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Does Public Transit Affect Crime? The Addition of a Bus Line in Cleveland

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DOES PUBLIC TRANSIT AFFECT CRIME? THE ADDITION OF A BUS LINE IN CLEVELAND

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NOTE: WE ARE PLEASED TO PUBLISH THIS PAPER AS WINNER OF THE GRADUATE STUDENT AWARD IN ECONOMICS AT THE ANNUAL CONFERENCE OF THE OHIO ASSOCIATION OF ECONOMISTS AND POLITICAL SCIENCE 2015. AS SUCH IT HAS BEEN REVIEWED BUT HAS NOT UNDERGONE A DOUBLE BLIND REVIEW PROCESS.

ABSTRACT

Public transportation affects crime rates in neighborhoods surrounding its implementation. It can give criminals easier access to potential targets and decrease the probability of getting caught, or it can give lower-income individuals better access to reliable transportation, which decreases the probability of those individuals getting involved in criminal activity. This paper analyzes available criminal data, property data, and public assistance data for the city of Cleveland to study the effects on property crime rate after the 2008 implementation of a public bus line. The paper's hypothesis is that there is a difference in the mean crime rate before and after the bus implementation, to be tested with a t-test. Using fixed-effects and pooled OLS models, the findings were that the bus caused an increase in the mean property crime rate in the census tracts touching that line by about 1.4%. This provides evidence that public transportation does in fact increase crime rates in areas surrounding it. Given that the nature of this study is to only observe the effects in the short-run, a possible extension and follow-up study would be to revisit this issue when more years of crime rate data are available for the tracts used.

INTRODUCTION

How does public transportation affect crime rates in the areas through which it runs? Public transit offers urban residents a reliable, inexpensive alternative to purchasing and maintaining a car. Leading experts in the field of regional economics argue that lower-income individuals live in city centers because that is where the most public transportation is located (Glaeser, Kahn, & Rappaport, 2000). This helps reduce crime in areas because as lower-income people have greater access to jobs, they are less likely to engage in criminal activity. Other public transportation benefits include reducing road congestion, sprawl, and air pollution, which is beneficial for the environment.

On the other side of this issue, public transit may help facilitate crime. Pickpockets often target the crowds that gather at the stops waiting for the next pickup. Also, rails and buses give criminals greater access to the city in which they live: "[T]ransit shapes the crime pattern of the city by moving large proportions of high-risk populations around the city along a limited number of paths and depositing them at a limited number of destination nodes…" (Brantingham, 1991).

It is an important issue with significant policy implications for city governments. Cities should take the potential costs and benefits of public transit into consideration when making expenditure decisions regarding adding additional routes, as well as police and other safety forces. This also affects population size and a city's makeup; crime is a deterrent for many when choosing where to live.

By analyzing how transit affects nearby property crime rates, the following question can be studied: Using data on a census-tract level, does adding a bus line in Cleveland cause crime rate to increase, decrease, or does it have no effect? This paper hypothesizes an increase to property crime rates in those areas surrounding the bus line relative to areas located farther away. The mean crime rate for property crimes is different in areas with a bus route versus those without a bus route in them. Performing a t-test can test this hypothesis.

This paper uses available crime, housing, and public assistance data for the city of Cleveland to estimate the impacts of the implementation of bus line on property crime rate in the surrounding areas. The HealthLine, operated by the Cleveland Regional Transit Authority, began running in 2008. This is a 24-hour bus service with 58 stops on its 6.8-mile route. A trip from start to finish takes approximately 40 minutes (McCahon and Bitto, 2014). Figure 1 shows the route of the HealthLine.

The bus line begins in Public Square, which is located in downtown Cleveland. This area is the heart and center of Cleveland, in close proximity to everything from cultural events to major office buildings. It then runs through University Circle, including Cleveland State University and multiple museums and hospitals. It ends at Windermere Street in East Cleveland. The entire line runs along Euclid Avenue, which serves as the border for several census tracts.

LITERATURE REVIEW

The existing literature provides evidence for public transit increasing crime levels. Ihlanfeldt (2003) used fixed and random effect models on Atlanta data, and found that additional transit caused an increase in crime in the city center and a decrease in the suburbs. Block and Davis' (2004) findings included more robberies near areas with more public transit. Looking at environmental characteristics for a particular area, Loukaitou-Sideris (1996) found that bus stops had an effect on crime in Los Angeles.

