Cost-Efficient Valuation of Aesthetic Amenities

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Abstract
In order to avoid costly data collection practices common in hedonic valuation of aesthetic amenities, easy-to-collect secondary County tax and geospatial data are used to derive estimates for spatial effects on residential land values.

Three Georgia Counties were selected due to data availability: Clarke, Henry, and Richmond. All properties meeting panel-design criterion are included in analysis samples. Large datasets prompt the omission of traditional hedonic model variables such as property characteristics. The focus of analysis is directed toward Canopy and Impervious land-cover estimates. Focal means are calculated at different ranges for immediate and neighborhood-wide assessment of surrounding cover. Community variables designed to describe neighborhood composition are included. Class, the measure of average size and Density, the average distance between nearby homes, are calculated at same neighborhood ranges as Focal means. Regressors also include distances to Schools, Hospitals, Airports, and Highways.

Pooled Ordinary Least Squares performed with data normalized by log-transformation yields practical, statistically significant results. Consistency of estimates among Counties provides assurance of model viability, while variety is still strong between all Counties. Some concerns of data reliability and appropriateness of goodness-of-fit measure are voiced for any future analysis.

Introduction

Environmental aesthetics are confirmed by many studies to have a significant impact on sales prices of houses. These findings are both statistically and economically viable, meeting reasonable assumptions and utilizing sound mathematical formulation techniques. Understanding how spatial characteristics influence buyer behavior could potentially provide an individual contractor, firm, or even governing body, an advantage in market analysis. Realtors could promote the energy efficiency or neighborhood-wide psychological benefits of canopy cover, city planners could have more concrete evidence supporting the environmental benefits of their proposed projects, and a new area of public goods resource valuation could be debated and theorized by economical minds in an international depth.

Few studies have found an effective vehicle to put their findings into practice. Extensive variability among geography, climate, and even culture limit the scope of most models to the regions in which the data was collected. Property appraisal is performed by considering structural characteristics and market values of other surrounding properties. Consumer behavior of retailers and buyers, on the other-hand, is also influenced by environmental aspects seldom available in tax digest data. Consumer preferences can be determined, this but requires on-sight valuation and home-owner surveying, which can be resourcefully expensive and operationally problematic.

In order that these barriers are overcome but not overlooked, this study will describe a method of evaluation whereby preceding literature guides statistical analysis of inexpensive and easily-collectible data while curtailing to the analysts' location of interest.

Assessment of Neighborhood Ambiance

The primary effect of interest in this paper is the environmental description provided by the balance of canopy and impervious land-cover. Canopy cover describes the location-specific properties of plant-life, whether through anthropogenic or natural development. Not to be

confused with any remaining non-vegetative cover, impervious cover describes area where water can't percolate through surface soil. Such a characteristic is seen in items such as roofs, sidewalks, parking lots, roads, severely impacted soil, etc. Overlap of land-cover types is common, and as a result the two aren't direct compliments of each other. However, this overlap is limited, but to what degree is impossible to say.

Another neighborhood attribute is as popular for analysis as it is pertinent. Distance variables allow us to quantify consumer interest in long-range neighborhood features. Often, distances are recorded from the property itself to specific items or areas such as schools, central business districts, workplaces, and so on. We consider public schools, hospitals, airports, and highways, each having their own importance, while also potentially serving as a proxy for distance to business districts. We also consider distances between neighboring buildings, but this will be discussed later. While distances are useful and pertinent, they can also be misleading, and often prove to be statistically insignificant, depending on how they are determined. When straight-line measurement is performed, coefficients don't reveal road-length interest of consumers. When they are calculated by minimizing total length of road segments that connect subject and feature points, estimates fail to describe individuals concern for proximal benefits. These benefits could come from factors like walking commute, aesthetic qualities of neighboring locations/buildings, or traffic flow. They can also account for negative externalities in the same fashion. Since these characteristics are an important determinant of neighborhood features, this project uses straight-line measurement calculation of distance values.

In addition to traditional neighborhood regressors, we have introduced new Community variables to account for neighborhood class and concentration of surrounding buildings. Class refers to the general size of surrounding buildings, while Density reveals the average distance between each property, both within specified neighborhood ranges. If formatted correctly, these two variables should valuate the aesthetic benefit of subdivision composition and organization.

Omission of Traditional Hedonic Variables

In most hedonic studies where the subjects are residences, building characteristics are included for analysis. Unlike this paper, these studies are usually confined to a single specific subdivision or residential neighborhood. This is optimal when including building characteristics as most buildings within the same subdivision maintain similar design features. This homogeneity allows for standardization of quality, in that most characteristics are similar among a majority of residential units in the selected community. In our study, all possible properties that meet certain criterion are selected from the full population of three separate Georgia Counties. The entire spectrum of quality effects is contained within these samples, and with no practical means of objective grading, many variables common to residential hedonic studies are omitted.

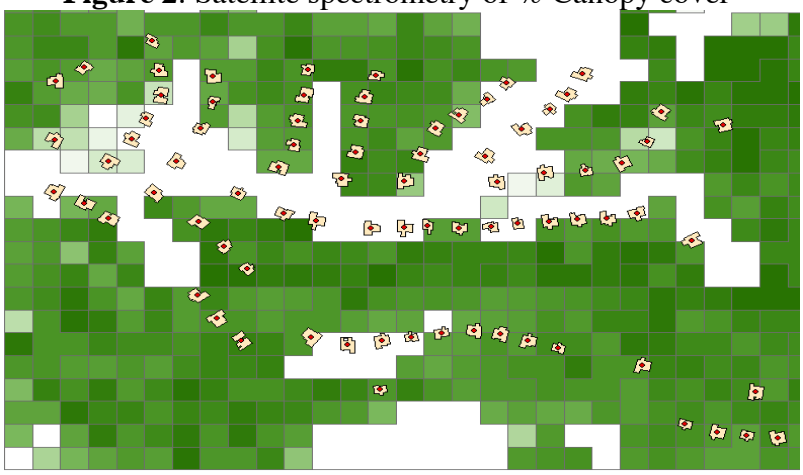
Data

Georgia Counties Clarke, Henry, and Richmond were selected for analysis due to availability of data. Of the handful of Georgia Counties that provide the geospatial and tax data necessary for this analysis, these three offered the data at no charge to the University of Georgia (UGA). Property data was collected from County tax assessor and commissioner offices, while land-cover data was acquired from UGA geospatial databases. The overlap of available data yielded land-cover and tax digest data only available for the years 2001, 2005, and 2008; datasets were constructed in panels, with the subject of each panel being a residential unit.

Figure 1: Aerial image of Clarke County neighborhood

Land-cover values were determined by satellite spectrometry imaging. The neighborhood aerial image in Figure 1 corresponds to a spectrographic readout pixilated in Figure 2. Each pixel defines a 30 x 30 meter plot of land, the values of which are scaled as percentages.

