Tax Delinquency and Location Efficiency: Evidence from Wake County, NC

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Abstract

Using a sample of 82,888 residential properties in Wake County, North Carolina, I investigate the relationship between neighborhood location efficiency and homeowner tax delinquency using a logistic regression model. I use two proxies for location efficiency: (1) a binary variable for public transit within or outside a quarter-mile and (2) frequency of public transit service within a quarter mile of the neighborhood (census block group). I find that the probability of tax delinquency decreases with both measures of location efficiency, though my results are not statistically significant. These results are directionally in line with previous studies that modeled probability of mortgage default based on differences in location efficiency. They suggest that government policies around land use and transportation provision may impact likelihood of paying property taxes and broader homeowner financial health. Additionally, this study demonstrates the feasibility of using tax delinquency data to investigate questions that relate neighborhood characteristics and homeowner financial health, which has not been done before and offers several advantages over more commonly-used mortgage loan performance data.

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Property tax delinquency harms neighborhoods through multiple channels. Most directly, delinquency leads to lost tax revenue and thereby compromises the ability of local governments to provide services. Tax delinquency is also associated with other symptoms of homeowner financial distress, including neglected maintenance and possible foreclosure and vacancy, leading to neighborhood blight. In this study, I seek to illuminate risk factors for tax delinquency by examining the relationship between tax delinquency rates and location efficiency – a measure of neighborhood density and accessibility. While other studies have looked at the effect of location efficiency on mortgage default risk, no previous studies have applied the same analysis to tax delinquency.

Property taxes are one of the most important sources of revenue for local government. In the United States, local governments collect $443 billion in property taxes annually, which represents 72 percent of locally-generated tax revenue and a quarter of their overall budgets (U.S. Census Bureau, 2015). Therefore, tax delinquency can have a significant effect on the ability of governments to provide services at the local level. The most extreme example of tax delinquency remains the City of Detroit, where a confluence of factors including economic decline and a breakdown in the contract between residents and city officials left half of properties delinquent after the Great Recession (Alm et al., 2014). In North Carolina, the situation is not as extreme but Wake County alone still reports more than $5.5 million in outstanding taxes from 11.6 thousand unpaid bills (2016). Property taxes in North Carolina become delinquent if not paid by January 5 and tax liens are advertised in March of each year (N.C. Gen. Stat. § 105-360(a)).

Negative effects of tax delinquency extend beyond lost revenue. Tax delinquent homes, often ill-maintained due to the financial constraints of their owners, are associated with neighbourhood blight and increased crime (Spelman, 1993). When delinquent homes are put on the market, this also increases the supply of homes for sale. These factors can push down the market prices of surrounding properties, reducing neighbourhood wealth by depressing asset values (Alm et. al, 2016, Whitacker and Fitzpatrick, 2012, Immergluck and Smith, 2006, Lin et al., 2009, Harding et al., 2009). Avoiding tax delinquency can prevent significant negative externalities from being imposed on entire neighbourhoods.

One developing line of research focuses on the impact of neighbourhood characteristics on the financial wellbeing of homeowners, particularly in regards to mortgage default risk (Rauterkraus et al., 2010, Pivo, 2014, An and Pivo, 2015). Neighbourhood characteristics play an important role in where people choose to live and how people live upon taking up residence in a community, especially for choices around transportation (Holtzclaw et al., 2002). These choices can help decide home prices and the financial position of homeowners. This study builds off of existing literature to examine the relationship between location efficiency, measured as the transit accessibility of neighbourhoods, and probability of tax delinquency in residential housing.

While both tax delinquency and mortgage default data measure similar financial stress, using tax delinquency to investigate the association between location efficiency and homeowner financial health can offer new insights for a number of reasons. Tax delinquency can occur after a mortgage is already paid off, or when financial pressures are not so severe as to lead to mortgage default (Alm et. al, 2016). This makes tax delinquency a potentially more sensitive signal of homeowner financial distress. Additionally, data on tax delinquency is more widely

available than mortgage loan performance data, allowing a more comprehensive property-level analysis.