Other papers and authors found different results. Plano (1993) found no statistically significant results linking crime and public railways; however, a critique of his methods is that Plano did not control for other potential crime factors in the area (Ihlanfeldt, 2003). Robin, Loukaitou-Sideris, and Iseki (2003) found no link between crime and distance to public transit areas, nor did they find significant results that support the argument, public transit moves crime to the suburbs.

THEORY

A basic theory for why property crime exists is taken from Brueckner (2011), who used a condensed and simplified version of Becker's theory of crime (1968). First, we assume that there are only two outcomes for people: to earn wages as a legitimate worker, or to live off of money gained from criminal activity. As rational, utility-maximizing individuals, people choose to be one or the other, depending upon which outcome has a higher expected income.

Expected income for a legitimate worker is simply the wage rate multiplied by the number of hours worked. Because this paper focuses on property crimes, the equation for a criminal's expected income from robberies, burglaries, etc. is:

(1) (1-a)*L-aJ-e,

Where "a" is the apprehension rate, "L" is the value of the stolen goods, "J" is the cost of jail time, and "e" stands for the cost of materials needed to commit a certain crime. Therefore, expected income is the monetary value of stolen goods multiplied by the probability of not getting caught minus the costs of jail time multiplied by the probability of getting caught minus the time and monetary costs associated with committing a particular crime (Brueckner, 2011).

If the value that the equation yields is greater than what an individual expects to earn from a legitimate job salary, then an individual will choose to be a criminal. This theory predicts that socially and economically disadvantaged people are more inclined to become criminals because their expected wages would be much lower than average. This implies that the incentive to be a criminal is larger for them.

From equation 1, the larger the value of stolen goods, *L*, the bigger the payoff a criminal expects. Greater amounts of goods and money are more easily found in wealthier neighborhoods, which imply that criminals want to target these neighborhoods over lower income ones. This incentive can be applied to public transit by giving criminals greater mobility to reach these areas.

Another way public transit influences this equation is through *a*, the apprehension rate. Public transit gives criminals an easier route of escape. If a criminal robs a house and then goes into a crowded subway station or gets on the next bus, authorities then have a more difficult time locating and identifying him or her among many other people. Therefore, the apprehension rate is lower, and criminal activity more attractive.

While the original model did not include spatial elements, it can be expanded to include them by looking at *e*. Since there is less time and money involved in committing crime closer to where an individual lives, *e* will be lower for potential locations to commit crime near the individual, and *e* will be higher for areas that are further away.

Brantingham and Brantingham (1984), from the criminal justice field, describe a specific relationship between crime and the ease of which a criminal can access a city. They state that criminals choose, all else equal, to target areas closer to them. In other words, the shorter the trip, the easier a criminal finds committing the crime. Public transportation increases mobility, and that affords criminals greater access to different areas in cities and with less time required.

EMPIRICAL METHODOLOGY

Important factors must be addressed to explain the model. For instance, the census tracts surrounding the bus line are filled with different individuals with varying characteristics. One tract may be a bigger target for criminals than others or have a higher median income than others. This implies that locating in a census tract is not randomly selected, and so these factors need to be controlled for. The only difference between the tracts should be whether they contain the bus line or not.

Comparing the census tracts around the bus line to other similar areas that do not have the bus line provides valuable insight into whether the crime rate changed because of the bus or because of other unobserved factors. For example, the Great Recession began in Cleveland, as with many other areas, in 2008, which also happens to be the year of the bus implementation. Given the likely assumption that all neighborhoods and census tracts in Cleveland suffered the devastating effects of this economic event equally, the potential spike in crime rate due to the recession will be controlled for.

To begin the analysis, only the tracts touching the bus line were used in the analysis. As these census tracts remain constant during the time period used, a fixed-effects model was determined appropriate to use. A one-way fixed-effect model was used on this data, holding tract constant, to control for unobserved characteristics. A two-way model will be used later, but it is inappropriate for this test because the effects of the bus binary variable are cancelled out if time is also controlled for. The general one-way fixed-effect model can be seen in equation 2:

(2) $$Crime\ Rate_{it} = \beta_0 + \beta_1 Bus_{it} + \beta_2 X_t + Tract_t + \varepsilon_{it}$$

$Crime\ Rate_{it}$: Crime rate in census tract i in time period t

$\beta_1 Bus_{it}$: If the census tract i is touching the busline in time period t

$\beta_2 X_t$: A vector of tract specific characteristics for each time period.