Figure 2: Satellite spectrometry of % Canopy cover



House locations were detailed by respective polygons constructed by Tax Appraisers or Commissioners of each County. The centroid of each polygon was determined in order to assign the most spatially appropriate pixel value to each residential unit. Since the property rarely sat in the center of a single pixel, local cover values were determined using focal means calculation, that is, the mean of a single land-cover value was determined by considering the pixel it represents as well as those surrounding it. Figure 3 illustrates the process in which focal means are calculated.

Figure 3: Focal means calculation, 9x9 pixel = 3 meter radius (local)

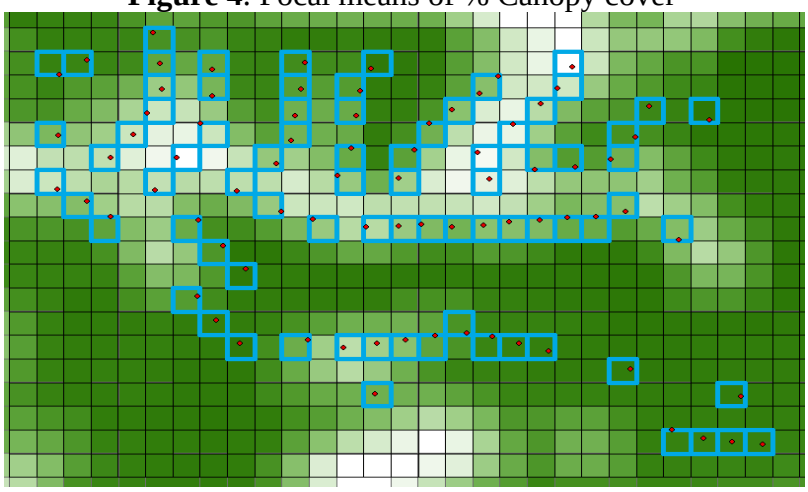
1	2	3	4	3	4
2	2	3	5	5	4
3	3	4	4	5	5
3	3	4	4	5	5
4	4	5	5	6	7
5	6	6	6	7	7

-	-	-	-	-	-
-	2.6	3.3	4	4.3	-
-	3	3.6	4.3	4.7	-
-	3.7	4	4.7	5.1	-
-	4.4	4.8	5.3	5.8	-
-	-	-	-	-	-

(1+2+3+2+2+3+3+3+4)/9 = 2.6

Each property centroid was then assigned the value of the pixel in which it resided while overlaying the focal means layer, Figure 4.

Figure 4: Focal means of % Canopy cover



Focal means were ran for local cells (9x9 pixel or 3 meter radius) as well as the neighborhood ranges described in the following paragraph.

Every variable subject to customizable buffer ranges was calculated with varying emphasis on neighborhood sizes, while the viewable area around each house is considered an explicit "neighborhood." Varying the distance of the eye-line (radius) from the building centroid yields multiple neighborhoods for each property. Radii of 100, 250, 500, 750, 1000, 1250, and 1500 meters were considered for this study to thoroughly and confidently describe a minimum practical range that is statistically significant.

Figure 5: Neighborhood ranges (250, 500, 750, and 1000 meter radii)

Community variables were also computed using these ranges. Class variables detail the average size of all buildings within each neighborhood, while Density variables do the same but for average distance between building centroids. To clarify, all range variables are described by function and distance; each property has 4 neighborhood variables, Canopy, Impervious, Class, and Density, each calculated separately for 7 different ranges. As a result each property ID is assigned 28 potential neighborhood variables. There is no intention to illustrate the effects of all 7 ranges; one range will be selected for the finalist dataset after preliminary analysis. See Table 1 for clarification of terms discussed in the data section.

Table 1: Terms

Term	Units	Type	Description
Range	Meters	Definition	Radial distance of area around property (observation)
Lot Value	Acres	Response	Land value/acre of property parcel
Class	Square Feet	Regressor	Average size of neighboring properties (buildings) within range
Density	Feet	Regressor	Average distance between properties within range
Distance	Miles	Regressor	Distance between property and nearest feature

It is important to recognize the nature of this data such that one does not get hung up on the strict quantitative measurements of land-cover value. The interaction of stereotypes implied by these variables can reveal neighborhood ambiance. To illustrate, imagine the aesthetics of a low-canopy, high-impervious housing subdivision with small average distances between large houses. Though everyone may conceive an entirely different landscape, a distribution curve should exist within which most individuals share reasonably similar design features. Finding and functionalizing that distribution will allow researchers to effectively determine consumer monetary assessment of qualitative features, in this case, neighborhood aesthetics. Further, using the aforementioned variables, these procedures can be performed without costly surveying techniques.

Preliminary/Data Analysis

To find the most appropriate range for neighborhood and community analysis, regressions were performed at each radius; the results of each can be found in section 1 of the appendix, while model format is explained in the methods section. A radius of 750 meters was chosen for final analysis, as it is the smallest of ranges that maintains good statistical significance. Tables 2 and 3 shows summary statistics for the final dataset, followed by brief discussion.

Table 2: Range

	Min – Max by County			Units
	Clarke	**Henry**	**Richmond**	
Lot Value (thousands)	1.44 – 4,671	0.18 – 966	1.51 – 1,540	acres
Canopy	0 – 100	0 – 100	0 – 100	%
Impervious	0 – 90	0 – 100	0 – 100	%
Local Canopy	0 – 95	0 – 95	0 – 88	%
Local Impervious	0 – 90	0 – 81	0 – 99	%
Neighbor Canopy*	6 – 90	0 – 89	0 – 76	%
Neighbor Impervious*	0 – 74	0 – 71	0 – 85	%
Class (thousands)	1.16 – 17.02	0.83 – 37	0.80 – 12.46	square feet
Density	58 – 509	0 – 438	44 – 217	feet
Schools	0.02 – 4.19	0.14 – 20.56	0.02 – 21.22	miles
Hospitals	0.1 – 9.68	0.26 – 39.47	0.16 – 36.23	miles
Airports	0.43 – 11.98	0.05 – 24.5	0.43 – 29.35	miles
Highways	0.01 – 5.11	0.03 – 12.52	0 – 10.73	miles

* neighbor values are calculated from the 750 meter range

Table 3: Data Behavior

	Mean / Std. Dev. by County			Units
	Clarke	**Henry**	**Richmond**	
Lot Value (thousands)	110.65 / 165.19	73.15 / 71.68	58.73 / 65.72	acres
Canopy	42 / 30	20 / 28	27 / 27	%
Impervious	18 / 16	24 / 21	32 / 19	%
Local Canopy	43 / 24	23 / 22	27 / 22	%
Local Impervious	17 / 12	22 / 16	30 / 15	%
Neighbor Canopy*	47 / 13	34 / 15	29 / 16	%
Neighbor Impervious*	18 / 11	20 / 13	30 / 14	%
Class (thousands)	2.5 / 0.85	2.25 / 1.08	1.86 / 0.73	square feet
Density	113 / 35	103 / 28	67 / 14	feet
Schools	0.88 / 0.54	4.23 / 2.79	4.68 / 3.94	miles
Hospitals	2.96 / 2.04	17.56 / 8.74	6.71 / 4.23	miles
Airports	4.71 / 2.21	9.26 / 3.85	10.68 / 4.55	miles
Highways	0.82 / 0.74	3.29 / 2.59	1.29 / 1.25	miles
# of Observations	26,529	99,432	75,620	