Understanding the effect of neighbourhood characteristics on resident behaviour would allow city officials and other interested parties to better assess delinquency risk and community health. Additionally, this study adds to recent empirical literature on the benefits of sustainable building and community design, helping city planners and prospective home buyers appreciate the comprehensive impacts of location efficiency beyond reducing commute times and greenhouse gas emissions.

Literature Review

Becoming Tax Delinquent

Many factors explain probability of tax delinquent, related to the homeowner, the property, the neighbourhood, and government policy (Park and von Rabenau, 2014).

Financial distress puts a homeowner in the position to make choices about allocating limited household resources, including from taxes to other areas. The decision to become delinquent contains multiple inter-temporal aspects; an owner may become delinquent in the current period, facing the uncertain prospect that the city begins foreclosure proceedings, and can still pay taxes and fines in a future period. Therefore, in some cases defaulting on property taxes may be a means for an owner to borrow capital for maintenance, mortgage payments, or other costs. When the interest rate available to a borrower is above the penalty rate on delinquent property taxes, property owners in need of capital are incentivized to delay tax payments (Deboer and Conrad, 1988). However, there is also an additional cost of guilt associated with delinquency versus other forms of borrowing (Alm et al., 2014). For credit-constrained homeowners, tax delinquency may be one of their few options to find capital. Therefore, it is no

surprise that taxes are often the first operating cost that owners in financial difficulty will decide not to pay when deciding between mortgage payments, maintenance, and taxes (Scafidi et al., 1998). Tax delinquency can be an early signal of homeowner economic hardship.

Property and neighbourhood characteristics are also implicated in the decision to default. Studies show that homeowners are more likely to abandon buildings in poor condition (Scafidi et al., 1998) and that the condition of neighbouring properties influences the decision of an owner to abandon their own property (Sternleib et al., 1974). Abandonment is closely related to tax delinquency, and in some cases authors define abandonment by tax delinquency (Scafidi et al. (1998) measure abandonment as the transfer of deed from owner to government upon failure to pay taxes). Alm et al. (2014) also find a higher probability of tax delinquency in neighbourhoods in Detroit where police response times are longer, suggesting a breakdown in the social compact in these areas. The authors link the delinquency decision to two broad factors: (1) financial necessity and (2) the social contract between the city and homeowner. These factors can be related to the individual circumstances of the homeowner as well as the broader neighbourhood.

This study is interested in how one neighbourhood characteristic – location efficiency – is related to the risk of tax delinquency. Previous literature on mortgage loan performance suggests a channel from location efficiency to delinquency through impacts on financial necessity (Rauterkraus et al., 2010, Pivo, 2014, An and Pivo, 2015). These studies hypothesize that location efficiency decreases expenses by allowing savings on vehicle ownership and increases asset value of the homeowner because location-efficient homes hold value better. However, other channels may also be implicated, as discussed later.

Location Efficiency

A highly location efficient community is densely populated, mixed-use, and transit-rich. These areas provide many public and private benefits: lower transportation expenditures due to reduced automobile-dependence, less greenhouse gas emissions from fewer and shorter car trips, greater social cohesion nurtured by walkable community spaces, and health benefits of being able to commute via foot or bike. City planners began promoting location efficient homes in the 1990s to combat urban sprawl. During the same period, loan providers became interested in location efficiency because of the benefit of savings on transportation, which increases financial security by allowing residents to free up income usually spent on car ownership and maintenance (Blackman, 2001).

No studies to date investigate the direct relationship between physical neighbourhood characteristics and tax delinquency, as far as I am aware. However, tax delinquency often precedes mortgage default, brought on by the same inability of a homeowner to meet their financial obligations (Scafidi et al., 1998). This suggests that that similar variables may help explain mortgage default and tax delinquency. Existing studies on mortgage loan performance find that location efficient properties are less likely to default, based on savings from automobile independence and because these properties tend to generate more income and value over time.

