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Identifying the Impacts of Rail Transit Stations on Residential Property Values[1]

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Prior studies that have empirically investigated the impact of rail station proximity on property values have not fully investigated the factors that may account for this relationship. Stations may raise the value of nearby properties by reducing commuting costs or by attracting retail activity to the neighborhood. Possibly countering these positive effects are negative externalities emitted by stations and the access to neighborhoods that stations provide to criminals. This paper sorts out these effects by presenting the results from estimating a hedonic price model and auxiliary models for neighborhood crime and retail activity. Results show that all four effects play a role in defining the relationship between property values and rail stations, but the relative importance of these effects varies with distance from downtown and the median income of the neighborhood.

I. INTRODUCTION

Many cities are confronting problems brought about by rapid population growth, such as traffic congestion, air pollution, and sprawling development patterns. Growth causes these problems because of the heavy reliance on the automobile as the primary transportation mode for the journey to work. To reduce this reliance and thereby mitigate the unwanted side effects of population growth, the construction or extension of a rapid rail transit system is often prescribed. According to its proponents, because rail transit is valued as a viable alternative to automobile transportation, it will reduce the number of

[1] The comments of Christopher Bollinger, Haynes Goddard, and two anonymous reviewers improved this paper.

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drivers on the road and encourage more compact patterns of growth by drawing residents close to rail stations. One way to investigate this argument is to measure the premium that homeowners are willing to pay to be close to a rail station. If transit service provides a real economic benefit, the value of that benefit should be capitalized into the price of nearby parcels.

While a number of studies have empirically investigated the effect of rail station proximity on property values, none has fully investigated the underlying factors that may account for this effect. A total of four factors can be identified —two which may cause higher property values and two which may cause lower property values in station areas. One of the positive factors is the access advantage provided by rail stations. If rail offers a better transportation alternative to driving in terms of reduced commuting time or less tangible benefits such as a less stressful commute, then commuters should be willing to pay for these benefits by offering more for properties close to rail stations. The second factor that may cause higher property values in station areas is that neighborhood commercial services, such as retail establishments, may be attracted to these areas. Though primarily meant to serve customers coming through the transit station, these additional services may also benefit nearby residents, regardless of whether or not they ride the train. One factor that may counter these positive impacts are negative externality effects emitted by the station, such as noise, pollution, and the unsightliness of the station (especially if it includes a parking lot). The other negative factor is that crime may be higher in station areas, because of the improved access to the neighborhood provided to outsiders.

From a policy perspective, it is obviously important to understand the role that each of the above four factors plays in defining the relationship between property values and rail stations. Depending on these roles, strategies can be developed to maximize the attractiveness of rail stations and thereby alleviate automobile congestion, vehicle emissions, and low density suburban sprawl.

The purpose of this paper is to present a hedonic analysis of the impact of MARTA (Metropolitan Atlanta Rapid Transit Authority) rail stations on residential property values within the Atlanta region. This analysis assesses the importance that commuting cost savings, station externalities, crime, and retail development play in defining the relationship between property values and station proximity. The methodology involves estimating two sets of equations: (1) hedonic price models to study the direct impacts of improved accessibility and negative externalities and (2) neighborhoods crime and retail employment equations to study the indirect effects that stations have on property values by attracting retail development and criminal activity.

II. LITERATURE REVIEW

The literature relevant to our analysis includes studies that have estimated the effects of rail transit on residential property values, crime, and commercial development. Findings from each of these three types of studies are briefly summarized in this section.

Property Value Studies

There are a large number of empirical studies that have related property value to distance from a rail station, including two that have focused on Atlanta's MARTA. Studies on rail systems other than MARTA are briefly mentioned below, while the MARTA studies are described in more detail.[2]

The most widely studied transit systems have been the BART system in San Francisco (Davis [11]; Lee [22]; Dornbusch [13]; Baldassare et al. [3]) and the Washington D.C. METRO (Damm et al. [10]; Aterkawi [1]; Grass [17]). Researchers have also studied the ''EL'' in Chicago (McDonald and Osuji [24]), the rail line in Toronto (Dewees [12]), the commuter rail line in Philadelphia (Boyce et al. [6]; Voith [32]), the Miami Metrorail system (Gatzlaff and Smith [16]), and the New York City rail transit system (Anas and Armstrong [1]). The results of these studies have been mixed, but the majority do find that rail stations have a positive (but relatively modest) impact on nearby property values. However, in some cases no significant price affects are observed (Lee [22]; Gatzlaff and Smith [16]) or a negative effect is found (Dornbusch [13]; Burkhardt [8]). A possible reason for these mixed results, even among studies of the same rail system, is a failure to account for the simultaneous and competing effects of rail stations on nearby properties. Typically, a single variable is used to measure a property's distance to the nearest rail station. A finding of higher values closer to the rail station is taken as support for the hypothesis that transit access is valued because of transportation cost savings. If station proximity has no effect or a negative effect on property values, the importance of the negative externalities emitted by the station are emphasized as an offsetting or dominant factor. This simple accounting of the effects of transit access rests upon two questionable assumptions. First, the relative magnitudes of the commuting benefits provided by transit access and the external costs emitted by the station are assumed to vary only with distance to the nearest station. However, the net benefit from station proximity may also vary with station characteristics, the median income of the neighborhood, and the distance the station is located from the CBD center.[3] Second, the net benefit measured by the estimated coefficient on distance to the nearest station is assumed to reflect just commuting cost savings and the disamenity costs of noise or congestion. However, because measures of neighborhood crime and opportunities for shopping within the neighborhood are typically excluded from the property value equation, the estimated coefficient

[2] An excellent tabular summary of earlier studies can be found in Landis et al. [21].

[3] The possible effects of these factors are discussed below in Section III.

on the distance to the nearest station may also reflect the effects of stations on crime and retail development.