* neighbor values are calculated from the 750 meter range

The range of data was altered such that properties with lot values of less than $1000 were excluded in hopes of minimizing properties with recording errors, inherited land, etc. Table 3 reveals clear implications about the balance of canopy and impervious land-cover, while Clarke

County has the lowest impervious cover, it also maintains the highest canopy. Henry and Richmond both fall in the middle ground, but are still comparable. It seems that neighborhood cover is somewhat consistent among all three Counties, though they still reflect the behavior of non-focal cover. Class and density, with the exception of Richmond density, are consistent as well. This suggests that general layouts of common residential subdivisions of each County are similar to one another.

Methods

The final dataset is in panel format, while the nature of analysis is hedonic with spatial statistic applications. Panel data analysis typically begins with Pooled Ordinary Least Squares (POLS) regressions, and then is compared with Fixed Effects (FE) methods. Omitted from this report are the FE results, as they proved to be less reliable or practical. With FE being removed from consideration, most other advanced panel data analysis methods, particularly Random Effects, were overlooked.

POLS in performance is essentially the same as Ordinary Least Squares (OLS); while the explanation of difference, by some, is a mathematical necessity, as the technique evaluates duplicate observations with updated, developed, or redefined features. POLS, along with nearly all panel analysis methods, often includes some sort of classification system whereby the bulk of explanatory power of output estimates are described in the changes or differences among multiple records of the same observation. In this instance, classification of this type is ignored; this paper addresses these concerns only in the exclusion of single-observation panels. As a result, each property observation is one of either two or three subjects within its respective panel. This method was chosen for a few different reasons: first, the amount of single-panel observations could be heavily influenced by changes in economic status between 2001 and 2008, introducing possible bias concerns; second, as discussed in the data section, dataset construction was limited by data availability of every type; and finally, little statistical reliability was found in methods using classification systems during other preliminary analysis. To further account for potential bias from changes in economic status, regressions were classified by subject year.

Results/Conclusions

A QQ-plot constructed from residuals of POLS revealed problems with normality. Also, though White tests indicated no heteroscedasticity, the traditional and more reliable method of visual inspection proved to be more difficult than anticipated. Due primarily to the issues of non-normality, a natural log transformation of the response variable, Lot Value was implicated for additional POLS analysis. Residual plots indicate that the transformation was successful in normalizing the data, while it also facilitates better inferences concerning heteroscedasticity. White test results and residual plots for the 750 meter range are available in the second section of the appendix.

Table 4 shows the POLS estimates and respective t-values and R-Squares for both the non-transformed and log-transformed models. Though both seem to maintain statistically significant estimates and reasonable goodness-of-fit measures, the log-transformed model should be the more reliable of the two, as it has been normalized. POLS results for each range are available in the section 1 appendix.

Table 4: Pooled Ordinary Least Squares, 750 meter radius

	Coefficients (T-Value) by County					
	Clarke		Henry		Richmond	
	No Trans	Log Trans	No Trans	Log Trans	No Trans	Log Trans
Canopy	47.50	0.0007	-19.13	0.0008	56.50	0.0014
	0.84	3.10	-1.95	8.48	3.82	8.59
Impervious	-153.09	-0.0015	15.97	0.0000	42.14	0.0003
	-1.64	-3.87	1.10	0.07	2.28	1.41
Local Canopy focal 3 meter	172.81	-0.0008	-14.47	-0.0020	63.22	0.0013
	2.12	-2.28	-1.04	-14.48	2.64	4.92
Local Impervious focal 3 meter	3684.37	0.0242	2132.01	0.0240	956.53	0.0185
	25.29	39.43	91.56	103.40	31.67	54.00
Neighbor Canopy focal range	575.64	0.0047	262.84	-0.0001	353.55	0.0101
	5.41	10.54	16.68	-0.87	13.34	33.54
Neighbor Impervious focal range	2008.29	0.0058	1359.84	0.0136	-830.54	-0.0105
	11.89	8.17	44.47	44.72	-22.45	-24.93
Class range	4.42	0.0001	0.77	0.0000	34.62	0.0003
	3.36	17.83	4.95	15.97	68.79	52.64
Density range	-533.26	-0.0083	-317.21	-0.0066	354.38	0.0059
	-12.55	-46.04	-40.56	-84.42	12.11	17.81
Schools	4611.27	0.0465	-941.89	-0.0090	-168.79	0.0015
	2.24	5.36	-14.42	-13.79	-2.25	1.77
Hospitals	-12717.32	-0.1267	-145.65	-0.0092	-1723.90	-0.0404
	-16.27	-38.42	-6.71	-42.65	-26.06	-53.74
Airports	-9272.69	-0.0648	15.23	-0.0068	-270.97	0.0004
	-17.83	-29.54	0.36	-16.17	-4.77	0.65
Highways	11175.26	0.1345	-558.84	0.0021	-532.14	0.0149
	6.73	19.22	-8.00	2.98	-2.59	6.38
Year-01	91761.35	11.45	34950.12	10.90	-47852.04	9.10
	10.46	309.52	26.29	821.46	-20.34	340.26
Year-05	94131.26	11.63	39165.20	11.06	-35122.58	9.27
	11.47	335.86	28.34	802.21	-14.47	336.13
Year-08	98450.33	11.76	16783.58	10.87	-13425.91	9.56
	10.15	287.51	9.71	630.39	-4.81	301.32
R-Squared	**0.21407**	**0.4988**	**0.5202**	**0.6620**	**0.2991**	**0.35763**

Reviewing these results, we can infer that neighborhood analysis is appropriate in our model. Both canopy and impervious land-cover estimates are less consistent across each County and more often statistically insignificant than focal means estimates at even the local range. However, that is not to say consistency is a notable feature of focal means land-cover estimates; local canopy effects vary greatly among Counties while local impervious effects are practically uniform. Ultimately, neighborhood estimates appear to be the best measure of land-cover effects on property values, as they are practical and maintain relative consistency.

Community estimates have interesting results. While Class is consistent in direction, it isn't so much in magnitude; this is just the opposite for Density. If preference of neighborhood makeup can be assumed subject to location, our findings indicate that residents of Clarke County appreciate more crowded neighborhoods made up of medium-sized houses. Those in Henry are also partial to crowded communities, though less than Clarke residents, and seem to have little concern for surrounding properties. Low Class estimates in Clarke and Henry could indicate an appreciation for diversity among communities in building size and type. Residents of Richmond County seem to prefer spread-out neighborhoods with larger homes.