Rising demand for homes in location-efficient neighbourhoods means that prices in these areas are increasing faster relative to conventional neighbourhoods (Tu and Eppli, 2001). Strong demand decreases the risk of price decline and, if future outsized demand was not captured in the original sale price of the home, leads to better returns for the homeowner on their investment. These factors contribute to the financial health of the property owner. However, the financial benefit will depend on whether the value of walkability features, including ability to eliminate or

reduce car dependence, are fully captured in the price of the property. Previous studies take the premise these features are not completely included in the property sales price, so location efficiency offer a positive net financial benefit (Rauterkraus et al., 2010, Pivo, 2014, An and Pivo, 2015).

Rauterkus, Thrall and Hangen (2010) found that probability of mortgage default increases with vehicle ownership, based on 40,000 mortgages in Chicago, Jacksonville, and San Francisco. The authors link this effect to budgetary savings from lower vehicle ownership and, potentially, better home value performance. Rauterkus et al. (2010) find more nuanced results for walkability: they identified that default probability is negatively associated with walkability in high-income neighbourhoods but positively associated with walkability in low-income neighbourhoods. They propose that low-income, high-default neighbourhoods tend to be in walkable areas – causality runs from low income (and higher delinquency risk) to location efficiency rather than the other way around. While Rauterkus et al. (2010) generally affirm the hypothesis that location efficiency decreases mortgage default risk, their study also shows the difficulty in establishing causation. Estimation techniques must be sensitive to underlying differences in the populations of location efficient and inefficient areas as residents may have different base delinquency risk. In my model, I add variables for percent black population and property value to control for neighbourhood wealth and demographic differences.

Looking at a cross section of 37,385 loans in the Fannie Mae multifamily portfolio, Pivo (2014) found that properties where 30 percent or more of the workers commute to work by subway or elevated train were 58 percent less likely to default. Pivo (2014) suggests that renters and investors favour properties in more transit-rich locations, improving cash flow and value and decreasing default rates. An and Pivo (2015) also conclude that location efficiency significantly

reduces mortgage default risk: more commercial properties in their national study within a quarter mile of a fixed-rail transit station have a 30 percent lower default risk, ceteris paribus. An and Pivo (2015) also find that more walkable properties, based on a walkability index of distance to various amenities, have lower default risk. Their findings came from 22,813 analyzed loans in the CMBS universe. Similar to Pivo (2014), An and Pivo (2015) interpret that properties built in efficient locations have lower default risk because they produce better income and value.

Existing literature supports the hypothesis that transportation accessibility can reduce mortgage default risk. In this study, I seek to test whether the same relationship holds true for tax delinquency, using data from residential properties in Wake County, NC.

Data

Current studies on the financial benefits of location efficiency focus on mortgage default risk. However, a limitation of analyzing mortgage performance is access to data. Property-level mortgage loan performance data is not made publically available. While commercial analytics providers collect mortgage datasets, these generally require a user fee, mask home addresses for privacy protection, and are not population-level. LPS Applied Analytics owns the largest loan-level dataset of mortgage assets, but this database still only represents two thirds of the U.S. mortgage market (Rauterkus et al., 2010). In contrast, tax delinquency data is widely and freely available, thanks to the popularity of naming and shaming penalties for tax delinquency. Twenty-three U.S. states publish lists of the names, addresses, and other information of individuals and businesses owing taxes, including North Carolina (Perez-Truglia, 2015). Since these public lists are comprehensive, they allow data on the tax delinquency status of every property in a given area to be collected and analyzed.

In this study, I gather data on the delinquency status of 347,270 properties as of March 2016 from the Wake County Department of Revenue. Since I am interested in residential housing, I only keep properties coded for use as "residential." Where an account has overdue taxes from multiple years, I add together all taxes due so as to only have one entry per account. This leaves me with a list of 281,886 parcels. Once the list is compiled, I join the delinquency data to parcel data from NC Center for Geographic Information and Analysis. I attach demographic variables from the 2010 Census and American Community Survey and locational characteristics from the Environmental Protection Agency (EPA).

