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# THE EFFECTS OF THE ANNOUNCEMENT AND OPENING OF LIGHT RAIL TRANSIT STATIONS ON NEIGHBORHOOD CRIME

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**ABSTRACT:** *The debate over crime and rail transit focuses on whether such investments "breed" criminal activities with new targets of opportunity or transport crime from the inner city to the suburbs. Yet, little empirical evidence exists on whether new rail transit actually does lead to increased crime rates around stations. In order to study this question, we test the relationship between crime and rail transit with the 2007 opening of the Charlotte light rail line. We use Geographical Information Systems software and micro-level data on reported crimes to generate measures of criminal activity in and around light rail transit (LRT) stations. We then implement a quasi-experimental before-and-after methodology using two alternate transit corridors to control for differences between neighborhoods that contain LRT stations and other neighborhoods. We find light rail does not actually increase crime around stations. Instead, we see a decrease in property crimes once the station locations are announced, which remains relatively stable after the light rail begins operating.*

## INTRODUCTION

Rail transit[1] systems have received a great deal of attention and investment in recent years. Advocates and many public officials have extolled the expected benefits associated with rail transit systems including the alleviation of traffic congestion and improved air quality resulting from fewer automobiles on the roads. For many such advocates, these anticipated benefits exceed the capital and ongoing operational costs necessary to implement and support such a system. Detractors often draw attention to the high capital costs relative to the projected ridership, which

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is often a small fraction of the commuting population. This second type of argument derides such investments as wasteful on both efficiency and effectiveness grounds. Furthermore, some detractors also argue that fixed line rail systems represent an inappropriate use of government funds to direct investment in certain areas as opposed to allowing market forces to dictate where development will and will not happen in a metropolitan area. Finally, many opponents of rail transit fear that it will transport inner city crime to suburban neighborhoods and increase criminal activity around station areas. Public meetings, local newspaper stories, political cartoons, and activist blogs are replete with examples of fears that rail transit and the various stops along the lines will increase crime at the station and/or in the neighborhood around the station (see e.g., O'Toole, 2008; Spivak, 2008; The Antiplanner, 2007).

Much of the work on crime and the presence of rail transit has focused on perceptions of crime as opposed to crime statistics. Numerous news stories highlight how suburban communities and neighborhood groups often perceive that transit lines transport inner city crime, gangs, and drugs to the suburbs (Carlson, 2000; Ferguson, 1994; Gustafson, 2008; Nussbaum, 2009). Even some of the limited scholarly research has focused on these perceptions. For instance, Ross and Stein's (1985) study of Atlanta's MARTA rail system found that crime is the second greatest concern of residents, after traffic congestion. There is also an overall widespread public concern that light rail will increase or "breed" crime, particularly property crime in areas adjacent to stations. But data and analyses supporting these public perceptions have been limited (Poister, 1996).

In this article, we seek to advance this line of inquiry on this relationship using crime statistics. Specifically, we provide two time periods of analysis to disentangle the effects of reported crime related to public and private investment in and around proposed light rail transit (LRT) stations from the effects of crime due to the opening of LRT stations. The first time period occurs between the announcement and opening of LRT stations when public and private investments occur in anticipation of LRT. The second time period relates to after the opening of LRT, where there is an increase in access and opportunities for criminals. Specifically, our research addresses the following questions regarding light rail and crime:

(1) Does crime in the area around a proposed light rail station increase with the announcement of the proposed site?
(2) Does crime in the area around a new light rail station increase with the opening of a new station?
(3) Do these changes differ from other similar neighborhoods without stations over the same time periods?

To answer these questions, we examine the complex relationship between crime and transit by focusing on the effects of the South Light Rail corridor in Charlotte, North Carolina. Announced in 2000, the LYNX Blue Line began its South Corridor operation in late 2007. Comparisons to two other corridors that have not been built provide a basis upon which to draw conclusions about the effects of light rail on crime. This represents an improvement over previous studies that overcomes potential biases due to unobserved neighborhood attributes that likely influence both crime and the location of LRT. Results can be used to construct more accurate and informed cost-benefit analyses to assist communities debating the merits of such infrastructure investments.

## THEORY AND LITERATURE ON CRIME AND TRANSIT

There are two reasons why rail transit[2] may increase crime, both tied to long-standing debates over urban form. First, rail transit may improve the mobility of criminals. Second, rail transit may increase crime because the presence of a rail station undermines an area's defensible space thus

decreasing safety in the immediate neighborhood.[3] These arguments represent another facet of the continuing classic debate between rational planning and the human elements of urban living. Jane Jacobs's work, a response in large part to the Chicago School of Park and Burgess and their defended neighborhood, extolled the interaction of people in urban spaces while attacking the urban renewal programs of the 1950s and 1960s (1961). The planning profession fought back through scholars such as Lewis Mumford (1962) and practitioners like Robert Moses in New York (Caro, 1975). Today, that debate has yielded the more contemporary efforts of Oscar Newman's defensible space approach (1996) and the New Urbanism movement personified by the works of Andrés Duany, Elizabeth Plater-Zyberk, and Jeff Speck (2001). Both traditions focus on urban structure and design forms, and both have explicit implications for public safety and public transit. This debate is reflected in criminal justice research in the work of Brantingham and Brantingham (1995), who refer to these same phenomena as crime generators versus crime attractors.

Some scholars investigating the transit and crime linkage as part of this larger debate note that transit-oriented investments breed crime by linking central city crime with outlying areas, providing gangs a means of access and territorial control, as well as serving as a conduit for bringing drugs into suburban communities (Carlson, 2000; Ferguson, 1994; Gustafson, 2008; Nussbaum, 2009; Poister, 1996). Victims are likewise introduced to new areas around the light rail stations. They are often less familiar with their surroundings making them easier prey for criminals. Researchers cannot explain nor can public safety officials prevent crimes without understanding the environment in which they take place (Smith & Clarke, 2000).