Most distance variables are statistically significant in both models. The Henry non-transformed and the Richmond log-transformed models are the only to say otherwise, both in

regards to Airports. Referring to the normalized models, it appears that distance from schools is preferred by Richmond and Clarke residents, as is distance from major highways. Henry home-owners are also partial to distance from highways, but actually appreciate nearer proximity to schools. Apparently short commutes to hospitals are uniformly desired by people in each County. Distances to airports are different among counties, but the lack of statistical significance disturbs any hope of consistence or reliability.

Yearly differences are an issue for conversation as well. Table 3 shows relative similarity among each year for Clarke County. For Richmond, the log-transformed model has notably different estimates than the original, firstly being the direction. Additionally, the log model maintains consistent Year estimates while those of the original have increased since 2001. Alternatively, Henry County has similar Year estimates for 2001 and 2005 followed by a drastic drop in 2008. This isn't reflected in the log model. It appears that a log transformation allows for greater consistency of Year estimates, another testament to the reliability of the normalized model.

Concerns

While these findings appear reasonably reliable by low R-Squared spatial statistics modeling, the format and nature of the data calls into question the appropriateness of allowing this model to be considered a spatial one. The primary area of concern is that of the neighborhood estimates. Our results indicated relatively consistent findings, but a second glance at all ranges may shake our confidence. Section 1 of the appendix reveals results of POLS models at each range. A steady increase in statistical significance and consistency in the neighborhood estimates can be correlated with the rise of range radius. In other words, as the analytical area around each property grows, so does the explanatory power of the model. This is risky; a larger range could swallow a greater deal of information, in-effect creating large estimates of irrelevant parameters. As land-covers are somewhat negatively correlated, statistical significance could also grow at the same rate of correlation. As an R-Squared cannot be heavily relied upon for these models, perhaps the most appropriate goodness-of-fit measure is one referenced in all fields of scientific analysis, repetition of findings. In the same spirit, known theories should be considered when observing model behavior, which can be done by residual analysis.

Having yet to publish/present (or find) articles utilizing methods similar to those in this paper, the only form of repetition we have is that of consistency among Counties. This consistency is discussed in the results section in regards to the neighborhood land-cover estimates. As for residual analysis, plots detailed in the appendix and reviewed in the results section support the log-transformation method and also indicate data reliability, narrow though it may be. Without preceding literature or a better goodness-of-fit measure, the limited explanation of these indirect measures will have to suffice for now.

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Appendix

1. Pooled Ordinary Least Square Regressions Results

Non-Transformed

Clarke	Coefficients (T-Value) by Range						
	100	250	500	750	1000	1250	1500
Canopy	24.23	31.21	34.58	47.50	54.27	56.53	54.92
	0.39	0.55	0.61	0.84	0.95	0.99	0.97
Impervious	-184.00	-98.53	-106.72	-153.09	-177.03	-191.26	-205.10
	-1.92	-1.05	-1.15	-1.64	-1.90	-2.05	-2.20
Local Canopy	33.09	267.45	224.41	172.81	162.41	158.93	165.05
focal 3 meter	0.19	2.58	2.65	2.12	2.03	2.01	2.10
Local Impervious	4263.67	3124.91	3318.18	3684.37	3862.98	3963.15	4037.38
focal 3 meter	21.15	18.53	22.08	25.29	26.88	27.81	28.50
Neighbor Canopy	267.65	274.30	513.33	575.64	546.15	506.79	390.29
focal range	1.38	2.59	5.17	5.41	4.63	4.01	2.90
Neighbor Impervious	-37.28	1902.62	2365.11	2008.29	1864.72	1563.65	1247.17
focal range	-0.19	11.13	14.30	11.89	10.61	8.66	6.73
Class	17.98	12.95	5.89	4.42	2.81	5.51	7.91
range	12.54	9.04	4.59	3.36	2.04	3.74	5.08
Density	-260.21	-322.05	-470.74	-533.26	-565.29	-755.65	-947.42
range	-13.84	-13.05	-12.86	-12.55	-11.93	-13.88	-15.36
Schools	-3929.18	-476.73	4110.83	4611.27	4215.96	4993.75	4837.14
	-1.98	-0.24	2.02	2.24	2.04	2.42	2.36
Hospitals	-16523.05	-14861.47	-13097.56	-12717.32	-12250.36	-11022.79	-9821.15
	-22.53	-19.88	-17.10	-16.27	-15.20	-13.23	-11.37
Airports	-12141.91	-11094.68	-9645.55	-9272.69	-8842.55	-7942.31	-7035.68
	-24.58	-22.30	-18.97	-17.83	-16.53	-14.33	-12.24
Highways	3578.03	5841.86	10347.96	11175.26	11262.00	12446.51	13398.18
	2.22	3.64	6.33	6.73	6.72	7.37	7.88
Year-01	110365.79	91932.50	87129.48	91761.35	97314.70	105862.15	119918.91
	16.59	12.34	10.68	10.46	10.36	10.77	11.63
Year-05	114847.71	94367.84	88986.33	94131.26	99507.94	108409.47	122861.68
	19.91	14.03	11.81	11.47	11.22	11.62	12.49
Year-08	141421.94	106223.04	92146.52	98450.33	103957.87	115521.28	133447.61
	22.52	13.93	10.48	10.15	9.84	10.35	11.30
R-Squared	**0.2089**	**0.2133**	**0.2171**	**0.2141**	**0.2123**	**0.2126**	**0.2129**