$Tract_t$: The tract in time period t

ε_{it}: The error term

An F-test performed on the data showed significance, which signifies that fixed effects are present in the data. This means that a fixed-effects model would be more appropriate than a pooled OLS model. Results from a Hausman test determined there were no random effects[2].

A two-way fixed-effect model was used to control for time and census tracts when data combined touching and bordering census tracts.

Two-Way Fixed Effects Model:

(3) $$Crime\ Rate_{it} = \beta_0 + \beta_1 Bus_{it} + \beta_2 X_t + Tract_t + Time_i + \varepsilon_{it}$$

Where time is measuring the time period for each census tract and all other variables are described above. An F-test performed on the data also showed significance. A Hausman test determined that, again, there were no random effects present in the data. A pooled OLS regression also was used if the F-test failed to show significance for fixed effects.

DATA

This paper used data from myriad sources to perform empirical research. The first piece of necessary data is the bus route location to determine necessary census tracts for the study. Using Google Maps and Cuyahoga County census tract boundary maps created by the Census Bureau, 11 tracts touching the HealthLine in some way were used, as well as 19 tracts that bordered those but did not touch the bus.

The Cleveland Police Department's crime data was extracted on a census-tract level to compare areas around the bus line to areas unaffected by the implementation. This research focused only on property crime. The numbers are based on where the crime was committed, which may be different than the residence location of the perpetrator and the victim. The equation used to determine the crime rate of each census tract is shown in equation (4):

(4) $$\frac{\text{Number of crimes/tract} * 100{,}000}{\text{Census tract population}^{3}}$$

Data regarding number of properties and home values was extracted from the Cuyahoga County Fiscal Office. This includes the number of property parcels classified as residential, commercial[4], and industrial, and the number of those parcels that have no buildings. Other data from this source includes the median value of single-family homes for each census tract. The home values were calculated by using market value, including taxable and nontaxable parcels.

Public assistance data came from the Cuyahoga County Department of Job and Family Services. The variable obtained from this source — percentage of people living in the census tract on food stamps — was a proxy for poverty level. An individual qualifies for food stamps if "their household's gross monthly income is at or under 130 percent of the federal poverty guidelines" (Job & Family Service Brochure, 2012). Exceptions are also granted if someone older and/or disabled is living in the house with the individual, and utility bills also can be a factor in determining eligibility. The data source reported the rate quarterly each year, and calculated it as shown in equation (5):

(5) $$\frac{\text{Number of individuals on food stamps} * 1{,}000}{\text{Census tract population (est)}}$$

Creation of Variables & Manipulation of Data

Variables were created to consolidate the quarterly data on the average number of individuals using food stamps. This was accomplished by taking the mean of the four quarterly numbers in order to get one single data point for each year. This was done for the number of individuals on assistance and the tract-level rate developed in equation 6.

The Cleveland Police Department data page used the number of crimes multiplied by 100,000 because that is what is most often reported when sources list crime rates on the state and federal levels; however, for this study that number unnecessarily inflates crime rates to almost absurdly large levels. Because of this, the second data manipulation used divided the crime rate by 1,000 in order to garner more meaningful results.

Purchased plots of land are classified as residential, commercial, or industrial. The total parcel by type of variable did not remove vacant parcels from the count, which means that pieces of land with no buildings but zoned for one of the above were counted. To fix this, a variable was created that subtracted the total parcels from the vacant ones. This left only parcels with buildings standing on the ground. These variables were then multiplied by 100 and divided by the number of total parcels to get a percentage. The Cuyahoga County Fiscal Office — the data's origin — provided this variable, but used vacant parcels of land in the count. Once these were removed, the office's methods were used to recalculate the rates.

A time variable and a time-squared variable were created to check for non-linearity in the data. A binary variable for the bus also was created, as well as a binary for whether the tract touches where the bus route would be, either before or after the bus began to operate. Finally, an interaction term for time and the bus was created. A description of variables is available in table 1. A complete list of summary statistics is available in table 2.

DATA LIMITATIONS

Because of the way crime rates are measured, the results may be misrepresented. The census tracts used are in the downtown Cleveland area, which may render recorded crime rates less reliable since

downtown is mostly commercial and less residential, and more people come to work there daily than there are residents in that area. As there is no data available on the amount of workers coming to the area daily versus the number of residents, population was the best alternative.

Census tract data is not available for locations other than the city of Cleveland. Three tracts that touched the bus route and eight tracts that bordered those were located in East Cleveland, while three bordering tracts were located in Cleveland Heights. No data was available for these tracts, so these 14 tracts were removed from the sample.