To measure location efficiency, I use data from the EPA Smart Location Database, which characterizes the built environment and transit accessibility of metropolitan neighbourhoods in the United States. The database includes more than 90 indicators, most at the block-group level. In keeping with previous literature, I use distance to a transit stop to measure location efficiency. Additionally, I add a variable that measures frequency of transit service within a census block group. The EPA database does not include locational attributes for every census block group, so I cut out census blocks without data on distance to a transit stop. This leaves a final list of 82,888 parcels in Wake County.

I control for demographic variables at the census-tract level (percent black) and property characteristics at the individual-level (assessed parcel value, year built). No data on homeowner characteristics is available at the property level.

Table 1: Definitions and summary statistics for variables *(n=82,888)*

Variable	Definition	Min	Max	Mean	Std. Dev.
delinquent	Binary for delinquent (1) or not (0) above $500 as of May 2016	0	1	.0074	.0857
quartermile	Binary for transit service within (1) or outside (0) 0.25 miles of population weighted census block group centroid	0	1	. 2033	.4025
transitfreq	Aggregate frequency of transit service within 0.25 miles of block group boundary per hour during evening peak period	0	569.7	41.61	47.35
propvalue	Combined value of the land and structure belonging to the property	19,086	$7.25*10^7$	257,005	367,541
structyear	Year the house was built	1760	2016	1980	22.56
pctblack2010	Percent black in census tract in 2010 census	0.65	85.15	25.06	21.17

Table 2: Contingency table for explanatory variables

Variable	Delinquent Value	Min	Max	Mean	Std. Dev.
quartermile	0	0	1	. 2034	.4026
	1	0	1	.1909	.3933
transitfreq	0	0	569.7	41.48	47.23
	1	0	569.7	58.99	58.59

Empirical Methods

Following Rauterkus et al., 2010, and Pivo, 2014, I estimate delinquency probability using a binomial logistic regression model. A logistic model is particularly suitable for empirical studies with binomial variables, such as delinquent/current. The model estimates the probability of property owner being delinquent, $P(loan\ status = 1)$, as a logistic function of explanatory variables:

$$P(loan\ status = 1) = \frac{1}{1 + e^{-(\alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots \beta_k x_k)}}$$

As shown above, the positive monotone transformation of the linear probability predictor preserves the model's linear structure while keeping the output between zero and one. Thus, the model overcomes one of the major limitations of the linear regression model in analyzing categorical data.

The model reports coefficients as odds ratios. An odds ratio calculates the odds of an outcome in one group divided by the odds of an outcome in another group. Therefore, if an odds ratio is equal to one, this implies that there is no difference in the outcome of interest between treated and non-treated groups.

The most common alternative model used in studies of default risk is the proportional hazard model, which focuses on the time that passes before an event (e.g. default or delinquency) occurs as a function of various associated covariates. The main benefit of this model versus a logic model is that it is less sensitive to bias from data censoring (Pivo, 2013). However, I use a cross-sectional dataset to predict default at a fixed point in time, rather than time-to-default as would a proportional hazard model. Given that I'm not using panel data, censoring isn't a concern.

Discussion

Table 3: Logistic regression results for delinquent, explanatory variable = quartermile

	Odds Ratio	P> |z|	95% Confidence Interval	
quartermile	.928	.481	.754	1.14
lnpropvalue	.338	.000	.253	.453
structyear	.982	.000	.978	.984
pctblack2010	.994	.852	.933	1.06
lnpropvalue_pctblack2010	1.00	.481	.997	1.01
constant	$8.70*10^{19}$	.000	$3.72*10^{16}$	$2.03*10^{23}$

Table 4: Logistic regression results for delinquent, explanatory variable = transitfreq

	Odds Ratio	P> |z|	95% Confidence Interval	
transitfreq	.999	.635	.998	1.00
lnpropvalue	.341	.000	.255	.457
structyear	.982	.000	.977	.984
pctblack2010	.995	.865	.934	1.06
lnpropvalue_pctblack2010	1.00	.483	.997	1.02
constant	$1.13*10^{20}$	.000	$3.26*10^{16}$	$3.91*10^{23}$