Capone and Nichols (1976) argue that criminal mobility is related to urban structure. From this rational decision-making perspective, if a criminal is looking for a victim, several potential targets exist. All things being equal, the criminal will choose the closest target. This is also known as the "distance decay theory," because the further away the crime, the more time, energy, and money the potential offender must expend (Phillips, 1980). As other scholars have noted, most criminals travel only short distances to conduct their business, usually about a mile or two (Rengert, Piquero, & Jones, 1999; Rhodes & Conly, 1991; Spelman, 2005). Thus, this perspective suggests that a rail station attracting riders might attract potential victims for criminals in the local area (Brantingham & Brantingham, 1995). What is less clear is whether this would represent a net increase or simply a relocation of criminal activities.

Additionally, some criminologists suggest that public rail lines (light or heavy rail) increase crime by transporting large proportions of high-risk populations around the city, which provides opportunities for criminals (Brantingham & Brantingham, 1984, 1995). They conclude that there is a strong spatial bias that results in more short trips than long trips within any particular category of crime. The transit system becomes a means of connecting criminal with victim.

Other scholars have pushed this argument further asserting that the presence of a rail station affects safety in the immediate neighborhood (Block & Block, 2000). They assert that the degree of risk of becoming a victim of crime varies from place to place across the city and that residents view rail transit stations as dangerous places for several reasons (Block & Block, 2000; Block & Davis, 1996). First, rail transit stops provide cover for potential offenders because riders stand around and this is not thought of as suspicious activity. Second, stations provide easy exit and entry for criminals. Finally, potential targets of criminals typically live away from the area and may not be familiar with surroundings. This reflects the incomplete cognitive map available to such travelers as differentiated from the sense of safety they derive from the familiarity of their home neighborhood (Suttles, 1972). Empirical research in the Bronx and Chicago concludes that robberies do not increase in the rail stations; however, they do increase 1 to 1.5 blocks away. And while transit managers typically hire security for the station area, they neglect nearby streets and this, therefore, contributes to increased robberies (Block & Block, 2000; Block & Davis, 1996).

**TABLE 1**

**LRT and Crime Literature**

| Study | Scope | Methods | Findings |
|---|---|---|---|
| Plano (1993) | Three Baltimore station areas | Looks at trends, no controls | Cannot attribute increase in crime to rail |
| Loukaitou-Sideris and Banerjee (1994) | Blue LR line in LA | Site station surveys, cluster analysis | Decrease in crime after announcement |
| | | In-depth interviews with public officials | Little reduction after operation |
| | | Crime data within 1/4 mile of 22 stations | |
| Block and Block (1996) | Chicago & Bronx, robbery only | Spatial analysis | Increased 1–1.5 blocks from stations |
| Poister (1996) | MARTA extensions in Atlanta | Neighborhood crime data | Crime increases when stations open. |
| | | 3 years prior and 19 months post | Followed by a decrease to earlier levels |
| Loukaitou-Sideris, Liggett, and Iseki (2002) | Green line in LA | Mix of qualitative and quantitative methods to analyze crime statistics, census and ridership data, and built environment data. | Crime depends on ridership & land use |
| Ihlanfeldt (2003) | MARTA in Atlanta | Panel neighborhood crime data | Depends on neighborhood characteristics |
| | | Fixed effects and random effects models | Increases crime in the inner city |
| | | | Decreases crime in the suburbs |
| Liggett, Loukaitou-Sideris, and Iseki (2003) | Green line in Louisiana | Piecewise regression to identify spatial shifts in crime hotspots | Crime has not been transported to the suburbs |

A methodological limitation in much of the work to date on crime and transit stations is that scholars are not placing the station areas in the larger metropolitan context. As a result, one cannot conclude whether the apparent increase in crime is a net increase for the area, a relocation of existing crime within the area, or consistent with changing crime rates for the city/region as a whole (and thus not attributable to the presence of the station).

The public debate over new rail transit investments often includes accusations that new rail stations are associated in some manner with a higher incidence of crime. In general, the research to date suggests that the crime problem related to rail stations may be overstated or simply wrong. There is little empirical evidence available to support that building a rail line or a station will indeed increase crime. Table 1 highlights some of these studies.

These studies indicate that there is no clear, consistent support for the common public declarations that rail stations breed increases in crime. Poister (1996) as well as Liggett, Loukaitou-Sideris, and Iseki (2003) find no relationship between rail transit and crime, while Ihlanfeldt (2003) finds a slight increase in central city neighborhoods but no change or a decline in suburban communities with a new rail station. Others cannot support that crime is directly related to the presence of rail transit (Plano, 1993).

In fact, there are many reasons why crime might actually decrease with the announcement or opening of rail transit. First, areas around stations may become safer due to substantial public

investments (e.g., improved street-lighting) along rail corridors. Additional police may patrol the station areas or cameras and other security equipment may be installed which make areas safer.

New transit-oriented developments may "gentrify" older areas of a center city thereby bringing in people to a neighborhood with higher socioeconomic status than previous residents. Public investment in infrastructure along the corridors, such as sidewalks and streetlights may also improve property values and therefore the socioeconomic status of residents. At the same time, such infrastructure can increase the interactions of individuals with more eyes on the street, which can lower the likelihood of street crime (Jacobs, 1961).