Certain tract characteristics — population, unemployment status, race, and income level, et al. — are only updated every decade. Since the analysis began five years after a census year, the numbers were not easily estimated and cannot be used in this study. Further study could be done if such data was available on a yearly basis.

EMPIRICAL RESULTS

The mean property crime rate in tracts without the bus route was, statistically, significantly less than the tracts with the bus. This can be seen in table [NO NUMBER PROVIDED]; however, this t-test does not capture the full magnitude of the situation. The bordering census tracts and the ones that touch the tract bus before implementation are treated the same in this analysis.

To fully analyze the situation, the mean crime rate three years before and three years after the bus implementation was studied separately. Comparing the crime rates of the tracts touching the bus and the border tracts shows the changes from those periods. After running a t-test on both time periods, it is clear that the mean crime rate rose in the tracts touching the bus, while it declined in the tracts bordering those tracts but not touching the bus. The difference in means can be seen in tables 4 and 5. The difference of these means is approximately 1.27%.

An OLS regression was run to see the trend of the city of Cleveland's property crime rates during the time period. The results are in table 6. The negative relationship with time period, *T*, implies that crime rates are decreasing over the time. After researching this trend, the literature agrees. Property crime rates are on a downward trend in Cleveland since the early 1990s (Gillipsie, 2011). While the city of Cleveland's crime rates decreased as a whole over that time period, including the bordering census tracts, the crime rate of the census tracts that touched the bus line increased slightly during that same period.

Only looking at the census tracts with the HealthLine bus, before and after implementation, is a one-way fixed-effects model run. This analysis is a starting point because any changes found in crime rate could be attributed to unobserved reasons; border tracts are needed for use as controls. The results can be seen in table 7.

When the data was contained in one dataset, a standard OLS regression did not yield many significant results. The coefficient on the bus binary variable was positive and statistically significant in all models; however, when the fixed-effect model was used, the coefficient changed in magnitude, making it less influential than in the OLS. Most of the other signs were as expected in the fixed-effects model with the exception of home value. As home values increase, crime rate decreases — the opposite of what the theory suggests. That, however, can be possibly explained by the fact that as people spend more money on their homes, they are more willing to invest in better home security, which reduces crimes. Complete results can be found in table 4.

The results from the fixed-effect model on the full-sized data sample shows evidence that after the bus was implemented, the property crime rate increased by 2.8% in areas touching the new line compared to everywhere without a bus. This supports the view that public transit increases property crime rates in surrounding neighborhoods.

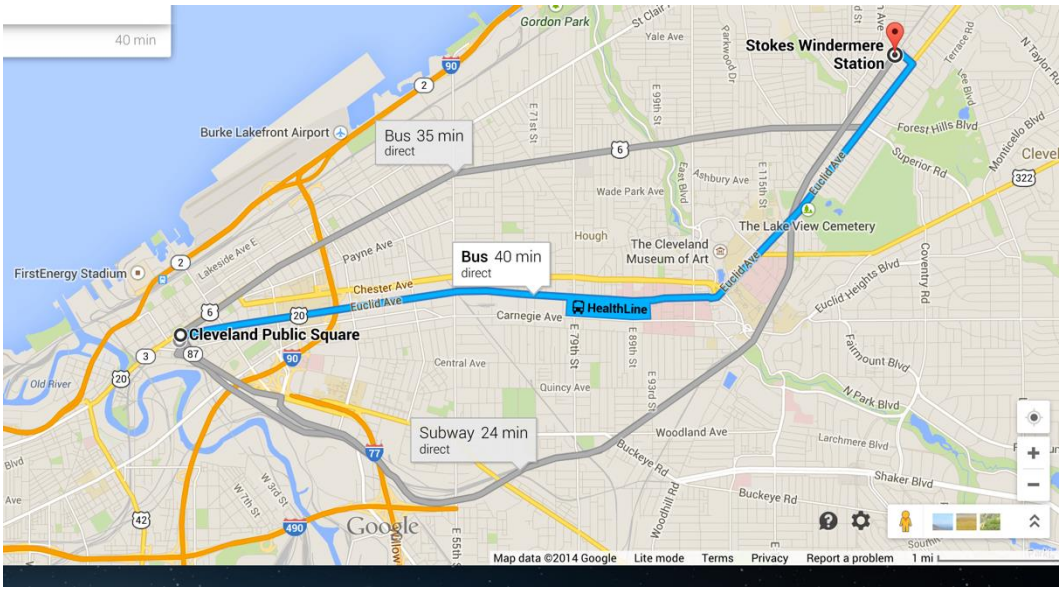
Finally, the time periods before and after the bus began operating were examined, with the *touch* variable marking the census tracts that would border the bus line after 2008, the year of implementation. This sheds light on how crime rate changes without worrying that one set of census tracts contains more criminal activity than the other set. An F test and Hausman test held no significance, so a pooled OLS regression was determined appropriate to use. The census tracts touching the bus line before it began running had a positive effect on crime rate. It is statistically significant and the impact is equal to 6.13%. After the bus began operating, the same set of tracts' effect on the crime rate increased to approximately 7.50%. This is a difference of about 1.37%. The full table of results is in table 9.