Previous studies of MARTA include Nelson and McCleskey [27] and Nelson [26]. Nelson and McCleskey use a simple hedonic regression to determine impacts of elevated stations on property values along one section of the rail line. The authors use both distance to the nearest station and a dummy variable for houses within one-half mile of a station as measures of proximity. They find only weak support for the hypothesis that proximity to stations increases property values. This study looked at only three elevated stations along a short, contiguous section of the line. The authors contend that their weak or ambiguous results occurred because of opposing forces: benefits associated with access to transportation versus negative effects resulting from station noise and unsightliness. In the study conducted by Nelson alone, the same section of the MARTA rail line is used in an attempt to differentiate between the effects of a rail station on high income versus low income neighborhoods. The author's contention is that transit access will be more important to low income residents who are more likely to rely on public transit, while for high income residents nuisance effects will dominate. In support of his argument, Nelson finds a negative, concave house price gradient away from rail stations for low income neighborhoods and a positive and convex gradient for high income neighborhoods. Neighborhood income is measured by separating houses north of the rail line, representing the high income area, from those south of the line, which is the low income side. While it is true that along this section of rail line neighborhoods to the north are more affluent, the rail line also represents a racial divide, with a larger percentage of black residents south of the rail line. Thus, it is possible that residents north of the rail line do not want to live close to a station not because of negative externalities from the station, but because it is too close to this racial divide.

Crime Studies

Only two studies have investigated whether rail stations increase neighborhood crime. In a study of the Baltimore Metro system, Plano [29] looked at trends in crime rates for neighborhoods surrounding three rail stations using data from years just before and just after the stations opened, comparing these to trends in crime rates for Baltimore County as a whole. No significant relationship is found between the trends in crime rates and the opening of the rail stations. However, there are no controls for other factors that might have affected crime rates.

In a study of the MARTA system, Poister [30] also looks at time series data of criminal activity near rail stations before and after station opening dates. The study considers only two contiguous stations on the same section of the rail line, using neighborhood and county monthly crime data from 1990 to 1994. The graphical ''event study'' depiction of neighborhood crime rates before and after the station openings shows little or no overall impact on crime rate trends in the neighborhoods surrounding the stations. A simple regression model attempting to measure changes in the overall trend in crime rates near the stations both before and after the station opening dates also offers little evidence to support the hypothesis that rail stations cause an increase in local crime. However, like Plano, Poister uses only the opening dates of the stations to explain changes in crime rate trends, ignoring other explanatory factors that may have been correlated with these dates.

Commercial Development Studies

Whether rail stations cause nearby commercial development has been investigated for San Francisco's BART (Dvett et al. [14]; Cervero et al. [9]), Atlanta's MARTA (Bollinger and Ihlanfeldt [4]), and Washington D.C.'s METRO (Green and James [18]). The BART studies show small positive impacts, the MARTA study finds no impact, and the METRO study finds large impacts. Except for Bollinger and Ihlanfeldt [4], the above studies make simple comparisons before and after station openings or between station and nonstation areas. Little, if any, allowance is made for possible confounding influences coming from nonstation related factors. In contrast, Bollinger and Ihlanfeldt's model includes an extensive set of control variables.

In contrast to the above studies, our focus is narrowly on the effect of rail stations on retail development, because we believe that it is retail activity that is most desirable to nearby residents. Bollinger and Ihlanfeldt also estimate a separate retail employment equation for Atlanta and find no station effect. In contrast, our model does yield a positive effect after interacting station proximity with distance from the center of the Atlanta central business district (CBD).

III. ACCOUNTING FOR THE EFFECTS OF RAIL STATIONS ON PROPERTY VALUES

To account for the direct and indirect effects of rail stations on residential property values, we estimate a standard hedonic price model (Rosen [31]; Freeman 15]) and two auxiliary regression equations: one that relates neighborhood crime to distance from a station, and another that relates neighborhood retail employment to station distance. In this section, we describe how the results from these three regressions can be used to decompose the total impact of a rail station on property values into its separate components.

The property value equation we estimate can be expressed in simple linear form as[4]

$$P = \alpha_0 + \alpha_Z Z + \beta_L L + \beta_C C + \beta_R R + \gamma_S S + \varepsilon, \tag{1}$$

[4] Although a linear form is used here to simplify the exposition, in estimating (1) we statistically reject the linear model in favor of the semilog.

where P is the price of the house, Z is the set of physical characteristics, L is the set of location characteristics other than crime and retail activity, C is a measure of neighborhood crime, R is neighborhood retail employment, and S describes the proximity of the house to a rail station. Greek letters represent parameters to be estimated.

From Eq. (1), the total impact of a rail station on nearby property values can be expressed as the sum of direct and indirect effects,

$$\partial P/\partial S = \gamma_S + \beta_C * \partial C/\partial S + \beta_R * \partial R/\partial S, \tag{2}$$

where the first term on the right hand side of (2) is the direct effect (γ_S) of a station on property value, the second term is the indirect effect a station may have on property value by causing crime to rise in the neighborhood, and the third term is the indirect effect resulting from a station attracting retail activity to the neighborhood.

To obtain estimates of $\partial C/\partial S$ and $\partial R/\partial S$ separate auxiliary neighborhood crime and retail equations are estimated,

$$C = \psi_0 + \theta_N N + \psi_S S + \nu \tag{3}$$

$$R = \varphi_0 + \pi_Q Q + \varphi_S S + \delta, \tag{4}$$

where N is the set of location characteristics that affects area crime, Q is the set of location characteristics that affects retail activity, and S measures neighborhood proximity to a rail station. Upon substitution of our estimates into (2), we have all terms identified:

$$\partial P/\partial S = \gamma_S + \beta_C * \psi_S + \beta_R * \varphi_S. \tag{5}$$

The direct effect represented by γ_S reflects some combination of a positive commuting benefit provided by station proximity and a negative impact resulting from the negative externalities emitted by the station. Because the relative importance of these opposing forces is expected to vary with distance from the station, S is measured by a set of dummy variables representing location within one of several contour rings moving outward from the center of the nearest station.