The remainder of this paper builds upon the prior research on the association between rail stations and crime and applies a new approach to the recently constructed light rail[4] system in Charlotte, North Carolina. One of the methodological shortcomings of several previous designs has been that elements of neighborhood change may bias estimates. Also, there is debate over whether construction and investment prior to the commencement of rail transit operations or the actual opening of the station might have impacts on crime. The initial announcement reflects the intention of the current governing regime to make a large multi-million dollar economic development investment in an area. According to Elkin (1987) and Stone's (1989) regime theory, the business influence in the area is not limited to holding mobile capital; rather, business is they are an active part of the governing coalition and use this position to further claims on public authority and resources. The "regime" operates as a stable alliance between the public and private sectors to craft local policy decisions. The private sector possesses the resources whereas the public sector has the capability to foster public legitimacy. If we use regime theory to better understand the dynamics of the investment process, the designation of a particular geographic corridor to light rail denotes a consensus among business leaders (including developers in this case) to invest in both the public and private infrastructure surrounding the proposed line. Gentification therefore would be encouraged along transit corridors. Growth machine theory also promotes a similar point of view in the area of land use policy decisions (Logan & Molotch, 1987). Developers were not neutral in the case of designating the light rail corridor in Charlotte, but instead understood that their properties would increase in value as growth took place. Significant private investment in the area could cause gentrification which might lower crime in the proposed corridor area. Therefore, this study emphasizing the importance of examining neighborhoods before and after the announcement of station location, and after the actual opening of an existing alignment. The study goes further by comparing those neighborhoods to neighborhoods along separate proposed alignments as a control group.

## Rail Transit in Charlotte

As with most American cities currently engaged in light or heavy rail transit planning, Charlotte's road to launching its light rail system was a long one, with initial discussions beginning in the late 1980s. In 1994, the City adopted a land use plan that explicitly targeted five transit corridors throughout the city. Land use decisions, including changes to zoning codes, were to be made with the intention of redeveloping properties in decline or underutilized, and developing new land in a manner that would guide growth to achieve higher residential densities as part of the "Smart Growth" movement of the 1990s and recent transit-oriented development principles. These corridors radiate from the central business district and reach out to the edges of the county, with the original intention of crossing the county lines in partnership with the surrounding communities; a regional goal that still has not been realized.

In November 1998, Mecklenburg County residents passed a one-half cent sales tax increase. While the entire county participated in the referendum, the City of Charlotte assumed the responsibilities of the technical planning and ultimate operation of the services through the Charlotte

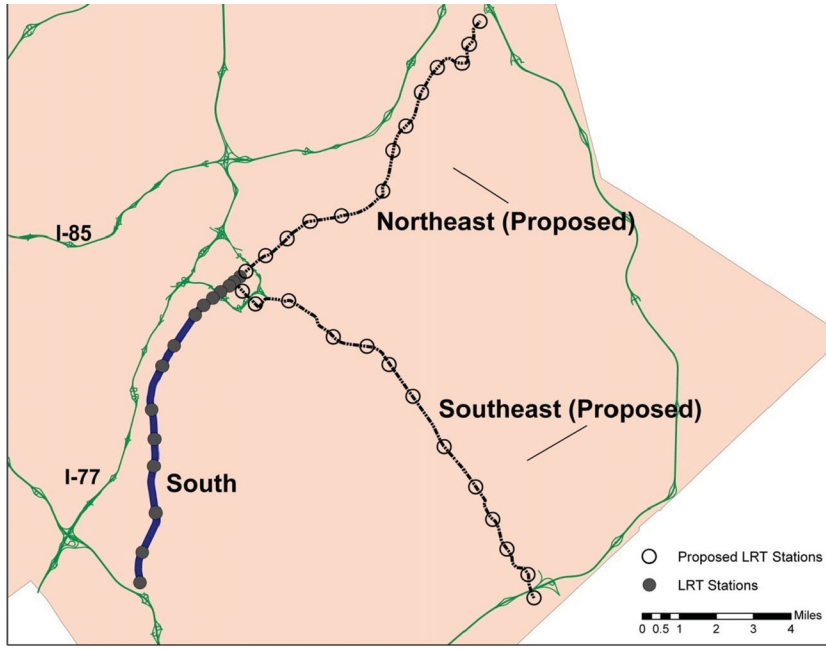


**FIGURE 1**
**Map of Proposed and LRT Stations in Charlotte, NC**

Area Transit System (CATS). These tax revenues were dedicated to the implementation of the land use plan, and the operation and extension of current services. In September 2000, the Metropolitan Transit Commission, consisting of the mayors and managers from the county and all six municipalities within the county as well as nonvoting members from municipalities outside the county, made the official decision to establish light rail for the South transit corridor.[5] This 9.6-mile route stretches from the downtown nearly to the county line at the southern terminus with 15 stations along the route. The Blue Line officially began service in November 2007. The final construction costs were about $49 million dollars a mile with a total cost of over $450 million.[6]

The planning process for choosing the South Line identified two alternate corridors, the Northeast and Southeast.[7] These "finalist" corridors were considered throughout the entire planning process up until the announcement of the South Line in September 2000. Additionally, the Northeast corridor was originally the preferred alignment when talks about LRT began in the late 1980s. Figure 1 highlights both the existing South Line that was announced in 2000 with the Northeast and Southeast corridors as well as their existing and proposed LRT stations.[8] All three alignments contain a number of similarities, including connecting downtown to residential neighborhoods as well as using existing transportation corridors and rights of way to determine the placement of the LRT alignment. The two alternate alignments (Northeast and Southeast) serve as the control group in subsequent analyses.

Table 2 highlights the characteristics of neighborhoods that contain or whose centroid is located within one mile of LRT stations for these corridors. These neighborhood data are based on the Neighborhood Statistical Areas (NSAs) from the City of Charlotte's 2000 Neighborhood Quality of Life Study.[9] This neighborhood data are primarily Census 2000 geographies and data, which have been supplemented by the City of Charlotte. It allows us to include variables for property