Henry	Coefficients (T-Value) by Range					
	100	250	500	750	1000	1250
Canopy	-36.24	-30.43	-21.21	-19.13	-21.71	-23.38
	-3.41	-3.15	-2.18	-1.95	-2.21	-2.38
Impervious	-109.36	69.79	24.96	15.97	13.97	10.88
	-7.36	4.88	1.73	1.10	0.96	0.75
Local Canopy	-51.13	-23.21	-29.54	-14.47	1.67	15.76
focal 3 meter	-1.72	-1.38	-2.04	-1.04	0.12	1.17
Local Impervious	1795.38	1528.07	1982.09	2132.01	2180.40	2233.41
focal 3 meter	56.09	58.02	82.60	91.56	95.58	98.98
Neighbor Canopy	178.71	239.41	280.04	262.84	217.39	143.91
focal range	5.54	15.13	18.85	16.68	12.70	7.81
Neighbor Impervious	1094.39	1687.63	1282.81	1359.84	1584.02	1628.45
focal range	34.10	62.07	43.88	44.47	49.70	49.31
Class	-7.13	-4.66	1.12	0.77	0.13	0.03
range	-27.46	-17.65	5.33	4.95	1.15	0.40
Density	-126.19	-254.26	-384.61	-317.21	-245.56	-204.41
range	-37.09	-49.92	-54.09	-40.56	-29.52	-23.06
Schools	-1566.86	-1036.54	-852.48	-941.89	-951.56	-966.58
	-24.44	-16.35	-13.17	-14.42	-14.52	-14.69
Hospitals	-427.13	-240.24	-135.36	-145.65	-142.04	-142.36
	-20.62	-11.64	-6.36	-6.71	-6.46	-6.38
Airports	-137.20	-68.09	26.25	15.23	-34.92	-74.58
	-3.26	-1.65	0.63	0.36	-0.83	-1.77
Highways	-1237.12	-656.73	-617.99	-558.84	-424.77	-351.63
	-18.26	-9.78	-9.00	-8.00	-6.02	-4.95
Year-01	54230.35	46259.33	42994.18	34950.12	28082.22	26046.09
	53.74	41.92	34.60	26.29	20.04	17.62
Year-05	60617.84	50421.41	47704.98	39165.20	31549.25	29142.37
	57.53	43.72	36.79	28.34	21.75	19.11
Year-08	52301.77	31982.35	28923.92	16783.58	3727.28	-507.32
	45.48	24.20	18.41	9.71	2.00	-0.25
R-Squared	**0.5192**	**0.5377**	**0.5269**	**0.5202**	**0.5195**	**0.5182**

Richmond	Coefficients (T-Value) by Range						
	100	250	500	750	1000	1250	1500
Canopy	-5.77	80.39	69.75	56.50	54.78	52.66	53.37
	-0.36	5.13	4.68	3.82	3.67	3.48	3.49
Impervious	98.86	60.58	44.56	42.14	45.74	46.07	44.33
	4.97	3.11	2.40	2.28	2.45	2.44	2.32
Local Canopy	57.52	-34.85	33.54	63.22	81.94	115.89	124.32
focal 3 meter	1.05	-1.15	1.34	2.64	3.45	4.85	5.18
Local Impervious	177.57	1000.45	990.00	956.53	986.49	1035.84	1055.60
focal 3 meter	3.61	27.12	31.61	31.67	32.81	34.22	34.65
Neighbor Canopy	331.93	642.20	376.91	353.55	397.18	391.54	408.60
focal range	5.67	21.09	14.10	13.34	14.51	13.77	13.84
Neighbor Impervious	290.85	-142.82	-826.32	-830.54	-757.27	-692.34	-771.72
focal range	5.42	-3.64	-22.39	-22.45	-19.98	-17.88	-19.57
Class	39.10	21.62	37.20	34.62	29.15	23.36	22.74
range	119.07	63.93	79.59	68.79	53.91	39.90	36.27
Density	-278.25	280.74	70.36	354.38	676.20	1015.02	1028.81
range	-27.70	15.38	2.79	12.11	20.90	28.75	27.27
Schools	-290.30	-376.56	-120.61	-168.79	-466.18	-748.92	-810.53
	-4.00	-4.91	-1.61	-2.25	-6.11	-9.62	-10.22
Hospitals	-1128.48	-1378.23	-1632.77	-1723.90	-1841.04	-1969.46	-1940.82
	-17.27	-20.34	-24.82	-26.06	-26.99	-27.91	-26.78
Airports	-421.11	-330.94	-159.89	-270.97	-193.15	-165.11	-254.38
	-7.27	-5.55	-2.79	-4.77	-3.35	-2.81	-4.27
Highways	156.27	387.66	84.19	-532.14	-1376.79	-2160.67	-2439.98
	0.77	1.85	0.41	-2.59	-6.55	-10.05	-11.15
Year-01	-13529.37	-40884.67	-34170.29	-47852.04	-63363.00	-76635.31	-74834.85
	-9.21	-21.22	-15.61	-20.34	-25.38	-29.35	-27.70
Year-05	-2284.66	-29948.35	-21662.43	-35122.58	-50675.75	-64178.92	-62114.74
	-1.50	-15.05	-9.58	-14.47	-19.71	-23.89	-22.37
Year-08	11621.84	-17118.06	-1236.28	-13425.91	-29253.87	-43371.68	-39942.71
	6.97	-7.69	-0.48	-4.81	-9.81	-13.86	-12.31
R-Squared	**0.2648**	**0.2253**	**0.2888**	**0.2991**	**0.2828**	**0.2620**	**0.2460**

Log-Transformed

Clarke	Coefficients (T-Value) by Range						
	100	250	500	750	1000	1250	1500
Canopy	0.0006	0.0005	0.0006	0.0007	0.0008	0.0008	0.0008
	2.37	2.10	2.65	3.10	3.36	3.42	3.32
Impervious	-0.0015	-0.0011	-0.0013	-0.0015	-0.0016	-0.0017	-0.0017
	-3.78	-2.76	-3.37	-3.87	-4.14	-4.21	-4.35
Local Canopy	0.0015	0.0003	-0.0004	-0.0008	-0.0009	-0.0008	-0.0008
focal 3 meter	2.04	0.77	-1.09	-2.28	-2.61	-2.51	-2.41
Local Impervious	0.0244	0.0206	0.0229	0.0242	0.0251	0.0257	0.0261
focal 3 meter	29.08	29.06	36.22	39.43	41.15	42.49	43.34
Neighbor Canopy	-0.0007	0.0018	0.0039	0.0047	0.0049	0.0047	0.0042
focal range	-0.92	4.05	9.44	10.54	9.86	8.73	7.30
Neighbor Impervious	-0.0002	0.0081	0.0064	0.0058	0.0060	0.0048	0.0038
focal range	-0.22	11.23	9.15	8.17	8.03	6.27	4.77
Class	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
range	14.77	12.69	18.27	17.83	16.49	18.19	19.57
Density	-0.0043	-0.0049	-0.0075	-0.0083	-0.0086	-0.0099	-0.0111
range	-55.09	-46.81	-48.65	-46.04	-42.83	-43.02	-42.57
Schools	-0.0101	-0.0033	0.0412	0.0465	0.0404	0.0366	0.0275
	-1.23	-0.39	4.82	5.36	4.62	4.19	3.15
Hospitals	-0.1580	-0.1492	-0.1334	-0.1267	-0.1193	-0.1089	-0.0999
	-51.83	-47.44	-41.43	-38.42	-34.92	-30.82	-27.26
Airports	-0.0839	-0.0787	-0.0692	-0.0648	-0.0605	-0.0529	-0.0467
	-40.88	-37.61	-32.36	-29.54	-26.71	-22.51	-19.13
Highways	0.0983	0.0976	0.1290	0.1345	0.1332	0.1420	0.1493
	14.67	14.44	18.79	19.22	18.77	19.82	20.66
Year-01	11.57	11.47	11.46	11.45	11.44	11.48	11.54
	418.10	366.03	334.16	309.52	287.32	275.53	263.63
Year-05	11.74	11.63	11.63	11.63	11.61	11.65	11.71
	489.61	411.03	367.32	335.86	309.09	294.62	280.38
Year-08	11.95	11.77	11.77	11.76	11.74	11.79	11.86
	457.61	367.12	318.49	287.51	262.14	249.02	236.63
R-Squared	**0.5096**	**0.5007**	**0.5041**	**0.4988**	**0.4929**	**0.4922**	**0.4910**