Within any particular ring, the net benefit from station proximity may vary with the characteristics of the station, the income of the neighborhood, and the distance the neighborhood is located from the CBD center. Station characteristics that may matter include whether the station has a parking lot, whether it is above or below ground, and the number of buses serving the station. Each of these characteristics is therefore interacted with S. The negative externalities emitted by stations may be more of a bother to the residents of high income than low income neighborhoods. On the other hand, the transportation cost savings provided by station proximity may be greater for the residents of high income neighborhoods because these residents place a higher value on their travel time. To investigate whether stations have differential impacts between low and high income neighborhoods, S is interacted with the median income of the neighborhood. The travel time savings of rail over an automobile trip are higher at greater distances from the CBD center. Hence, the access effect would more likely dominate the externality effect farther out. S is therefore also interacted with distance from the center of the CBD.[5]

IV. EMPIRICAL METHODOLOGY

In this section we describe each of the three equations we estimate: the hedonic house price equation, the crime model, and the retail employment model. The hedonic model is estimated using individual parcel data, while the unit of observation for the crime and retail models is the census tract. Each equation is estimated separately.[6]

Hedonic Model

The primary data set used in this analysis includes information on sales of single-family homes in the Atlanta region from 1991−1994. These data were purchased from TRW Redidata and are based on country tax assessment records. The data include date of the sale, sales price, and various physical characteristics of the property. Our sample is restricted to properties located within the City of Atlanta and DeKalb County, because crime data were only available for these two areas.[7] However, these areas contained 31 of the 33 MARTA stations that were in existence during the years covered by our sales price data. The total number of observation in the model we estimate equals 22,388.

The variables used to estimate the hedonic model are described in Table 1. The dependent variable, sales price, is deflated using the Consumer Price Index

[5] Spatial differences in the effects of rail access on property values may also result from area differences in the elasticity of supply of housing. These differences are likely to be small within our study area because this area, which is the most central portion of the MSA, has long been highly developed. The MARTA rail system, on the other hand, is of relatively recent origin: its first stations opened along its east line in 1979.

[6] Separate estimation of each equation assumes that the errors of each equation are uncorrelated across equations. To test the null hypothesis of zero correlation we used the Lagrange multiplier test developed by Breusch and Pagan [7]. Three test statistics were computed: one for the crime and retail equations, one for the crime and hedonic equations, and one for the retail and hedonic equations. To conform to the tract panel data used to estimate the crime and retail equations, the residuals used from the hedonic equation are the average residuals for each tract-year combination. None of the test statistics is significant at even the 10% level of significance. We therefore accepted the null hypothesis of zero correlation in all three cases.

[7] Part of the City of Atlanta falls within Dekalb County, which represents the suburban county on the City's eastern boundary.

TABLE 1
Hedonic Model Variable Definitions

Variables	Description	Source
Dependent variable		
PRICE	Natural log of sales price	TRW
Parcel characteristics		
BED	Number of bedrooms	TRW
BATH	Number of bathrooms (full + half)	TRW
LOTSIZE	Lot area in square feet	TRW
AGE	Age of house at sale date	TRW
FIREPL	Number of fireplaces	TRW
BASEMENT	House has basement	TRW
Location characteristics		
EMPGRAV	Tract proximity to employment as measured by a gravity variable	ARC
DISTCBD	Number of road miles to CBD center	Digitized map
HWYHALFMI	Within one-half mile road distance highway interchange	Digitized map
HWYMILE	Within one-half mile to one mile road distance of highway interchange	Digitized map
HWY2MILE	Within one mile to two miles road distance of highway interchange	Digitized map
HWY3MILE	Within two miles to three miles road distance of highway interchange	Digitized map
MFGDEN	Density of manufacturing employment in tract	ARC
RETDEN	Density of retail employment in tract	ARC
PCTRENT	Percent of housing units occupied by renters	Census
PCTBLACK	Percent black residents in tract	ARC
MEDINC	Tract median income	Donnelly
PCTRR	Percent of tract within one-half mile of a freight rail line	Digitized map
CRIMDEN	Density of total crimes in tract	City of Atlanta, Dekalb County
MARTAQMI	Within one-quarter mile of MARTA rail stop	Digitized map
MARTAHMI	Within one-quarter to one-half mile of MARTA rail stop	Digitized map
MARTAMI	Within one-half mile to one mile of MARTA rail stop	Digitized map
MARTA2MI	Within one miles to two miles of MARTA rail stop	Digitized map
MARTA3MI	Within two miles to three miles of MARTA rail stop	Digitized map
PARKLOT	Nearest MARTA station has a parking lot	MARTA
AVONDALE	Located in Avondale Estates City	Digitized map
DECATUR	Located in Decatur City	Digitized map
DEKALB	Located in unincorporated Dekalb County	Digitized map
STONEMT	Located in Stone Mountain City	Digitized map
LITHONIA	Located in Lithonia City	Digitized map
DORAVL	Located in Doraville City	Digitized map
CHAMBLEE	Located in Chamblee City	Digitized map
FULTON	Located in unincorporated Fulton County	Digitized map
HAPEVL	Located in Hapeville City	Digitized map

for housing in Atlanta for the year in which the sale took place. The results reported below are from a semilog specification of the model. The semilog model has been widely used to estimate hedonic models and our application of a P_E test rejects a linear model in favor of the semilog (Greene [19, pp. 459–462]).

The physical characteristics entering the hedonic model as explanatory variables are the number of bedrooms and the number of bathrooms, the size of the lot, whether the house has a basement or a fireplace, and the age of the house at the time of the sale. This set of variables represents the union of all characteristics found in the property tax assessment files of the two counties represented in our data.

The neighborhood designation is the census tract and each sales observation is geocoded by address and matched to a tract. Neighborhood characteristics include the proportion of the tract within one-half mile of a freight rail line, the percentage of the tract's population that is black, the median income of the tract, and the percent of housing units within the tract occupied by renters. Percent black and median income are available annually from the Atlanta Regional Commission (ARC) and Donnelly Marketing, Inc., respectively.[8] Percent renters is only available for 1990 from the Census of Population and Housing, so that for individual tracts the number is invariant across years. Two additional neighborhood variables are also available from ARC annually: the tract densities of employment in the retail sector and in the manufacturing sector.[9] The latter density is included to capture negative externalities often associated with production facilities.