**TABLE 2**

**NSA Summary Statistics (2000)**

| | South Line | | Control | | Other Neighborhoods | |
|---|---|---|---|---|---|---|
| Variable | Mean | SD | Mean | SD | Mean | SD |
| Population | 3,280 | *2,131* | 3,864 | *2,319* | 2,810 | *1,999* |
| Population density | 4.63 | *1.86* | 4.75 | *2.23* | 3.30 | *2.51* |
| Percent homes—owner occupied | 0.43 | *0.24* | 0.44 | *0.19* | 0.61 | *0.25* |
| Median household income | 36,289 | *15,562* | 35,111 | *14,235* | 52,328 | *28,825* |
| Portion of households on food stamps | 0.09 | *0.11* | 0.09 | *0.10* | 0.07 | *0.10* |
| Portion of under-18 school dropouts | 0.10 | *0.05* | 0.11 | *0.06* | 0.08 | *0.06* |
| Portion of population over 65 years old | 0.11 | *0.05* | 0.09 | *0.05* | 0.12 | *0.06* |
| Portion of population under 18 years old | 0.11 | *0.09* | 0.12 | *0.12* | 0.09 | *0.12* |
| Transit usage | 0.78 | *0.23* | 0.77 | *0.31* | 0.52 | *0.42* |
| Property crime rate | 1.49 | *1.03* | 1.13 | *0.71* | 1.03 | *0.85* |
| Violent crime rate | 1.63 | *2.02* | 1.44 | *1.50* | 1.30 | *1.61* |
| N | 26 | | 17 | | 130 | |

All data based on 2000 Neighborhood Quality of Life Survey. Treatment and Control Neighborhoods within one Mile of LRT.

and violent crimes as well as the portion of residents that used bus transit in 2000.[10] As shown in Table 2, the South Line and control neighborhoods exhibit similar socio-economic characteristics across a number of variables that may impact the use of transit and property values. The only variables that show any noticeable difference in these characteristics are property and violent crimes, but the means for these variables are not statistically different at even the alpha = 10% level.

The characteristics of all other neighborhoods[11] in the City of Charlotte, given in Table 2, highlight the need for a control group. Comparing the South Line (Treatment) neighborhoods with all other Charlotte neighborhoods is likely to lead to mistaken inferences given that neighborhoods that receive LRT have fundamentally different characteristics than all other neighborhoods. Specifically, South Line neighborhoods are more populated and denser and have lower ownership, lower income, and higher bus transit ridership than all other neighborhoods.

## RESEARCH DESIGN

Poister's (1996, p. 74) research on crime and rail transit suggests that improved future studies of this question would utilize a quasi-experimental design employing multiple time series to compare crime trends in neighborhoods served by rail lines against similar areas without such. Furthermore, Loukaitou-Sideris and Banerjee's (1994) work highlights the importance of examining not the opening date of a new station but the effect of the announcement of a new station's location on crime. Therefore, we adopt a methodology for this research that is a before-and-after quasi-experimental research design with the assignment of treatment and control groups based on the planning and funding process for determining the light rail alignments in Charlotte. Specifically, we use a panel data set of monthly crime counts for 41 LRT stations, of which 26 represent our treatment group and 15 our control group. We then examine how crime changes from before to after the announcement of the selection of the South Line as Charlotte's first LRT alignment. We compare this crime change between the South Line and other corridors considered for LRT. This represents a difference-in-difference (DID) estimator. We apply the resulting DID estimator to two distinct dates: the announcement of the first corridor of light rail in Charlotte (South line) and the beginning of service operations for the South line. Observations before and after these

two time periods measure impacts related to the announcement and operations of the South line. We apply the results of these DID estimators to answer our three research questions proposed earlier.

The assignment of treatment and control groups is based on the announcement and commitment of public monies for the existing South line (Treatment) and the transit planning process, which considered alternate alignments that were ultimately not designated as the first LRT alignment (Control). The two alternate alignments (Northeast and Southeast) serve as the control group in subsequent analyses.

Implementation of a DID estimator with two time periods of interest merits a derivation of the estimation model incorporated into empirical results. Equation 1 contains an outcome variable $y$ at station $i$ in time period $t$ that is a function of a rail station's assignment to the treatment alignment ($T_i = 1$) or the control alignments ($T_i = 0$). They are the designated time periods before and after both the announcement of the South line in September 2000 ($A_t = 0$ or $A_t = 1$) and the beginning of operations for the South line in November 2007 ($O_t = 0$ or $O_t = 1$):

$$y_{i,t} = \alpha + \beta_1 T_i + \beta_2 A_t + \beta_3 O_t + \varepsilon_{i,t}. \tag{1}$$

In order to determine how outcome $y_{i,t}$ changes for the treatment group relative to the control from before to after both the announcement and the operation of LRT stations, the model requires two interaction terms between $T_i$ and $A_t$, and between $T_i$ and $O_t$. The result is estimation Equation 2, which captures the parameters of interest in $\beta_4$ and $\beta_5$. Estimates for $\beta_4$ and $\beta_5$ give the average impact of the announcement of light rail and the opening of light rail on outcome $y_{i,t}$, respectively:[12]

$$y_{i,t} = \alpha + \beta_1 T_i + \beta_2 A_t + \beta_3 O_t + \beta_4 A_t * T_i + \beta_5 O_t * T_i + \varepsilon_{i,t}. \tag{2}$$

This research design and regression specification have a number of advantages that were noted and recommended by previous scholars exploring this question. First, they control for any preexisting differences for areas around a rail transit station and between treatment and control stations. Therefore, if the area around a station has more opportunities for crime due to land use—e.g., retail stores, higher density, wealthier residential homes, insecure property infrastructure (no lighting or fences)—or access due to other transportation infrastructure (near a highway, bus line, etc.), it is already controlled for by the treatment, announcement and opening indicator variables ($T_i$,$A_t$,$O_t$). In essence, this specification accounts for any unobserved time-invariant neighborhood characteristics. Only time-varying elements of land use or transportation infrastructure can influence outcome $y_{i,t}$ in Equation 2. The implementation of this quasi-experimental research design allows the use of control stations to account for general trends of development or other elements of neighborhood change in neighborhoods considered for rail transit stations. Greenstone and Moretti (2003) adopt a similar methodology in examining the influence of local economic development efforts to attract large manufacturing plants. Land uses likely change from before to after the announcement and opening of the South line rail transit stations, but in essence that is also part of the outcome of interest. The impact of rail transit stations on outcome $y_{i,t}$ can be a result of both the increased access of residents and potential offenders to rail transit station neighborhoods as well as neighboring land development. Irrespective of the type of change that impacts outcome $y_{i,t}$, one can attribute the catalyst for this change to the implementation of the rail transit stations.