The controls used are log value of the land and structures associated with the property, the year the structure was built, and the percentage of black residents in the census tract. The coefficients all conform to expectations. Homes worth more money are less likely to be delinquent, likely reflecting differences in the income profile of the homeowner and neighborhood. Homes built more recently are less likely to be delinquent. This makes sense since these houses are more likely to be in better repair and in neighborhoods experiencing growth – Park (2015) suggests that neighborhood decline is one major factor driving the decision to become delinquent. The coefficients on percent black and the interaction term between percent black and property value are insignificant. This may reflect collinearity associated with the interaction term (discussed later).

Post-regression tests generally validate the validity of my model. A link test assesses specification by rebuilding the model using the linear predicted value and linear predicted value squared. If properly specified, the coefficient on linear predicted value squared will be insignificant. When run on my model, the link test produces a statistically significant coefficient for the predicted value from both models *quartermile* and insignificant coefficients for the predicted value squared from both models (Appendix B, Table 1). This indicates proper specification.

I use the variance inflation factor (VIF) to measure multi-collinearity (Appendix B, Table 2). This test runs a linear regression on each predictor on all other predictors, then obtains the R-squared from that regression to estimate linear dependence with other predictors. The VIF is defined as $1/(1-R^2)$, so VIF near one indicates low linear dependence. In my model, all variables have a VIF under two except for *pctblack2010* and the interaction term *lnpropvalue_pctblack*. These variables are understandably highly correlated, given that one is a product of the other. The multi-collinearity is unavoidable and not a concern for the model as it is restricted to the control variables and will not affect the coefficients for the variables of interest (*quartermile* and *transitfreq*).

Goodness of fit for a logistic regression can be assessed using a pseudo R^2, in my case the McFadden's-R^2 (one of the most commonly-used pseudo R^2). The value of McFadden's-R^2 ranges from 0 to 1, like a traditional OLS R^2, but the value tends to be much lower and is best used to compare different specifications of the same model rather than to compare models with different data sets. The McFadden's-R^2 is 0.104 for both of my models.

Both models produce estimated coefficients on location efficiency variables that are statistically insignificant at the 95-percent confidence interval. However, the coefficients of both models do suggest that more location-efficient properties in Wake County may have lower probabilities of delinquency, all else being equal. The first model (Table 3) suggests that the probability of being delinquent is about 7.2 percent lower for a property within a quarter square mile of a transit stop. The second model (Table 4) shows a very small decrease in odds of being delinquent for a property in a census block with one more unit of transit frequency per square mile. The very small estimated coefficient on *transitfreq* may reflect the low marginal effect of increasing transit frequency by one unit in an area already served by public transit.

Conclusion

The results of this study, while statistically insignificant, indicate that residents of Wake County in more location-efficient properties (with greater access to public transportation) may be less likely to become delinquent on their taxes. These findings are directionally in line with those of previous studies that investigated the relationship between location efficiency and mortgage default risk.

Additionally, this study demonstrates the feasibility of using tax delinquency data to investigate the relationship between property characteristics, such as location efficiency, and homeowner financial health. Tax delinquency offers several advantages over more-commonly used mortgage performance data: it is more widely and cheaply available and can often be collected on every property in a geographic area due to the prevalence of naming and shaming policies of government revenue departments in the United States.

The results have several implications with regards to public policy and risk management. Firstly, they suggest that homeowners in less transit accessible neighbourhoods may be more likely to experience financial hardship as measured by tax delinquency, all else equal. If confirmed in future studies, this result has implications for better predicting downside risks to expected tax revenue as well as for making decision about lending standards and where to target social programs that help homeowners meet their financial obligations. Secondly, this result helps illuminate the wide-ranging benefits of building transit for cities. If transit accessibility helps homeowners become more fiscally stable and more likely to pay taxes, this increases the incentive for Wake County and other governments to expand transit networks within their jurisdictions.