The final neighborhood characteristic is the crime measure. Crime data are available from the City of Atlanta and for Dekalb County for the years 1991–1994. Crimes include those tracked by the U.S. Federal Bureau of Investigation and labeled by the FBI as ''Part I crimes.''[10] There are two alternative measures of neighborhood crime that can be constructed with the data: the crime rate (crimes/residential population) and the crime density (crimes/acres). One argument for using the crime rate is that it may be a better

[8] ARC's population estimates, which are provided separately for whites and blacks, are updates of decennial census numbers obtained from monitoring changes in housing inventories (via building and demolition permits) and conducting field surveys. Donnelly's median income estimates are updates of decennial census numbers obtained via multivariate modeling techniques that utilize data from telephone surveys and secondary resources.

[9] ARC's employment estimates are based on a complete census of employers which is updated annually by surveying a sample of firms and relying upon secondary resources such as commercially available business lists and ES-202 data from the Georgia Department of Labor.

[10] Part I crimes include homicide, assault, rape, robbery, burglary, larceny, theft, and auto theft. The FBI focuses on these crimes because they are more readily reported and occur with enough frequency to allow for comparisons across jurisdictions and over time. Part I crimes also include arson, but this crime is not listed separately in the DeKalb County data and is therefore left out of the totals.

measure of the individual resident's risk of victimization.[11] On the other hand, the crime density may be more highly correlated with the average resident's knowledge of crimes committed in his neighborhood.[12] In preliminary regressions, both the crime rate and the crime density of the census tract were alternatively tried as the measure of neighborhood crime. In comparison to the crime rate, crime density yielded a t-statistic that is three times larger and an elasticity (evaluate at the point of means) that is five time larger. Based upon this comparison, only the results with crime density as the crime measure are reported below.

To measure the property's access to employment, two variables are used: (1) the road distance in miles of the property from the center of Atlanta's central business district and (2) a gravity variable measuring the tract's proximity to employment within the region.[13] CBD distance is included based upon the standard model of urban land use (Muth [25]), while the gravity variable is included in light of Atlanta's high level of employment decentralization.

The properties in our sample are found in 10 different local government jurisdictions. Differences in taxes and public services across these jurisdictions that may affect property values are captured by including a complete set of jurisdictional dummy variables, with the City of Atlanta serving as the reference category.

Finally, the hedonic model includes two transportation access variables—one for highways and the other for MARTA. The highway variables are a set of dummy variables which indicate whether the property is within a given contour ring moving outward from the nearest on-ramp to a controlled access, divided highway. These contour rings represent road distance from the interchange of within one-half mile, one-half to one mile, one to two miles, and between two and three miles. The MARTA variables measure the linear distance of the property to the nearest MARTA rail stop. Like the highway variables, the MARTA variables are distance contours: within one-quarter of a mile from the

[11] Criminologists have argued, however, that at the neighborhood level the crime rate is a less reliable measure of residents' probability of being victimized because crime is higher where business activity is greater and the latter activity varies greatly across census tracts (see Harries [20] for a review of the literature on this issue).

[12] Crime density may also be a better measure of neighborhood crime than the crime rate if people wish to avoid exposure to crime. The latter equals the probability of being either a victim of crime or a witness to a crime. This probability is better measured by the number of crimes in a unit of space than by the number of crimes per resident.

[13] The gravity variable is a measure of the average distance of the tract to employment in all other tracts and is calculated by:

$$\mathrm{EMPGRAV}_i = \left[\Sigma_j \mathrm{EMP}_j / d_{ij}\right] + \mathrm{EMP}_i,$$

where EMP is total employment, j represents all tracts other than tract i, and d_{ij} is the distance between the centroids of tracts i and j.

station, between one-quarter and one-half mile, one-half mile and a mile, one to two miles, and two to three miles.

As mentioned above, the effects of station proximity on property value may depend on the median income of the neighborhood, the property's distance from the CBD center, and the characteristics of the station. To investigate these factors, the station proximity variables are interacted with neighborhood median income, CBD distance, and whether the nearest station has a parking lot.[14] In preliminary estimation, we also interacted the station proximity variables with dummy variables indicating whether the nearest station is below ground and whether the station is served by a higher than average number of buses. Because these interactions were not statistically significant, they were dropped from our final regressions.

Crime Model

To maintain consistency between the hedonic and crime models, the dependent variable in the crime model is the density of crimes in the census tract. Crime density is available for each of the 206 census tracts in one study area for each of the years 1991−1994, resulting in a panel of 824 observations.

Table 2 lists the explanatory variables including in the crime model. These variables can be grouped into three categories: (1) measures of the tendency for residents of the neighborhood to engage in criminal activity, (2) measures of the attractiveness of the neighborhood as a target for crime, and (3) measures of access into the neighborhood.

Five variables are used to represent the tendency of the tract's residents to engage in criminal activity: the percent of the population aged 15 to 24 years, the density of persons below the poverty line, the percentage of the population that is black, the percentage of the population over age 18 that has received a high school diploma, and the percentage of the housing units occupied by renters. The first three variables identify groups with high arrest rates (Marvel and Moody [23]). The fourth variable is based on the idea that persons with more education commit fewer crimes because the opportunity cost of time spent in crime or in jail rises with the level of legitimate earnings. Percent renters is included based on the hypothesis that crime is higher in neighborhoods where residential mobility is greater (Patterson [28]).

The attractiveness of the neighborhood to criminals depends on two factors: the potential booty and the probability of getting caught. The potential booty is measured by the density of retail employment, the density of manufacturing

[14] An argument could be made for a complete interacted model, including all possible three- and four-way interactions between station proximity, parking, income, and distance to downtown. However, in order to compute the full direct and indirect impacts of rail transit stations on property values these same higher order interactions must be used in the crime and retail models. The data available for the estimation of these models are not sufficient to estimate such complex models.