CONCLUDING REMARKS

Using Cleveland data, this paper analyzed the effects of the HealthLine bus on crime rate in the surrounding areas. This is an important issue for cities. If adding extra public transit encourages crime, then that will deter new people and businesses from coming to the area; however, public transit provides reliable transportation for a large amount of people to travel to work and businesses. Using a fixed-effect model and a pooled OLS, evidence from the models shows that the bus increased the mean property crime rate in the area by approximately 2.8% and 1.4%. Both results from the different methods support the view that public transit increases property crime in surrounding neighborhoods.

There are a few ways this study could be extended. Crime data was only available up to 2010, which means that this analysis measured only the short-run impacts of the bus line on crime rate. For future research, as more years of data become available, the longer-run affects could be analyzed. Also, if data becomes available for East Cleveland, a comparison of crime rates between that city and Cleveland could be used. Finally, the Cleveland RTA is considering extending Healthline. If that were to happen, the extra locations could also be included in the data to study.

FIGURE 1: HEALTHLINE BUS ROUTE



Source: Google Maps

TABLE 1: VARIABLE LIST

Name	Description
Crime Rate	Number of Crimes in tract * 1,000/Tract Population Estimate
% of Parcels - Residential	Number of parcels classified as residential * 100/Total parcels
% of Parcels - Commercial	Number of parcels classified as commercial * 100/Total parcels
% of Parcels - Industrial	Number of parcels classified as industrial * 100/Total parcels
Home Value	Median value of homes in the census tract - using market value
% of Indiv. on Food Stamps	Number of individuals on food assistance * 1,000/Tract Population Estimate
T	Time period, 1-6 for 2005-2010
T Squared	Time period squared, to check for non-linearity
Touch (binary)	1 - Tract is touching the bus line before & after 2008 0 - Not touching (Border)
Bus Line (binary)	1 - Tract is touching the bus line after implementation 0 - Not touching or before 2008

TABLE 2: SUMMARY STATISTICS

Variable	N	Mean	Std. Error	Min	Max
# of Crimes	186	116.2	80.84	22	487
# of Residential Parcels	186	225.67	171.32	0	716
# of Commercial Parcels	186	67.94	49.61	1	243
# of Industrial Parcels	186	9.48	16.45	0	70
Home Value	186	34062.37	35800.24	0	268550
Individuals on food stamps	186	480.52	349	36	1339
T	186	3.5	1.71	1	6
T Squared	186	0.89	1.95	0	36
Bus	186	0.1774	0.38	0	1
Source: NEO Cando System, Case Western Reserve					

TABLE 3: DIFFERENCES IN MEANS (FULL SAMPLE)*

Variable	N	Crime Rate
Bus Line = 1	33	143.5
Bus Line = 0	153	82.66
Difference		60.87**
***significance at the .01 level ** significance at the .05 level * significance at the .10 level	Source: Cleveland PD *TTEST	

TABLE 4: DIFFERENCE IN MEANS 2005-2007*

Variable	N	Crime Rate
Border tracts before bus	60	7.02
Tracts touching bus before bus	33	13.46
Difference		**-6.43*** **
***significance at the .01 level ** significance at the .05 level * significance at the .10 level	Source: Cleveland PD	

TABLE 5: DIFFERENCE IN MEANS 2008-2010*

Variable	N	Crime Rate
Border tracts after bus	60	6.65
Tracts touching bus after bus	33	14.35
Difference		-7.70***
***significance at the .01 level	Source: Cleveland PD	
** significance at the .05 level		
* significance at the .10 level		