Future studies would benefit from including more cities across the US to see whether the effects found here vary outside of Wake County. Other studies on financial impacts of location efficiency typically focus on large urban areas with greater volume and quality of public transit services than Wake County, which currently only provides buses. Residents in denser cities with more transit options (such as subway or light rail) may have increased incentive or ability to abandon cars. This would allow residents to realize greater savings from location efficiency. Additionally, bigger, more transit-rich cities may demonstrate a stronger relationship between home value performance and location efficiency since the benefits of location efficiency are greater (given higher densities and quality of public transit). Home value performance is another potential mechanism through which location efficiency impacts the financial health of a homeowner. Therefore, a similar analysis using data from other cities may show stronger relationship between tax delinquency and location efficiency.

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Appendix A

Table 1: Correlation matrix, explanatory variable = quartermile

	Delinquent	Quartermile	Structyear	Propvalue	Pctblack2010
Delinquent	1.000				
Quartermile	-.0027	1.000			
Structyear	-.0562	-.1004	1.000		
Propvalue	-.0202	.0231	-.0360	1.000	
Pctback2010	.0879	-.0590	-.0544	-.2280	1.000

Table 2: Correlation matrix, explanatory variable = transitfreq

	Delinquent	Transitfreq	Structyear	Propvalue	Pctblack2010
Delinquent	1.000				
Transitfreq	.0317	1.000			
Structyear	-.0562	-.4080	1.000		
Propvalue	-.0202	.0329	-.0360	1.000	
Pctback2010	.0879	.2286	-.0544	-.2280	1.000

Appendix B

Table 1.1: Link test results, explanatory variable = quartermile

Delinquent	Coefficient	P > |z|	95% Confidence Interval	
_hat	.705	0.003	.245	1.16
_hatsq	-.0349	0.205	-.0888	.019
constant	-.575	0.232	-1.52	.369

Table 1.2: Link test results, explanatory variable = transitfreq

Delinquent	Coefficient	P > |z|	95% Confidence Interval	
_hat	.699	0.003	.238	1.16
_hatsq	-.036	0.195	-.090	.018
constant	-.588	0.222	-1.53	.356

Table 2: Collinearity diagnostics

Model Using Quartermile		Model Using Transitfreq	
	VIF		VIF
Quartermile	1.02	Quartermile	1.33
Lnpropvalue	2.35	Lnpropvalue	1.25
Structyear	1.05	Structyear	2.37
Pctblack2010	445.94	Pctblack2010	448.58
Pctblack_propvalue	423.31	Pctblack_propvalue	427.38