TABLE 2
Crime Model Variable Definitions

Variables	Description	Source
Dependent variable		
CRIMDEN	Density of total crimes (crimes/acres)	City of Atlanta, Dekalb County
Explanatory variables		
POPDEN	Population density	ARC
POVDEN	Density of persons below poverty level	Census
PCTBLACK	Percent black residents in tract	ARC
PCT1524	Percent persons age 15 to 24	Census
HSDIP	Percent persons over 18 with a high school diploma	Census
MEDINC	Tract median income	Donnelly
VACDEN	Density of vacant housing units	Census
POLICDEN	Density of police officers in jurisdiction	FBI
RETDEN	Density of retail employment	ARC
MFGDEN	Density of manufacturing employment	ARC
DISTCBD	Tract centroid distance to CBD	Digitized map
HWYDUM	Tract has controlled access highway	Digitized map
QMILE	Tract centroid within one-quarter mile of a MARTA rail stop	Digitized map
HMILE	Tract centroid one-quarter to one-half mile from rail stop	Digitized map
MILE	Tract centroid one-half to one mile from rail stop	Digitized map
MILE2	Tract centroid one to two miles from rail stop	Digitized map
MILE3	Tract centroid two to three miles from rail stop	Digitized map

employment, population density, and the median income of the neighborhood. Higher income and more populated areas, however, not only offer higher potential gains from crime but also an increased risk of getting caught. More people mean more potential witnesses, while higher income neighborhoods generally have better private and public security. Another variable measuring the criminal's risk is the per acre number of police officers serving the jurisdiction within which the tract is located.

Three variables are used to measure neighborhood access. First, the distance of the tract centroid from the CBD center measures the overall closeness of the tract to other parts of the region. Second, a dummy variable indicating whether the tract is bisected by an interstate highway provides a measure of quick access by automobile, since an interstate would likely provide the fastest getaway by car. Finally, the accessibility of the tract to a MARTA rail station must be measured. Our methodology for identifying the effects of station proximity on property values described in Section III requires that the station proximity measure used in the crime model match the one used in the hedonic model (i.e., the linear distance of the property to the nearest station). The measure chosen should also recognize that tracts are much larger in size than a single property and can be oddly shaped. Based upon these criteria, the best measure of tract proximity to a rail station is the linear distance of the centroid of the tract to the station. The tract centroid is the point in the tract that is closest on average to all other points in the tract. A tract that has its centroid closer to a MARTA station will have a larger area within a given impact area around the station, and should therefore be more heavily influenced by the presence of the station. To be consistent with the hedonic model, the linear distance between the station and the tract centroid is used to assign tracts to contour distance rings around the nearest station. These distance rings are the same as those used in the hedonic equation.

The independent variables entering the crime model, other than those that are fixed over time, are one-year lags. Lagging the variables serves two purposes. First, agents acting at the beginning of a year do not have perfect foresight of conditions later in the year. We assume a naive model of expectations, where the value expected for period t is equal to the value in $t - 1$. Second, lagging reduces the potential for endogeneity between the dependent and independent variables.[15]

Because the crime data are available as a panel, representing a cross-section of census tracts spanning a series of years, a Lagrange multiplier test was conducted to compare the appropriateness of a random effects model versus an OLS model. The OLS model is rejected in favor of random effects. This model allows for the possibility that there are one or more unobservable factors of the individual tract that are constant over time that effect the dependent variable.[16]

Above it was hypothesized that the effects of station proximity on property value may depend on the income of the neighborhood, the property's distance from the CBD, and whether the station has a parking lot. These same factors may affect how station proximity impacts neighborhood crime. Stations may cause more crime in high than in low-income neighborhoods because of the greater potential booty found in affluent homes. Stations may cause less crime

[15] Lagging does not result in the loss of one year of data because all explanatory variables are available for 1990. Both the crime and retail models are therefore estimated with the full panel of 824 observations.

[16] In the crime model and the retail activity model described below, the random effect is for census tract and not for time. Yearly dummy variables were tried in each equation and were jointly insignificant. Results on the other variables are insensitive to inclusion of time period dummy variables. A possible drawback to random effects is that biased coefficient estimates may result if the random effect is correlated with the regressors. A Hausman test is typically used to check this possibility, but in our case this test is invalid because our crime and retail models contain time-invariant regressors.

in neighborhoods farther from the CBD center because the attention of criminals may get diverted by intervening opportunities provided by closer-in station areas. Finally, stations with parking lots provide criminals who arrive by train with the opportunity to steal cars and thereby increase their mobility within the neighborhood, resulting in more crimes committed per time expended.

Retail Employment Model

The dependent variable in the retail model is the density of retail employment in the tract (retail employment/acres). The retail model parallels the crime model in most respects: the same panel of census tracts are used, OLS is rejected in favor of a random effects model, the independent variables are lagged one year, and the same set of station proximity variables are employed. A number of the other explanatory variables are also identical between the two models.

The variables used to estimate the retail model are described in Table 3. Five variables enter the retail model to measure the tract's proximity to retail customers: tract median income, a gravity variable to measure proximity to population, a gravity variable to measure proximity to nonretail employment, a dummy variable indicating the presence of a highway in the tract, and the distance between the tract centroid and the CBD center. Percent black is

TABLE 3
Retail Model Variable Definitions

Variables	Description	Source
Dependent variable		
RETDEN	Density of retail employment	ARC
Explanatory variables		
POPGRAV	Residential population gravity variable	ARC
PCTBLACK	Percent black residents in tract	ARC
MEDINC	Tract median income	Donnelly
DISTCBD	Tract centroid distance to CBD	Digitized map
MILLAGE	Millage rate of jurisdiction	Georgia Department of Revenue
GNONRET	Nonretail employment gravity variable	ARC
HWYDUM	Tract has controlled access highway	Digitized map
QMILE	Tract centroid within one-quarter mile of a MARTA rail stop	Digitized map
MILE	Tract centroid one-half to one mile from rail stop	Digitized map
MILE2	Tract centroid one to two miles from rail stop	Digitized map
MILE3	Tract centroid two to three miles from rail stop	Digitized map

included since other evidence on Atlanta suggests that commercial developers discriminate against black neighborhoods (Bollinger and Ihlanfeldt [5]). Also included is the property tax rate of the jurisdiction within which the tract is located. Finally, to parallel the hedonic and crime models, the effects of station proximity on retail employment are allowed to vary with neighborhood income, CBD distance, and whether the station has a parking lot. (See Table 4.)