TABLE 6: CLEVELAND CRIME RATE TREND

Method:	OLS
Constant	6793.27***
	(56.27)
T	-147.17***
	(-4.75)
N	6
Adj R Sq	0.8116
Root MSE	129.69
F	22.54***
***significance at the .01 level	Source: Cleveland PD
** significance at the .05 level	
* significance at the .10 level	

TABLE 7: REGRESSION RESULTS FOR TRACTS CONTAINING BUS

Method:	OLS	FE*	RE**
Constant	.200	-27.51***	-37.148***
	(.02)	(-3.12)	(-3.45)
T	-.39	2.58*	2.493*
	(-.09)	(1.95)	(1.74)
T-Square	.039	-.648***	-.647***
	(.07)	(-3.61)	(-3.30)
% of Parcels - Residential	-.142*	.004	.038
	(-1.70)	(.01)	(.19)
% of Parcels - Commercial	.3722***	1.737***	.823***
	(3.98)	(4.59)	(3.86)
% of Parcels - Industrial	.371	.721	.319
	(.70)	(.57)	(.32)
Home Value	-.0001	-.0001***	-.0001***
	(-1.50)	(-5.48)	(-5.63)
% of Indiv. on Food Stamps	.382***	1.131***	1.146***
	(3.55)	(16.52)	(16.32)
Bus Line (Binary)	1.81	5.081***	4.544**
	(.21)	(2.91)	(2.37)
n	66	186	186
R-Square	.4856	.9058	.5405
root MSE	10.84	32.52	39.85

***sig at the .01 level
** sig at the .05 level
* sig at the .10 level

Source: Neo Cando System
*Note: One-way fixed effects model
**Note: One-way random effects model

Dependent: Property Crime Rates

(t statistics in parentheses)

TABLE 8: REGRESSION RESULTS FULL SAMPLE

Method:	**OLS**	**FE***	**RE****
Constant	4.871	-41.874***	-36.491***
	(1.61)	(-5.77)	(-5.88)
% of Parcels - Residential	-0.0396	0.294**	0.246***
	(-1.03)	(2.53)	(3.31)
% of Parcels - Commercial	0.174***	0.775***	0.669***
	(3.63)	(4.23)	(5.98)
% of Parcels - Industrial	0.159	0.002	0.342
	(1.11)	(0.00)	(1.02)
Home Value	0.000003	-0.00007***	-0.00007***
	(.14)	(-6.75)	(-5.54)
% of Indiv. on Food Stamps	0.004	0.098***	0.0685***
	(1.17)	(17.47)	(12.11)
Bus Line (Binary)	4.787***	2.848***	2.935**
	(2.80)	(2.81)	(2.43)
N	186	186	186
R-Square	.2047	.9058	.5405
root MSE	8.47	3.25	3.99
***significance at the .01 level	Source: Neo Cando System		
** significance at the .05 level	*Note: This is a two-way fixed effects model		
* significance at the .10 level	**Note: This is a two-way random effects model		

Dependent: Property Crime Rates

(t statistics in parentheses)

TABLE 9: REGRESSION RESULTS BEFORE AND AFTER BUS

Method: OLS	**2005-2007**	**2008-2010**
Constant	-5.746	4.272
	(-1.01)	(.08)
T	1.865	.019
	(.35)	(0.00)
T-Square	-.520	-.017
	(-.40)	(-.01)
% of Parcels - Residential	.065*	-.098
	(1.69)	(-1.42)
% of Parcels - Commercial	.273***	.0333
	(6.14)	(.38)
% of Parcels - Industrial	.233*	.309
	(1.69)	(1.20)
Home Value	.00001	.00003
	(.52)	(1.12)
% of Indiv. on Food Stamps	.074**	.119**
	(2.01)	(1.98)
Tract touches Bus Route (Binary)	**6.132*** **	**7.496*** **
	(3.87)	**(2.90)**
n	93	93
R-Square Adj	.4090	.1455
root MSE	5.297	9.967
F	8.96***	2.96***

***significance at the .01 level
** significance at the .05 level
* significance at the .10 level

Source: Neo Cando System
Dependent: Property Crime Rates
(t statistics in parentheses)

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ENDNOTES

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[2]Results from the random-effects model are still included in table 4 in appendix B. While this is not the main model, it is similar and therefore lends support to the conclusions made from the fixed-effects model.

[3]Note that census tract level population is not available every year. The Cleveland Police Department and the Cuyahoga Dept. of J&FS estimated it from the total population given from census years 2000 and 2010.

[4]Commercial parcels include both business and apartment buildings.