Second, this design and model specification remove all time trends related to the time period of announcement and year of opening. Initially, one may be concerned that postannouncement

or postopening time periods contain higher or lower crime rates overall in Charlotte. Comparing postannouncement and postopening outcomes between the control and treatment groups mitigates this concern. Since all treatment and control stations are served by the same policing authority (the Charlotte-Mecklenburg Police Department), any citywide trends in crime or policing will affect both groups and therefore are accounted for in the estimations.

Third, the crime data represent reported crimes and not arrests. Most observations are the result of residents filing an incident report with the police. We acknowledge that all crimes are not reported to the police, but this is unfortunately a common shortcoming of any research using official crime data. This is only a concern if the likelihood a resident reports a crime to the police differs between treatment and control neighborhoods and before and after the announcement of LRT. We cannot find any characteristics of treatment or control neighborhoods that would support this concern.

## DATA

Detailed data for the location, funding, and planning process for the implementation of LRT and station locations come from a number of public documents available from CATS. Newspaper searches of the *Charlotte Observer* from 1985 through 2008 provided data on the timeline and details of the public planning process. We constructed the geospatial information used to characterize the location of crime relative to actual and proposed light rail stations from paper maps in geographical information systems using ArcGIS 9.3.

Since this paper hypothesizes an impact of rail transit on crime outcomes, detailed crime data are necessary to implement the research. Fortunately, the Charlotte-Mecklenburg Police Department provided access to a unique data set of reported crimes. The details in this crime file give the date and physical address of all reported crimes between January 1998 and December 2008. There were 1,042,559 observations in the original data set. After removing any observations that indicate reported crimes that were designated noncriminal, suicide/accidental death, missing person or runaway, we had 983,157 observations. This data set classifies crime according to 39 categories. In order to provide enough observations within a small distance of transit stations, we aggregated crimes into standard Federal Bureau of Investigation Uniform Crime Reports (UCR) classifications of assault, auto theft, drugs, larceny, burglary, robbery, and vandalism. Results are provided for the aggregate set of all crimes as well as seven major crime categories that may be related to rail transit station development and ridership.

Geospatial data on rail transit stations allow the assignment of monthly crimes to treatment and control stations within a *one-half mile* band around each station. This distance interval is chosen for several reasons. First, from interviews of rail transit commuters, O'Sullivan and Morrall (1996) find that over 75% of rail transit users in noncentral business district stations walk less than one-half mile to reach a station. The use of one-half mile is a reasonable estimate of the maximum distance that commuters and potential criminals are willing to walk to/from a station. Second, this distance is also the area chosen by city planners as part of the planning process for transportation infrastructure around rail transit stations. Third, other researchers investigating this relationship have also adopted this distance band (Liggett et al., 2003). Finally, some light rail stations are less than one mile apart and in order to avoid overlapping catchment areas for those stations, the analysis requires smaller distance bands. Later sensitivity analysis highlights the robustness of results to different distance intervals. In the end, the analysis employs a data set of 41 stations (15 actual and 26 proposed) over 132 time periods (monthly counts for 11 years), which results in 5,412 observations.

Figure 2 illustrates total reported crime trends for all of Charlotte and areas within one-half mile of treatment and control light rail stations. Vertical lines indicate the announcement