Appendix C

Figure 1: Delinquent Taxes and Distance to Transit

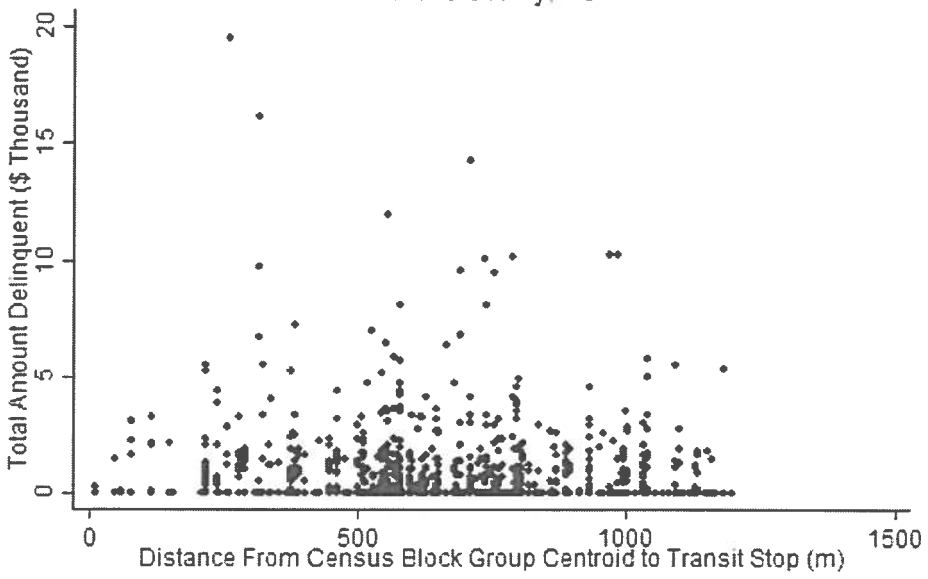

Figure 2: Delinquent Taxes and Transit Service Frequency

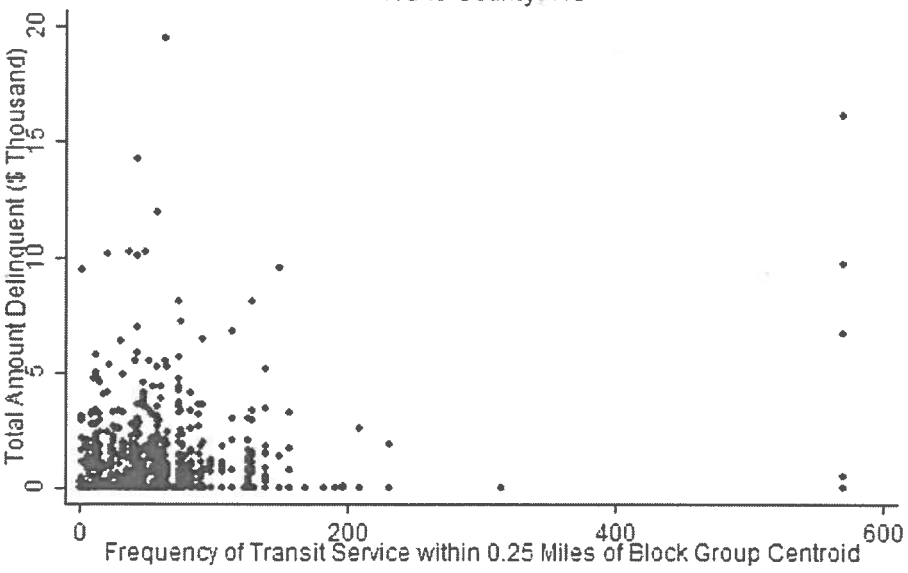

Figure 3. Delinquent Taxes and Year Built

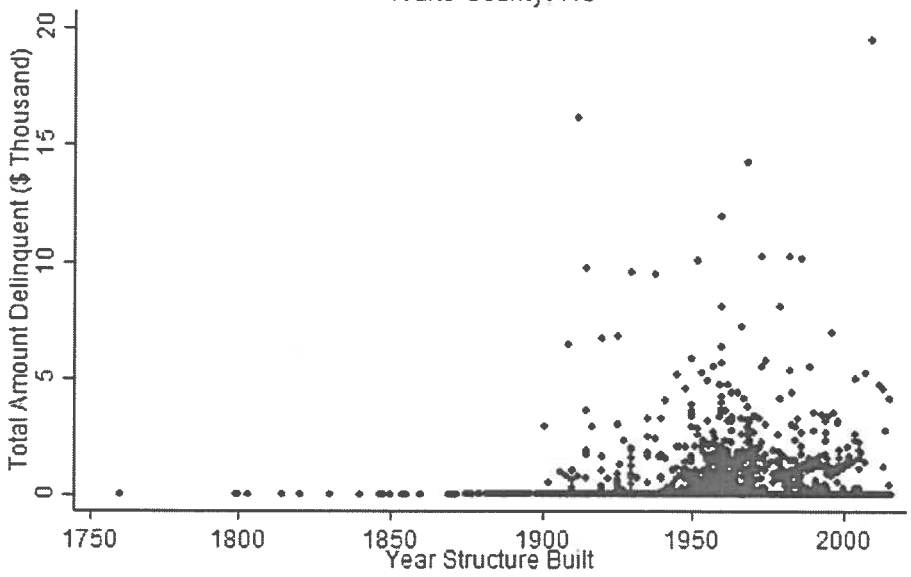