Henry	Coefficients (T-Value) by Range					
	100	250	500	750	1000	1250
Canopy	0.0009	0.0005	0.0008	0.0008	0.0009	0.0009
	8.49	5.48	7.77	8.48	8.71	8.95
Impervious	-0.0016	0.0006	0.0002	0.0000	-0.0001	-0.0001
	-11.09	4.29	1.06	0.07	-0.51	-0.86
Local Canopy	-0.0010	-0.0003	-0.0017	-0.0020	-0.0022	-0.0024
focal 3 meter	-3.34	-1.78	-11.86	-14.48	-16.31	-17.33
Local Impervious	0.0193	0.0172	0.0219	0.0240	0.0251	0.0257
focal 3 meter	61.95	66.20	92.25	103.40	109.44	113.18
Neighbor Canopy	-0.0003	-0.0010	0.0001	-0.0001	-0.0003	-0.0005
focal range	-0.86	-6.46	0.52	-0.87	-1.55	-2.55
Neighbor Impervious	0.0119	0.0170	0.0137	0.0136	0.0147	0.0153
focal range	37.97	63.22	47.42	44.72	45.98	45.99
Class	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
range	-4.39	10.81	17.53	15.97	18.26	21.58
Density	-0.0038	-0.0052	-0.0069	-0.0066	-0.0061	-0.0058
range	-114.62	-103.74	-98.48	-84.42	-72.82	-65.20
Schools	-0.0186	-0.0116	-0.0082	-0.0090	-0.0091	-0.0090
	-29.75	-18.44	-12.80	-13.79	-13.77	-13.53
Hospitals	-0.0116	-0.0105	-0.0092	-0.0092	-0.0092	-0.0089
	-57.41	-51.33	-43.66	-42.65	-41.60	-39.67
Airports	-0.0071	-0.0067	-0.0065	-0.0068	-0.0072	-0.0076
	-17.27	-16.49	-15.76	-16.17	-17.03	-17.84
Highways	-0.0120	-0.0037	0.0000	0.0021	0.0033	0.0040
	-18.17	-5.60	-0.01	2.98	4.67	5.57
Year-01	10.88	10.81	10.91	10.90	10.85	10.82
	1104.86	990.79	886.32	821.46	770.71	726.76
Year-05	11.07	10.98	11.08	11.06	11.00	10.98
	1077.37	962.97	862.50	802.21	755.52	714.66
Year-08	11.01	10.83	10.92	10.87	10.78	10.73
	981.63	828.64	701.39	630.39	575.42	534.87
R-Squared	**0.6762**	**0.6803**	**0.6712**	**0.6620**	**0.6570**	**0.6540**

Richmond	Coefficients (T-Value) by Range						
	100	250	500	750	1000	1250	1500
Canopy	-0.0001	0.0018	0.0016	0.0014	0.0014	0.0013	0.0013
	-0.60	9.92	9.60	8.59	8.13	7.70	7.51
Impervious	0.0011	0.0006	0.0003	0.0003	0.0004	0.0004	0.0004
	4.83	2.64	1.42	1.41	1.78	1.96	1.96
Local Canopy	0.0012	-0.0007	0.0007	0.0013	0.0018	0.0024	0.0026
focal 3 meter	1.89	-1.92	2.53	4.92	6.79	8.87	9.84
Local Impervious	0.0034	0.0173	0.0187	0.0185	0.0187	0.0191	0.0193
focal 3 meter	6.08	40.98	52.23	54.00	55.20	56.19	56.60
Neighbor Canopy	0.0074	0.0127	0.0099	0.0101	0.0111	0.0113	0.0116
focal range	11.13	36.55	32.47	33.54	35.80	35.56	35.31
Neighbor Impervious	0.0062	-0.0008	-0.0102	-0.0105	-0.0095	-0.0090	-0.0103
focal range	10.25	-1.73	-24.29	-24.93	-22.31	-20.80	-23.45
Class	0.0005	0.0002	0.0003	0.0003	0.0002	0.0002	0.0002
range	127.92	55.45	64.47	52.64	38.53	26.88	24.22
Density	-0.0056	0.0029	0.0021	0.0059	0.0097	0.0129	0.0131
range	-49.40	13.77	7.15	17.81	26.50	32.62	31.10
Schools	0.0046	0.0032	0.0034	0.0015	-0.0022	-0.0055	-0.0069
	5.58	3.62	3.99	1.77	-2.57	-6.33	-7.79
Hospitals	-0.0265	-0.0319	-0.0377	-0.0404	-0.0429	-0.0450	-0.0458
	-35.92	-41.17	-50.18	-53.74	-55.73	-56.88	-56.61
Airports	-0.0040	-0.0020	0.0009	0.0004	0.0016	0.0023	0.0018
	-6.10	-2.88	1.32	0.65	2.44	3.45	2.71
Highways	0.0467	0.0448	0.0296	0.0149	0.0003	-0.0111	-0.0173
	20.42	18.63	12.67	6.38	0.11	-4.61	-7.08
Year-01	9.65	9.19	9.27	9.10	8.92	8.79	8.83
	581.23	417.15	370.74	340.26	316.49	300.10	292.53
Year-05	9.80	9.34	9.44	9.27	9.09	8.97	9.00
	570.47	410.42	365.56	336.13	313.21	297.41	290.31
Year-08	10.01	9.52	9.71	9.56	9.37	9.25	9.31
	530.89	373.74	330.01	301.32	278.48	263.42	256.88
R-Squared	**0.3327**	**0.2808**	**0.3415**	**0.3576**	**0.3515**	**0.3402**	**0.3324**

