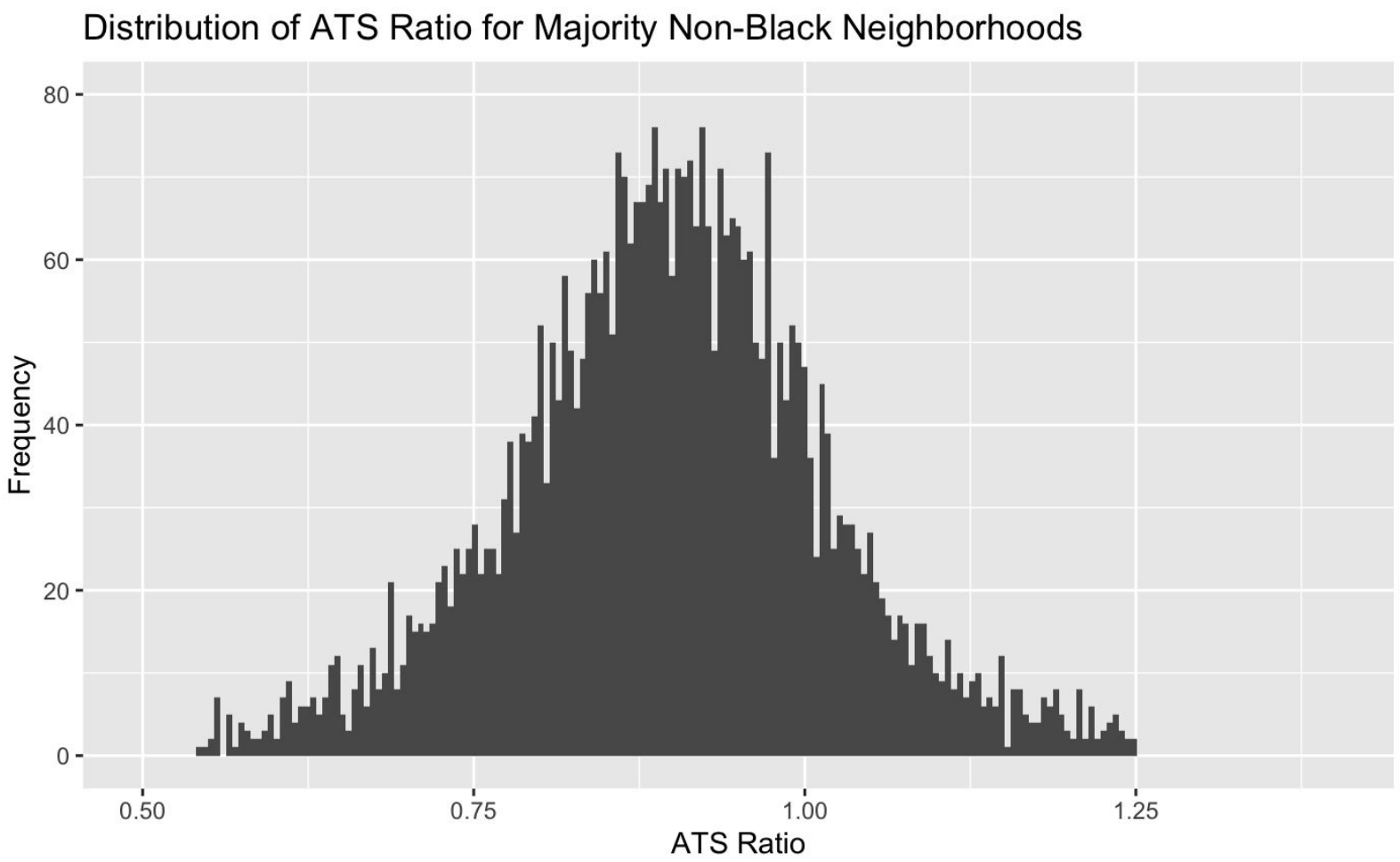
Multicollinearity is not a substantial issue