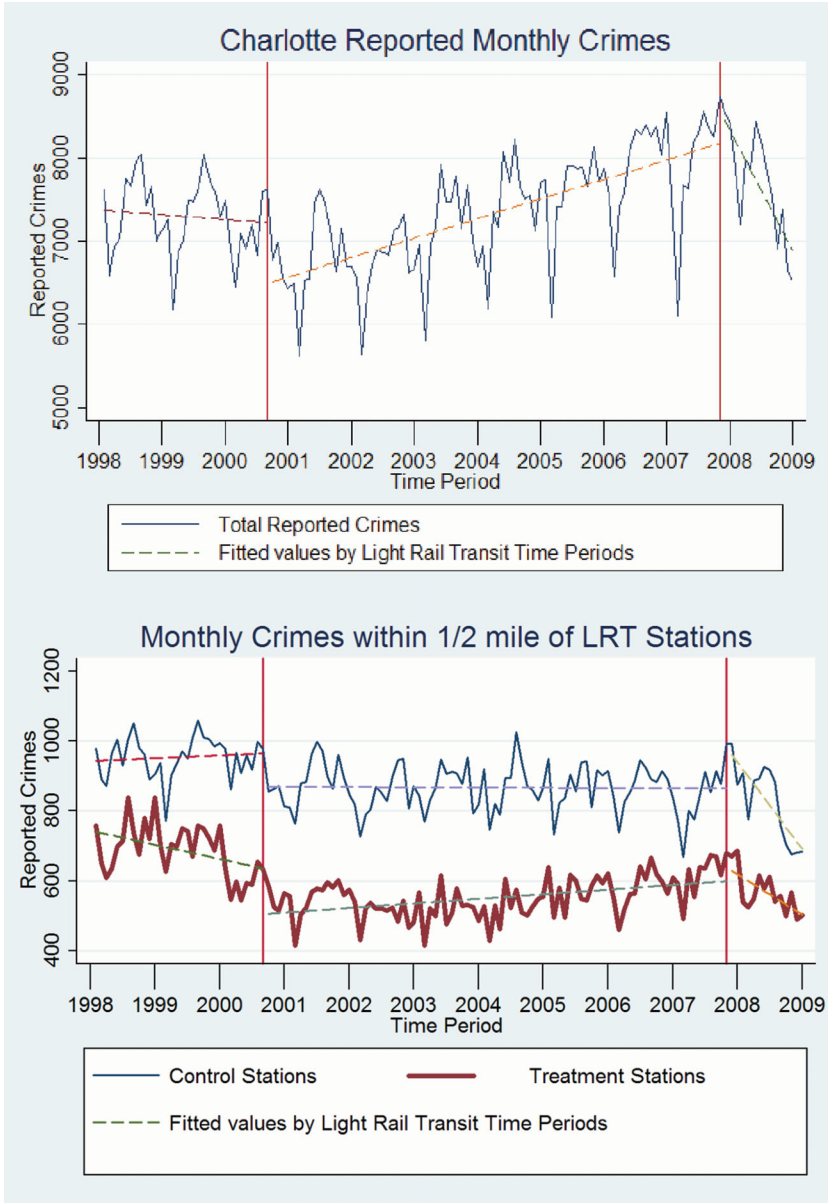


**FIGURE 2**
**Trends in Reported Crimes in Charlotte 1998–2009**

and opening dates of September 2000 and November 2007, respectively. The data are fairly noisy, but dotted lines indicate the fitted values of the data for each time period of interest. The figure shows very different crime trends between 1998 and 2008. All reported crimes in Charlotte decreased slightly prior to the announcement of LRT, increased after the announcement of LRT and then decreased again after the opening of LRT. Of course this is likely due to overall economic and city characteristics for these time periods. It does give a sense of the overall crime trends during our study time period. More relevant to our analysis is the bottom

of Figure 2, which indicates crime trends for our treatment and control neighborhoods around actual and proposed LRT stations. Here, we see some initial differences in crime trends between treatment and control stations, with control stations indicating higher crime counts overall and fairly constant crime throughout the study time period until the opening of LRT. This contrasts to the treatment stations, which experience a decline in crime around and after the announcement of LRT. This decline in crime levels off and even slightly increases up to the opening of LRT. The presence of some initial differences between treatment and control stations with respect to crime highlights the importance of our methodology controlling for crime counts both before and after the announcement as well as comparing postannouncement trends between treatment and controls stations. Additionally, we include a number of neighborhood covariates (given in Table 2) to further address any initial difference in the neighborhoods around treatment and control stations. Since these figures only provide aggregate crime counts, we also report that there was an average of 35.9 monthly crimes within one-half mile of a transit station. Of these crimes, 26.1 were property crimes (auto theft, burglary, larceny, or vandalism) and 6.7 were violent crimes (arson, assault, homicide/manslaughter, rape, or robbery). The remaining crimes were disorderly conduct, alcohol crime, or unclassified. Both panels in Figure 2 highlight a cyclical nature to crime with summer and fall months seeing an increase in crime and winter months a decrease in crime. To account for this issue, regression analyses include month fixed effects.

## RESULTS

Three sets of regression results provide outcomes for three groupings of crime categories: all crimes, property versus violent crimes, and individual crime categories.[13] Of interest in all reported regression tables are the two interaction terms given as the first two variables. These coefficients represent $\hat{\beta}_4$ and $\hat{\beta}_5$ from estimation Equation 2. Table 3 reports the coefficients from the regression of the all crimes model. For all reported crimes, there is a negative effect that is only significant at a 10% level on the announcement of stations along the South line and nonsignificant impacts of the opening of these rail transit stations. These results vary little between Walk-N-Ride versus Park-N-Ride stations.[14]

Aggregated crime results may just be masking differences between crime classifications. Therefore, Table 4 breaks down these effects for property and violent crimes. The results indicate a significant negative effect of light rail station announcement on property crimes and a nonsignificant positive effect for violent crimes. The estimated monthly decrease of 5.3 property crimes represents a decrease of 20% for average monthly property crimes. Effects are similar between Park-N-Ride and Walk-N-Ride stations.

Table 5 presents the results by specific crime classification. A number of crimes (larceny, residential burglary, and robbery) experience decreases after the announcement of South line light rail stations. The largest decrease in crime is attributed to larceny. Estimated coefficients for larceny indicate a decrease of 3.2 monthly crimes, which represents a decrease in average monthly larceny crimes of 25%. The burglary regression finds an average decrease of 1.0 monthly crimes after the announcement of light rail, which represents a decline of 26.3%. Estimates for robbery show a decrease of 0.47 monthly crimes, which represents a decrease of 32.4%. Across crime classifications, there is no impact after the opening of South Line stations. The presence of primarily negative crime impacts due to the announcement of light rail supports earlier discussion suggesting LRT-related development may gentrify neighborhoods and decrease crime. The lack of impact after the opening of light rail dispels public perceptions that LRT may breed or encourage criminal activity in these neighborhoods.

Results are consistent across a range of specifications for distance bands used to assign crimes to rail transit stations as well as different control groups. Table 6 presents a sensitivity analysis

**Table 3**

**Reported Total Crimes Within 1/2 Mile of LRT Stations**

| Variables | (1) Reported Crimes | (2) Reported Crimes *Only Walk-N-Ride Stations* | (3) Reported Crimes *Only Park-N-Ride Stations* |
|---|---|---|---|
| PostAnnouncement ∗ Treatment | −5.579 | −4.468 | −6.329 |
| | (2.807) | (3.698) | (3.846) |
| PostOpening ∗ Treatment | 2.430 | 4.066 | 0.688 |
| | (1.677) | (2.043) | (2.759) |
| PostOpening | −2.131 | −2.975 | −1.289 |
| | (1.138) | (1.698) | (1.528) |
| PostAnnouncement | −3.247 | −6.853** | 0.358 |
| | (2.030) | (2.813) | (2.634) |
| Treatment | 12.957 | 6.026 | −19.906 |
| | (7.053) | (8.826) | (11.034) |
| Constant | 71.983** | 118.587*** | 34.120 |
| | (28.133) | (18.017) | (24.938) |
| Observations | 5,412 | 2,772 | 2,640 |
| $R^2$ | 0.257 | 0.398 | 0.582 |

All regressions include month fixed effects and neighborhood covariates listed in Table 2. Robust standard errors clustered by LRT stations in parentheses. ***$p < 0.01$, **$p < 0.05$.

using three distance intervals: one-quarter mile, one-half mile, and one mile. These distances highlight that results are similar across specifications. Results are also robust in terms of the control group used. The full results incorporated both the Southeast and Northeast corridors to increase the sample size of station areas. The "Just South and Northeast Alignments" column excludes the Southeast corridor from analysis. This Southeast corridor is slightly different from other corridors in that the alignment will run in the center of a divided highway. Coefficients increase in magnitude as do *t*-statistics by the exclusion of the Southeast corridor.