2. White Tests for 750 meter POLS

Non-Transformed Model

	Clarke	Henry	Richmond
D.F	116	117	117
Chi-Square	1054	6423	4340
P-Value	0	0	0

Log-Transformed Model

	Clarke	Henry	Richmond
D.F	116	116	117
Chi-Square	1907	3843	5360
P-Value	0	0	0

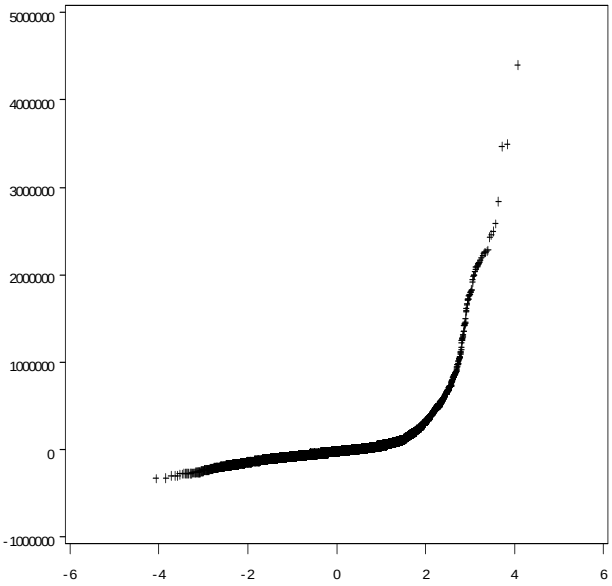
White tests performed in SAS, using SPEC option of PROC REG procedure

3. Residual Analysis plots for 750 meter POLS

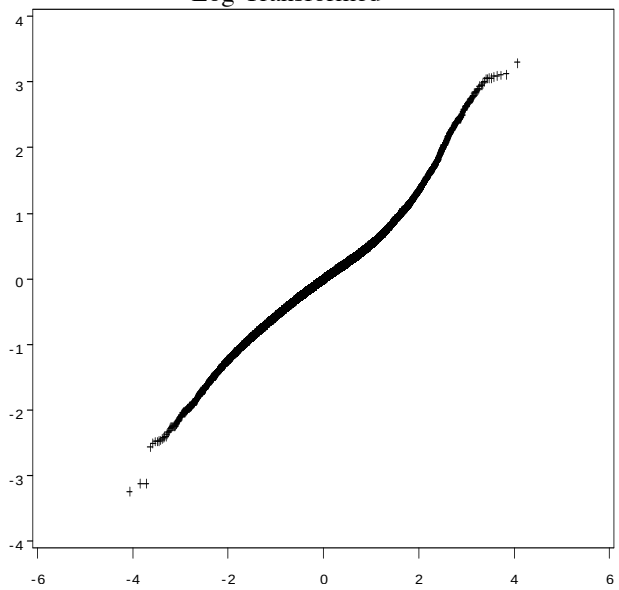
Clarke

QQ-Plot for Normality

Non-Transformed

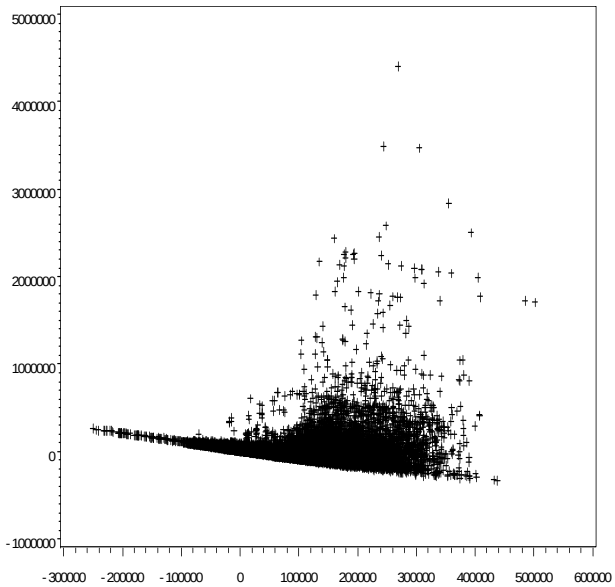


Log-Transformed



Residual vs. Fitted Plot for Heteroscedasticity

Non-Transformed



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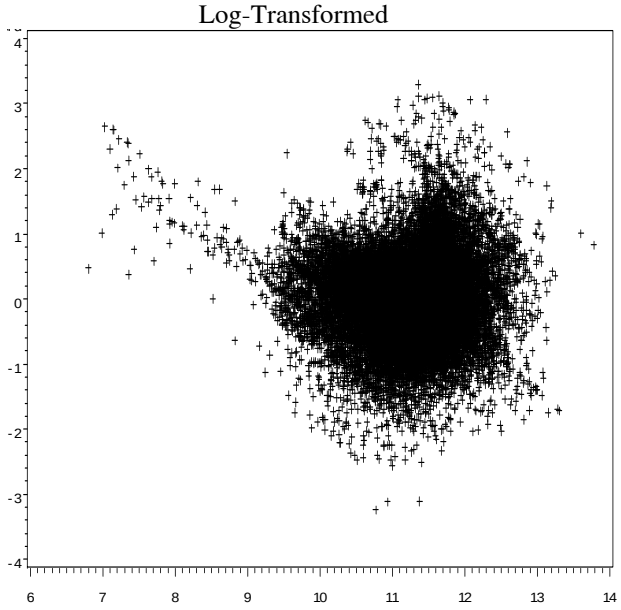
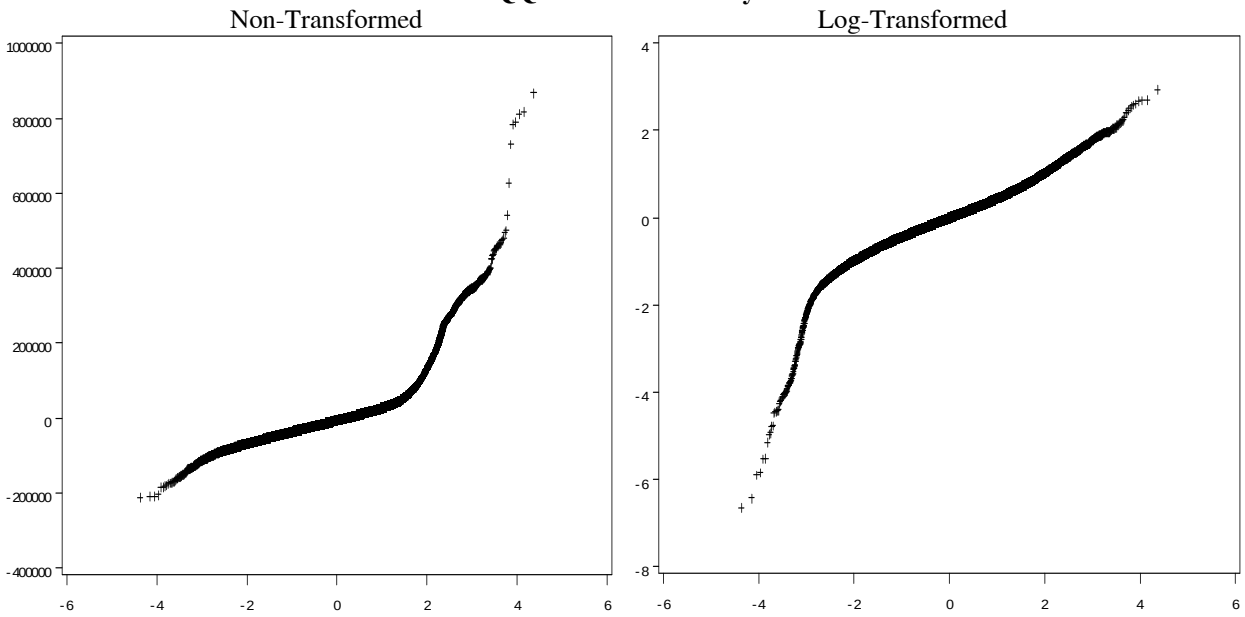
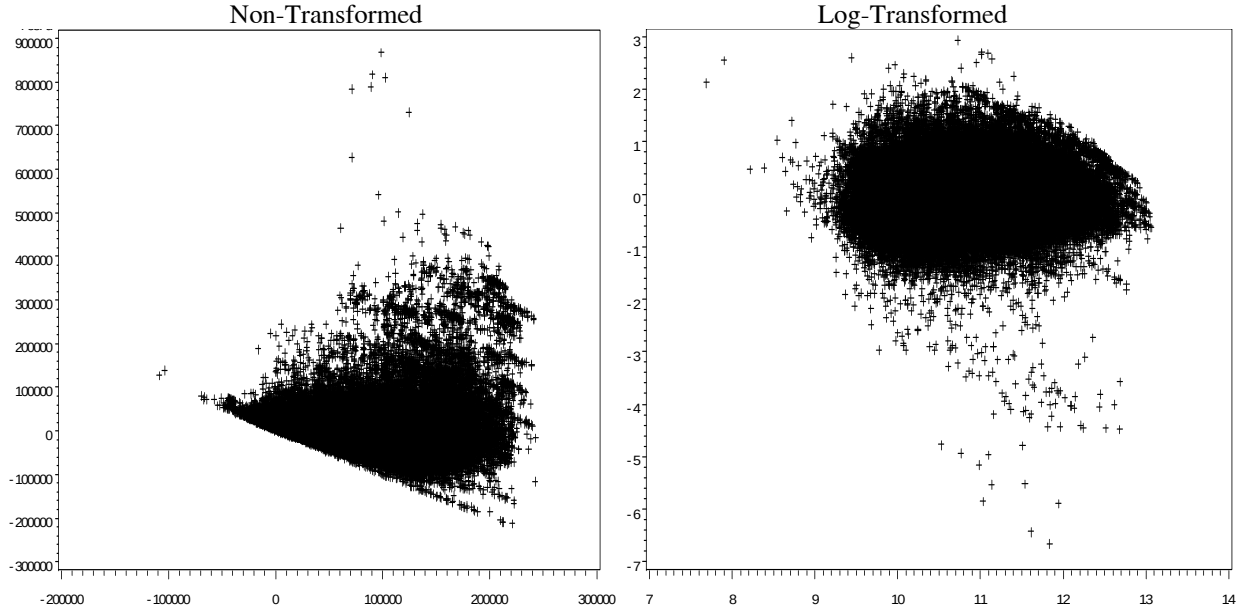