V. RESULTS

In this section the results obtained from estimating the hedonic price model, the neighborhood crime density model, and the retail employment density model are discussed in turn. Two specifications of each model are presented: (1) a basic model which excludes all interactions and (2) a model including the interactions of the station proximity variables with neighborhood income, distance to the CBD center, and whether the station has a parking lot.

Hedonic Model Results

Nearly 50% of the variation in the log of sales price is explained by our hedonic model. This compares favorably to similar models previously estimated in the literature. In addition, estimated coefficients are generally statistically significant with expected signs and in all cases have reasonable magnitudes. In light of our accounting methodology of station effects on property values, it is noteworthy that both the density of crime and the density of retail employment within the neighborhood have highly significant impacts on property value. This affirms the possibility that rail stations may affect property values indirectly by increasing crime or retail activity within the neighborhood.[17]

In the basic model, properties within a quarter of a mile from a rail station are found to sell for 19% less than properties beyond three miles from a station. However, properties that are between one and three miles from a station have a significantly higher value compared to those farther away. These results suggest that houses that are very close to stations are affected by negative externalities, but those at an intermediate distance are beyond the externality effects and benefit from the transportation access provided by the stations.

The model with interactions shows that the premium paid for being close (but not very close) to a station is greater in high- than in low-income neighborhoods. This result contradicts Nelson [26] and suggests that the higher opportunity cost of commuting time of higher income residents enhances the value they attach to transit access.

[17] A referee noted that rail access may also indirectly affect property values by changing the median income of the neighborhood. Including median income may therefore result in estimates that understate the true effect of proximity to rail services. To investigate this possibility, median income was dropped from the hedonic equation. The results indicate that the estimated effects of rail access on property values are insensitive to whether median income is included in the model.

TABLE 4
Hedonic Model Estimates

	Basic model[a]		Model with interactions	
	Est. coeff.	S.E.	Est. coeff.	S.E.
BED	0.099**	0.0083	0.101**	0.0083
BATH	0.176**	0.0102	0.179**	0.0102
LOTSIZE (1000s)	0.001**	0.0003	0.001**	0.0003
AGE	−0.005**	0.0004	−0.005**	0.0004
FIREPL	0.145**	0.0093	0.144**	0.0093
BASEMENT	0.120**	0.0123	0.128**	0.0124
EMPGRAV (10,000s)	0.004	0.0030	0.004	0.0030
DISTCBD	−0.024**	0.0024	−0.022**	0.0025
HWYHALFMI	0.069	0.0633	0.108	0.0728
HWYMILE	0.031	0.0207	0.041*	0.0213
HWY2MILE	0.077**	0.0166	0.080**	0.0173
HMY3MILE	0.066**	0.0164	0.052**	0.0173
MFGDEN	−0.030**	0.0133	−0.034**	0.0135
RETDEN	0.096**	0.0065	0.087**	0.0068
PCTRENT	0.506**	0.0432	0.466**	0.0451
PCTBLACK	−1.099**	0.0306	−1.042**	0.0323
MEDINC (1000s)	0.009**	0.0005	0.007**	0.0006
PCTRR	−0.001**	0.0002	−0.001**	0.0002
CRIMDEN	−0.056**	0.0102	−0.030**	0.0109
MARTAQMI	−0.187**	0.0683	−0.145	0.2755
MARTAHMI	0.024	0.285	−0.104	0.1221
MARTAMI	0.009	0.0193	−0.455**	0.0657
MARTA2MI	0.035**	0.0155	−0.111**	0.0506
MARTA3MI	0.035**	0.0145	0.024	0.0524
PARK			0.046*	0.0270
PARK*MARTAQMI			0.114	0.1936
PARK*MARTAHMI			−0.102	0.0949
PARK*MARTAMI			−0.114**	0.0486
PARK*MARTA2MI			−0.056	0.0368
PARK*MARTA3MI			−0.047	0.0404
MEDINC*MARTAQMI			−0.025	0.0215
MEDINC*MARTAHMI			0.002	0.0039
MEDINC*MARTAMI			0.015**	0.0017
MEDINC*MARTA2MI			0.005**	0.0009
MEDINC*MARTA3MI			0.004**	0.0008
DISTCBD*MARTAQMI			0.66	0.0517
DISTCBD*MARTAHMI			0.16	0.0123
DISTCBD*MARTAMI			0.016**	0.0071
DISTCBD*MARTA2MI			−0.002	0.0048
DISTCBD*MARTA3MI			−0.013**	0.0044
Constant	5.691**	0.0785	5.685**	0.0824
R-square	0.475		0.478	

* indicates significance at the 5% level (two-tailed test).
** indicates significance at the 10% level (two-tailed test).
[a] Also entering both the basic model and the model with interactions are the jurisdictional dummy variables.

The interactions between station proximity and the property's distance to the CBD center show that homeowners are willing to pay more for a house within a mile of a rail station farther from the center in comparison to closer in. This is expected because the cost savings provided by transit are experienced on the line haul portion of the trip, which is obviously greater for longer commutes.[18]

Finally, the interactions between house distance from a station and whether the station has a parking lot have negative coefficients in four of the five cases, but only for houses from one-half to one mile is the coefficient statistically significant. However, houses beyond three miles from a station sell on average for 4.7% more if the nearest station has a parking lot. This result suggests that homeowners who must drive to the nearest station (in comparison to those who are able to walk, bike, or make a short bus or ''kiss and ride'' trip) are willing to pay for the convenience of parking at the station.

Crime Model Results

Over 80% of the variance in tract crime density is explained by the random effects crime model (see Table 5). Five of the control variables are statistically significant and each has the expected sign: the density of poverty, the density of vacant housing, retail employment density, manufacturing employment density, and distance to the center of the CBD. The estimated coefficient on the latter variable shows a negative ''crime gradient,'' which supports the idea that crime is higher closer in, even though many neighborhood characteristics are controlled for with other measures.

In the basic model, tracts with centroids within a half-mile of a rail station have a higher density of crime. This lends support to the hypothesis that rail stations contribute to neighborhood crime by enhancing the neighborhood's access to outsiders.