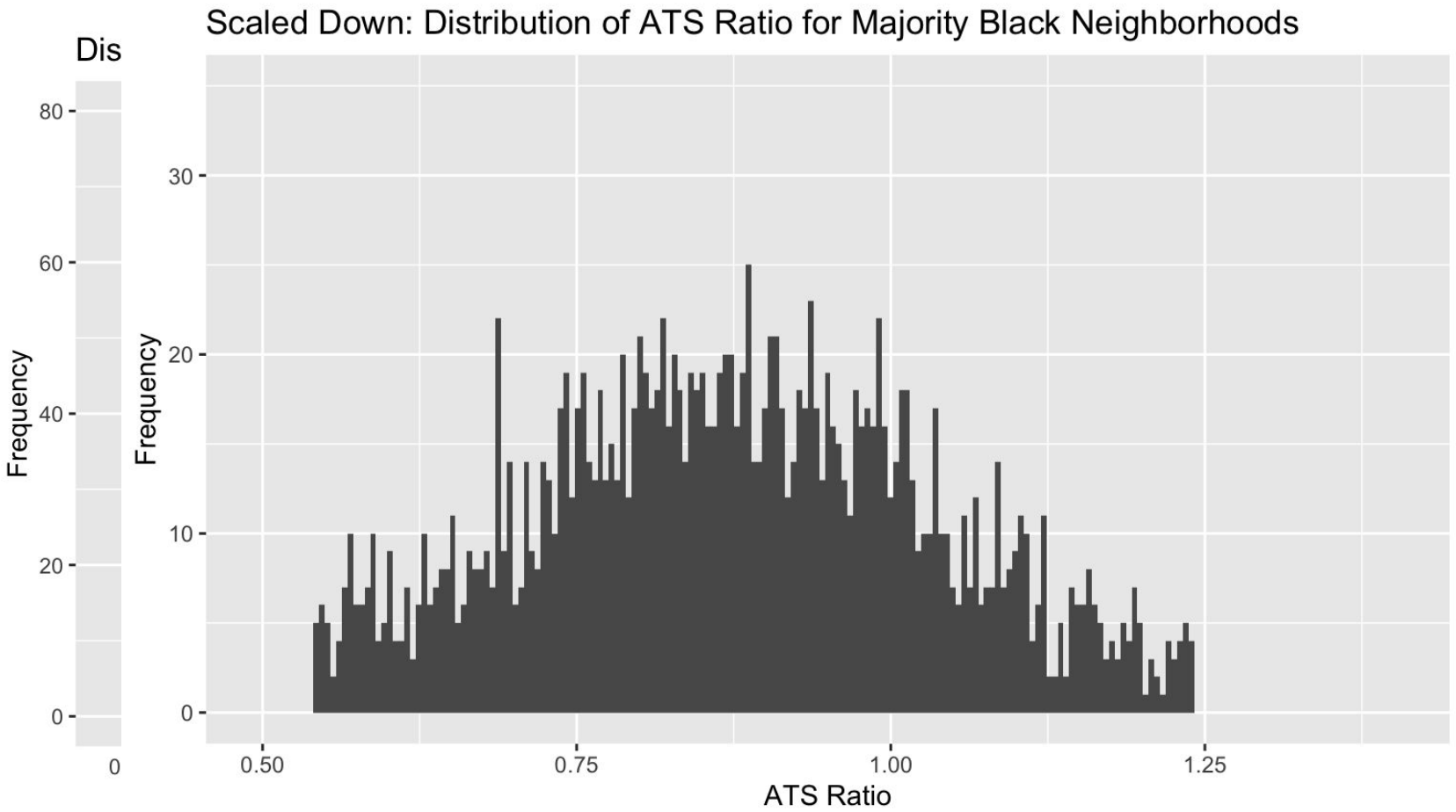
# Logistic Regression Analysis

## Exploratory Data Analysis




Distrib
80
60
40
20
0
Frequency
0.50


Distribution of ATS Ratio for Majority Non-Black Neighborhoods
80
60
40
20
0
Frequency
0.50
0.75
1.00
1.25
ATS Ratio


Dis
Scaled Down: Distribution of ATS Ratio for Majority Black Neighborhoods
Frequency
80
60
40
20
0
0
Frequency
30
20
10
0
0.50
0.75
1.00
1.25
ATS Ratio

# Question

It appears that the distribution of ATS Ratios for houses in Majority Black Neighborhoods is much flatter.

How can we test this?

We could determine the likelihood that an ATS Ratio is above or below 1 standard deviation given the ratio makeup of the neighborhood

# Background info

As we have seen, the ATS Ratio has a standard deviation of 0.13

An ATS Ratio one standard deviation below the mean is 0.89 - 0.13 = 0.77

An ATS Ratio one standard deviation above the mean is 0.89 + 0.13 = 1.02

We want to determine the likelihood of this occurrence, a standard deviation above or below, given the racial demographics of the neighborhood

# ATS Ratio 1 Standard Deviation Below

Simple
- Majority Black Indicator

Intermediate
- Majority Black Indicator
- Sale Price

Specific
- Majority Black Indicator
- Sale Price
- House Characteristics

Dependent Variable: ATS Ratio One Standard Deviation Below

| | Parameter | Simple | Intermediate | Specific |
|---|---|---|---|---|
| Percent Black | $\beta$ | 0.38058*** | 1.17450*** | 1.54064*** |
| | $\sigma^2$ | 0.05657 | 0.11267 | 0.17196 |

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

| | Parameter | Simple | Intermediate | Specific |
|---|---|---|---|---|
| Percent Black | Odds Ratio | 1.46*** | 3.24*** | 4.67*** |

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

# ATS Ratio 1 Standard Deviation Above

Simple
- Majority Black Indicator

Intermediate
- Majority Black Indicator
- Sale Price

Specific
- Majority Black Indicator
- Sale Price
- House Characteristics

Dependent Variable: ATS Ratio One Standard Deviation Above

| | Parameter | Simple | Intermediate | Specific |
|---|---|---|---|---|
| Percent Black | $\beta$ | $0.22^{***}$ | $-1.03^{***}$ | $-1.34^{***}$ |
| | $\sigma^2$ | 0.044 | 0.117 | 0.181 |

$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

| | Parameter | Simple | Intermediate | Specific |
|---|---|---|---|---|
| Percent Black | Odds Ratio | $1.25^{***}$ | $0.36^{***}$ | $0.26^{***}$ |

$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

# Acknowledgements

We really appreciate the opportunity to work with you.

This dataset is spectacular.

This project has been an indispensable learning opportunity.

# THANK YOU

Vinnie Palazeti
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