Henry

QQ-Plot for Normality



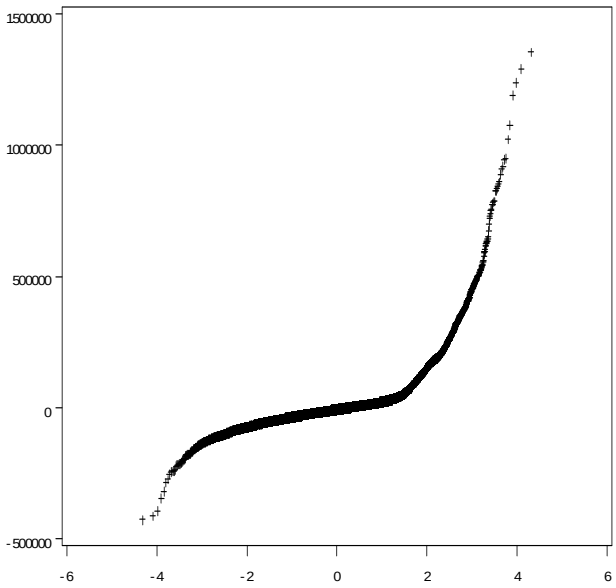
Residual vs. Fitted Plot for Heteroscedasticity



Richmond

QQ-Plot for Normality

Non-Transformed



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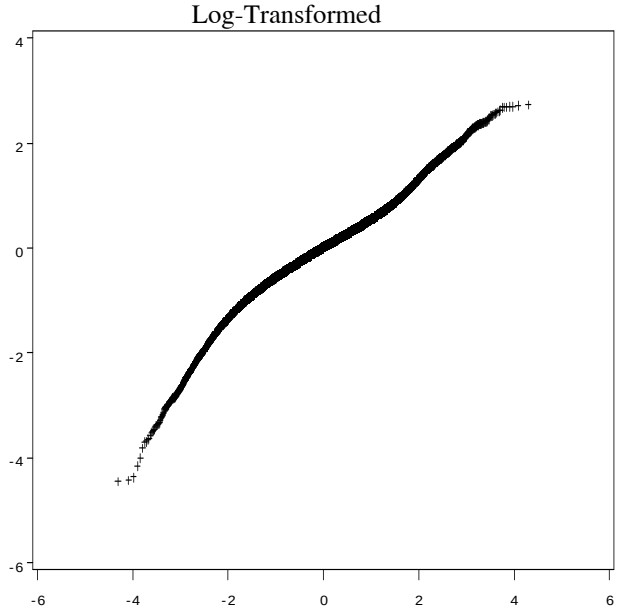
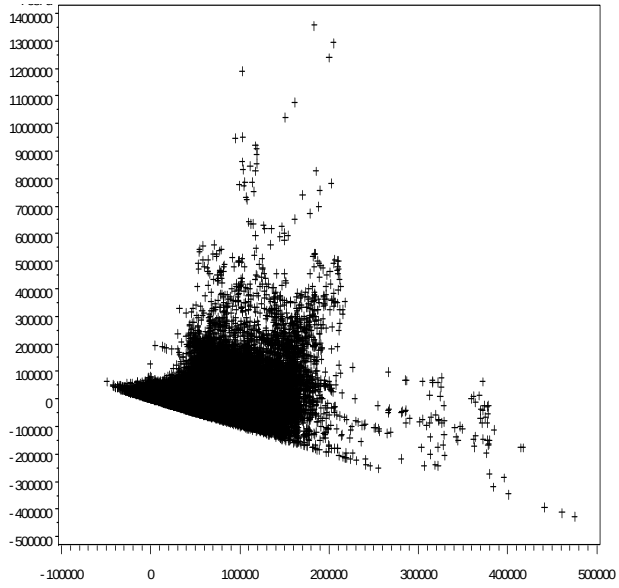


Residual vs. Fitted Plot for Heteroscedasticity

Non-Transformed



Log-Transformed