Turning to the model with interactions, the interaction of the station proximity variables with whether the station has a parking lot shows that the presence of a lot increases crime in tracts with centroids within a quarter of a mile of a station. However, for tracts with centroids between a quarter-mile and one mile from a station, a parking lot reduces crime. Apparently, a parking lot alters the distribution of crime around the station—increasing crime in and around the parking lot and decreasing crime farther away.[19]

The station proximity with neighborhood income interactions show that in tracts with centroids within a quarter of a mile of a station, an increase in income results in more crime, while the reverse is true for tracts within centroids between one-half to one mile of a station; however, the latter

[18] Close-in transit stations may also have less measured capitalization because there are alternative transit options in neighborhoods without rail services. However, in Atlanta these options are limited. There are no public transit services available other than those provided by MARTA and no bicycle paths in or around downtown.

[19] Perhaps the parking lot pulls crime closer to the station by providing cars to steal as getaway vehicles.

TABLE 5
Crime Model Estimates

	Basic model		Model with interactions	
	Est. coeff.	S.E.	Est. coeff.	S.E.
POPDEN	0.014	0.0114	0.020*	0.0105
POVDEN	0.257**	0.0219	0.291**	0.0215
PCTBLACK	−0.138	0.1943	−0.085	0.1783
PCT1524	0.181	0.5039	−0.207	0.4683
HSDIP	−0.494	0.3842	−0.128	0.3731
MEDINC (1000s)	0.004	0.0030	0.001	0.0031
VACDEN	0.275**	0.0366	0.222**	0.0317
POLICDEN	−2.002	3.9420	0.245	3.6180
RETDEN	0.411**	0.0286	0.385**	0.0287
MFGDEN	0.231**	0.0290	0.132**	0.0274
DISTCBD	−0.060**	0.0139	−0.010	0.0148
HWYDUM	0.031	0.0668	−0.005	0.0620
QMILE	1.522**	0.2852	4.166**	0.7711
HMILE	0.561	0.2506	1.674**	0.4948
MILE	−0.095	0.1246	1.798**	0.2881
MILE2	−0.006	0.1020	0.641**	0.2592
MILE3	0.054	0.0911	0.644**	0.2978
PARK			−0.047	0.1482
PARK ∗ QMILE			7.042**	1.7170
PARK ∗ HMILE			−1.426**	0.6109
PARK ∗ MILE			−0.463*	0.2405
PARK ∗ MILE2			−0.294	0.2341
PARK ∗ MILE3			0.049	0.2530
MEDINC ∗ QMILE			0.277**	0.0252
MEDINC ∗ HMILE			0.010	0.0263
MEDINC ∗ MILE			−0.017**	0.0084
MEDINC ∗ MILE2			0.005	0.0047
MEDINC ∗ MILE3			0.006	0.0054
DISTCBD ∗ QMILE			−4.350**	0.6459
DISTCBD ∗ HMILE			−0.009	0.2118
DISTCBD ∗ MILE			−0.124**	0.0325
DISTCBD ∗ MILE2			−0.044	0.0277
DISTCBD ∗ MILE3			−0.034	0.0252
Constant	0.954**	0.3590	0.092	0.3813
R-square	0.824		0.891	

* indicates significance at the 10% level (two-tailed test).
** indicates significance at the 5% level (two-tailed test).

coefficient, while statistically significant, is very small in magnitude. Recall that an increase in neighborhood income increases both the criminal's expected booty and the probability of getting caught. The results suggest that these opposing forces on crime play out differently at different distances from a station, but clearly the ‘‘booty effect’’ is dominant close to the station.

Finally, the interactions of the station proximity variables and distance to the CBD show that stations cause less crime farther out. This is consistent with the hypothesis that intervening opportunities for crime around stations located closer in divert criminals' attentions away from station neighborhoods located farther out.

Retail Model Results

The random effects retail model explains roughly 70% of the variation in retail employment density (see Table 6). In the basic model, three of the control

TABLE 6
Retail Model Estimates

	Basic model		Model with interactions	
	Est. coeff.	S.E.	Est. coeff.	S.E.
POPGRAV (10,000s)	−0.023	0.0143	−0.035**	0.0124
PCTBLACK	−0.802**	0.2406	−0.590**	0.2100
MEDINC (1000s)	−0.005*	0.0029	−0.000	0.0032
DISTCBD	0.016	0.0226	−0.039	0.0260
MILLAGE	−0.008	0.0058	−0.003	0.0052
GNONRET (10,000s)	0.130**	0.0078	0.191**	0.0083
HWYDUM	0.015	0.1547	−0.083	0.1330
QMILE	0.355	0.4733	0.809	0.7953
HMILE	−0.875**	0.3666	−5.469**	0.7165
MILE	−0.041	0.1584	−1.771**	0.3992
MILE2	−0.023	0.1240	−0.942**	0.3819
MILE3	−0.043	0.1173	−0.669	0.4536
PARK			0.016	0.1600
PARK ∗ QMILE			0.792	1.1910
PARK ∗ HMILE			2.485**	0.7712
PARK ∗ MILE			0.291	0.2528
PARK ∗ MILE2			0.090	0.2615
PARK ∗ MILE3			−0.022	0.2957
MEDINC ∗ QMILE			−0.285**	0.0177
MEDINC ∗ HMILE			0.003	0.0205
MEDINC ∗ MILE			0.007	0.0084
MEDINC ∗ MILE2			−0.002	0.0057
MEDINC ∗ MILE3			−0.002	0.0061
DISTCBD ∗ QMILE			0.461	0.5561
DISTCBD ∗ HMILE			0.797**	0.2822
DISTCBD ∗ MILE			0.138**	0.0377
DISTCBD ∗ MILE2			0.082**	0.0310
DISTCBD ∗ MILE3			0.068*	0.0351
Constant	2.175	1.0207	3.115**	0.9449
R-square	0.670		0.678	

* indicates significance at the 10% level (two-tailed test).
** indicates significance at the 5% level (two-tailed test).

variables are statistically significant: median income, percent black, and the gravity variable measuring the tract's proximity to nonretail employment. While the latter two variables have the expected sign, an increase in median income is found to reduce the density of retail employment in the tract, which is contrary to the hypothesis that retail employment is attracted to higher income neighborhoods. An explanation for the income result is that the supply of sites available for retail development may be more restricted by zoning in high income neighborhoods.