The growth in coefficients at larger distance intervals corresponds with the overall higher number of reported crimes in a larger geographic area. Distances of one-quarter mile average approximately 12.1 property crimes; one-half mile averaged 26.1 property crimes; and one mile averaged 48.3 property crimes. The one-quarter and one mile interval using the full treatment and control groups generated nonsignificant decreases in property crimes, but the half-mile interval estimates a decrease of 20%. Correspondingly, estimates for just the South and Northeast alignments generate a decrease in property crimes of 41% at the one-quarter mile interval and decreases to 36% and 25.1% for the one-half and one mile intervals, respectively. Coefficients indicate an increase in property crimes of 14.0% after the opening of light rail for the full set of stations at the one-quarter mile interval. The inconsistency and smaller *t*-statistics of this coefficient at different distance intervals and with different control groupings limits concluding that there was a positive impact of light rail stations opening on property crimes.

## CONCLUSIONS

This study evaluates whether the introduction of a rail transit system increases crime. While controlling for overall crime trends in the city utilizing two control transit corridors, our analyses indicate that the announcement of rail transit actually leads to a decrease in property crimes. Once the stations open, the crime decrease is maintained, and does not return to preannouncement levels. This dispels rail transit opponents' notion that light rail "breeds crime." In fact, we offer counter

**TABLE 4**

**Reported Property/Violent Crimes Within 1/2 Mile of LRT Stations**

| Variables | (1) Reported Crimes *Property Crimes Only* | (2) Reported Crimes *Violent Crimes Only* | (3) Reported Crimes *Walk-N-Ride and Property Crimes Only* | (4) Reported Crimes *Walk-N-Ride and Violent Crimes Only* | (5) Reported Crimes *Park-N-Ride and Property Crimes Only* | (6) Reported Crimes *Park-N-Ride & Violent Crimes Only* |
|---|---|---|---|---|---|---|
| PostAnnouncemenf ∗ Treatment | −5.250** | 0.154 | −4.235 | −0.629 | −6.117 | 1.172 |
| | (2.041) | (0.976) | (2.528) | (1.413) | (3.175) | (0.896) |
| PostOpening ∗ Treatment | 1.829 | 0.104 | 3.381 | −0.190 | 0.173 | 0.462 |
| | (1.424) | (0.518) | (1.655) | (0.552) | (2.406) | (0.899) |
| PostOpening | −2.355** | −0.516** | −3.152 | −0.653 | −1.560 | −0.380 |
| | (1.044) | (0.232) | (1.548) | (0.402) | (1.412) | (0.236) |
| PostAnnouncement | −2.379 | −0.890* | −4.405** | −1.740** | −0.353 | −0.042 |
| | (1.578) | (0.526) | (2.067) | (0.798) | (2.305) | (0.621) |
| Treatment | 9.919 | 0.295 | 5.267 | 0.227 | −12.537 | −8.056*** |
| | (5.415) | (1.888) | (7.472) | (2.245) | (7.404) | (2.497) |
| Constant | 58.564*** | 1.721 | 95.600*** | 12.626 | 28.045 | 0.699 |
| | (20.004) | (4.326) | (15.555) | (6.675) | (17.853) | (5.405) |
| Observations | 5,412 | 5,412 | 2,772 | 2,772 | 2,640 | 2,640 |
| $R^2$ | 0.224 | 0.180 | 0.317 | 0.433 | 0.535 | 0.522 |

All regressions include month fixed effects and neighborhood covariates listed in Table 2.
Robust standard errors clustered by LRT stations in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$.

**TABLE 5**

**Reported Crimes by Type Within 1/2 Mile of LRT Stations**

| Variables | (1) Assault | (2) Auto theft | (3) Larceny | (4) Residential Burglary | (5) Robbery | (6) Vandalism |
|---|---|---|---|---|---|---|
| PostAnnouncement | 0.319 | −0.199 | −3.235** | −0.987** | −0.471** | −0.199 |
| ∗ Treatment | (0.778) | (0.212) | (1.344) | (0.394) | (0.219) | (0.362) |
| PostOpening | −0.004 | 0.205 | 1.184 | 0.597 | −0.021 | −0.015 |
| ∗ Treatment | (0.427) | (0.239) | (0.959) | (0.435) | (0.163) | (0.223) |
| PostOpening | −0.288 | −0.641*** | 0.152 | −0.827*** | −0.193* | 0.106 |
| | (0.186) | (0.137) | (0.671) | (0.269) | (0.114) | (0.160) |
| PostAnnouncement | −0.977** | 0.178 | −1.603 | 0.238 | 0.226 | −0.718*** |
| | (0.396) | (0.185) | (1.065) | (0.155) | (0.182) | (0.226) |
| Treatment | −0.119 | −1.584*** | 6.485** | −2.125** | −0.593 | −1.467** |
| | (1.474) | (0.465) | (2.801) | (0.873) | (0.386) | (0.605) |
| Constant | 1.056 | −0.593 | 32.293*** | −0.946 | −0.684 | 0.655 |
| | (3.362) | (1.209) | (10.295) | (2.237) | (1.237) | (1.421) |
| Observations | 5,412 | 5,412 | 5,412 | 5,412 | 5,412 | 5,412 |
| $R^2$ | 0.155 | 0.159 | 0.156 | 0.165 | 0.143 | 0.148 |

All regressions include month fixed effects and neighborhood covariates listed in Table 2. Robust standard errors clustered by LRT station in parentheses. $^{***}p > 0.01$, $^{**}p > 0.05$.