Figure 4.1:Delinquent Taxes and Property Value

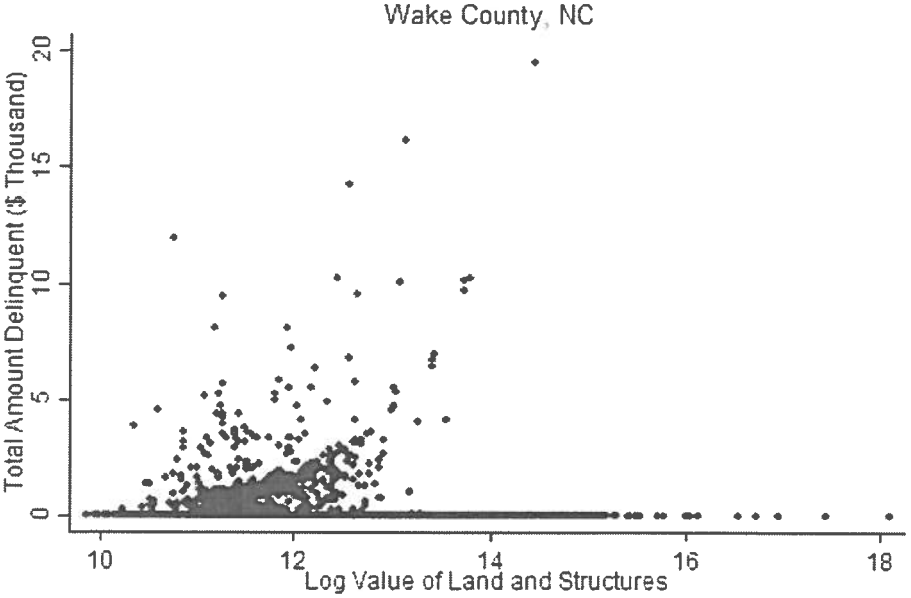

Figure 4.2: Delinquent Taxes and Property Value
Wake County, NC

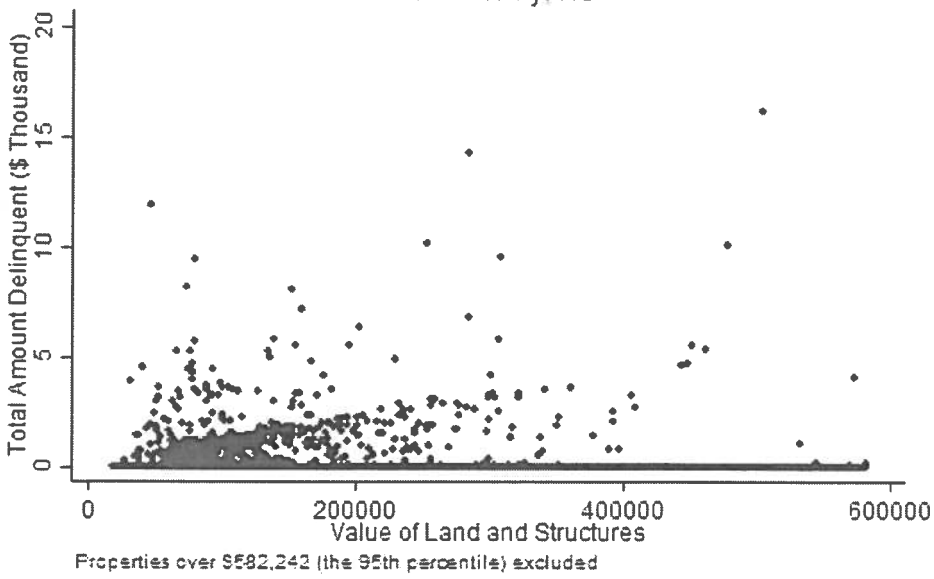

Figure 5: Delinquent Taxes and Percent Black
Wake County, NC