**TABLE 6**

**Sensitivity Analysis**

| | Full Control/Treatment Groups | | | Just South and Northeast Alignments | | |
|---|---|---|---|---|---|---|
| Coefficients | 1/4 Mile | 1/2 Mile | 1 Mile | 1/4 Mile | 1/2 Mile | 1 Mile |
| *Property Crimes* | | | | | | |
| PostAnnouncement | −2.485 | −5.250** | −5.634 | −5.023*** | −9.530*** | −12.110*** |
| ∗Treatment | (1.302) | (2.041) | (3.417) | (1.214) | (2.100) | (3.428) |
| PostOpening | 1.652** | 1.829 | 2.024 | 0.403 | 0.936 | −0.332 |
| ∗ Treatment | (0.765) | (1.424) | (1.908) | (0.902) | (2.044) | (2.671) |
| *Violent Crimes* | | | | | | |
| PostAnnouncement | −0.260 | 0.154 | 1.311 | −0.305 | 0.176 | 1.044 |
| ∗ Treatment | (0.537) | (0.976) | (1.601) | (0.625) | (1.246) | (1.897) |
| PostOpening | 0.256 | 0.104 | 0.583 | 0.280 | 0.400 | 1.248 |
| ∗ Treatment | (0.190) | (0.518) | (0.900) | (0.225) | (0.569) | (1.040) |

All coefficients based on separate regressions by indicated distance bands using regression specifications for columns 1 and 2 in Table 3.
Robust standard errors clustered by LRT station in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$.

evidence that suggests light rail may actually "impede crime." This could be due to public and private decisions to invest along rail transit corridors, which gentrifies surrounding neighborhoods and may decrease criminal activity. This has important policy implications for metropolitan areas that are considering light rail or light rail extensions. Fear of increased crime around stations appears unsubstantiated by this study. Extensions of rail transit stations to the suburbs or less-dense areas (as evidenced by controlling for the Park-N-Ride versus Walk-N-Ride stations) also appears not to lead to an increase in crime. This research is merely attempting to confirm/deny perceptions regarding LRT and crime. Therefore, future research should attempt to empirically link LRT to the individual motives behind specific crime types.

Our inquiry suggests several important future directions for research on the relationships between rail transit and crime. First, crime rates should be studied in other cities that have also introduced light or heavy rail to see if there are similar effects. Second, the link between the decrease in crime and the announcement of light rail should be further explored to better understand the level of public investment and economic development impact along the light rail corridor. Finally, the second corridor (the Northeast line, one of the control groups) was just announced in 2009. This will give us an additional test to see if the effects of light rail hold true for both the preannouncement and operational periods of this new line, as well as provide additional postopening crime data for the original line in order to measure any lagged changes associated with the line.

## ENDNOTES

1 For the purpose of this paper, we use the National Transit Database definition of rail transit, which refers to transit modes whose vehicles travel along fixed rails (bars of rolled steel) forming a track. Both light rail and heavy rail are included in this definition. The vehicles are usually electrically propelled, typically through motors on board the vehicles, but motors may also be at a central location, not on board the vehicles to pull the vehicles by cables (cable car (CC) or inclined plane (IP)). For commuter rail (CR), vehicles may be self-propelled or may be drawn by a locomotive. http://204.68.195.57/ntdprogram/Glossary.htm

2 We limit our literature review to only rail transit because it is a capital-intensive fixed asset that cannot easily be altered like a bus stop. We understand that there are structural differences between light and heavy rail, but in terms of assessing crime they both provide similar accessibility for criminals.

3 A third set of reasons could be attributed to the broader opportunity factors for offenders. See Clarke and Eck (1995) or Cornish and Clarke (2003).

4 Since the majority of studies are on heavy rail or commuter rail systems, we include these studies in our literature review. We acknowledge there may be differences in build and design that may impact crime around the stations.

5 This was the only corridor announced to be slated for light rail at that time.

6 Charlotte Area Transit System website—http://www.charmeck.org/Departments/CATS (5/1/09).

7 Information about the planning process for light rail transit in Charlotte is based on City of Charlotte planning documents and discussions with CATS officials.

8 The Northeast and Southeast are planned for LRT in the City of Charlotte's 2020 land use plan, but only the Northeast line had been announced by 2009. Proposed LRT stations are based on City of Charlotte planning documents current as of 2008.

9 In 1993, the City of Charlotte subdivided the city into 183 small, mutually exclusive planning districts called NSAs. The boundaries for the NSA began as census blocks and then were modified to better match the perceptions of residents and real estate professionals based on input from neighborhood meetings. Therefore, these geographies better define neighborhoods as perceived by residents than boundaries used by the U.S. Census. The city uses the boundaries of these areas for various economic, social, population, health, and crime-tracking purposes and to assist in developing neighborhood-specific policy plans.

10 The two crime variables are based on a location quotient given by the ratio of crimes per capita in a given neighborhood to average crimes per capita for the entire city. Therefore, a value of one indicates average crime per capita in a given NSA. The transit-usage variable provides the percent of NSA residents within a quarter mile of a bus transit stop.

11 This is defined as neighborhoods not within one mile of the South Line or control corridors.

12 The two interaction terms (A ∗ T and O ∗ T) in Equation 2 provide both differences between treatment and control neighborhoods as well as before and after our two time periods of interest. Specifically, A ∗ T captures the amount of crime after the announcement relative to before the announcement and after the opening for just treatment neighborhoods. Analogously, O ∗ T focuses just on relative crime after the opening in treatment neighborhoods.

13 Given the panel nature of the data set, all regressions include standard errors clustered by each LRT station. Regressions are estimated with OLS for ease of interpretation, but results are similar using a negative binomial model to account for the dependent variable, a count of reported crimes each month.

14 Charlotte Area Transit System (CATS) designates a station as Park-N-Ride and all other stations are classified as Walk-N-Ride. Walk-N-Ride stations contain no or limited parking areas and are located in densely populated areas. Park-N-Ride stations contain parking areas and commonly serve suburban commuters who leave their cars at the station, while riding rail transit to work. Walk-N-Ride and Park-N-Ride stations also act as a proxy variable for differences between urban and suburban rail transit stations.

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