In the basic model, none of the station proximity variables have a positive and statistically significant effect on retail employment. However, the model with interactions shows that rail stations have a positive impact on retail activity farther from the CBD. Tracts with centroids between one-quarter and one-half mile of a station experience the greatest increase in retail employment density with increasing distance from the CBD. For example, at 10 miles from the CBD center, the latter tracts have retail densities that are about five times greater than tracts located beyond three miles of a transit station.

In summary, the results from the hedonic model show that rail stations have direct effects on the values of single-family homes. These effects are found to vary with neighborhood income, distance to the CBD center, and whether the nearest station has a parking lot. The hedonic model also shows that the density of both crime and retail employment in the neighborhoods affects property values. Results from the two auxiliary equations show that the densities of crime and retail employment within neighborhoods are affected by station proximity. Thus, the hedonic and auxiliary models combined indicate that property values are also indirectly affected by station proximity through crime and retail activity.

VI. COMBINED PRICE EFFECTS

In order to assess the relative importance of the various station proximity effects on property values, the results from our three estimated models were used to calculate the price effects of proximity to a MARTA station using different combinations of distance to downtown, neighborhood income, and existence of parking at the station (see Table 7a and b). The amounts shown in the tables are equal to the difference between the average house price in the sample and a house in each MARTA proximity distance ring at the given distance to downtown and neighborhood income level, both with and without station parking.[20] For example, the numbers in the upper left cell in Table 7a (−12,169, 1198, and 19,819) represent the differences between the mean house price and a house that is within one-quarter of a mile of a MARTA station containing parking in a neighborhood with a median income of $10,000 at

[20] The distances to downtown and median income levels used in the tables are roughly the sample means and one standard deviation above and below the means.

distances of 2, 7, and 12 miles from the CBD, with all other house characteristics held constant at their mean values.

While price effects are calculated for all interacted variable combinations, it is not true that all of the coefficients used to compute the price effects are significantly different from zero in the empirical estimations. Thus, even though a pattern may be seen in the tables, it may not be supported statistically by the data. The significance of the station proximity interactions with neighborhood income and distance to downtown is indicated at the top of each column in the tables.

Overall, three conclusions are apparent from the results presented in Table 7:

(1) direct effects are generally larger in absolute value than crime or retail effects;

(2) retail effects are larger than crime effects, except in the immediate vicinity of stations located close to downtown; and

(3) total effects vary a great deal with neighborhood income level, distance to downtown, and distance from the station.

Regarding (3), the largest positive total effects tend to occur at the farthest distance from the CBD between one-quarter to one-half mile of a station. These effects are driven almost entirely by the retail effect. Apparently, stations help create retail nodes away from the CBD that homeowners find valuable. At the other extreme, the largest negative impacts of MARTA are found in high-income neighborhoods within one-quarter mile of a station, especially if the station is located close to downtown with a parking lot. Both crime and externality effects account for this result.[21]

There are other more specific patterns that can be seen in the tables:

(1) Large, positive direct effects are found in high-income neighborhoods between one-quarter and three miles of a station, with the largest effect occurring in the one-half to one mile ring at 12 miles from the CBD. This result reflects the higher premium that high-income homeowners place on transit access and the tendency for the access effect to be larger farther from the CBD.

(2) Beyond one-quarter mile of a station, negative direct effects are generally restricted to low-income neighborhoods. Apparently, for middle- and high-income neighborhoods, the commuting cost savings provided by transit exceed any costs caused by negative externalities.

(3) Negative crime effects are found mainly close to downtown, especially where the station has parking. This result suggests that people who might use public transit to get access to a neighborhood to commit crimes will not

[21] As noted in the table, for the 0 to $1/4$ mile distance ring neither the neighborhood income nor CBD distance interactions are statistically significant at indicated levels in Table 4. Hence, caution should be exercised in interpreting the externality effects within this ring. However, both interactions approach significance at the 10% level by a one-tail test.

TABLE 7

House Price Effects from Proximity to MARTA Rail Station with (a) No Parking and (b) Parking

(a)		Distance from MARTA rail stop											
		0–One-quarter mile				One-quarter–one-half mile				One-half–one mile			
Tract median income	Distance to CBD	Direct effect	Crime effect[1]	Retail effect[2]	Total effect	Direct effect	Crime effect[3]	Retail effect[3]	Total effect	Direct effect[1]	Crime effect[1]	Retail effect[3]	Total effect
$10,000	2 mi	−$12,169	$1,901	−$2,470	−$12,738	−$3,898	−$1,840	−$2,653	−$8,392	−$12,421	−$1,326	−$2,653	−16,400
	7 mi	1,198	1,901	7,192	10,290	−278	−1,781	2,585	527	−9,614	−477	−969	−11,060
	12 mi	19,819	1,901	18,988	40,708	3,653	−1,721	22,702	24,634	−6,574	389	1,818	−4,368
$30,000	2 mi	−25,754	−4,462	−2,653	−32,870	−2,001	−2,111	−2,653	−6,765	−741	−868	−2,653	−4,263
	7 mi	−17,727	1,901	−2,653	−18,480	1,782	−2,052	2,813	2,544	3,036	−10	−412	2,614
	12 mi	−6,545	1,901	−2,653	−7,298	5,890	−1,993	22,025	26,921	7,128	864	2,409	10,401
$50,000	2 mi	−33,912	−10,913	−2,653	−46,479	−19	−2,380	−2,653	−5,052	14,979	−406	−2,538	12,035
	7 mi	−29,092	1,901	−2,653	−29,844	3,935	−2,322	3,043	4,656	20,063	461	152	20,677
	12 mi	−22,377	1,901	−2,653	−23,129	8,226	−2,264	23,349	29,312	25,571	1,344	3,008	29,923

		One–two miles				Two–three miles			
Tract median income	Distance to CBD	Direct effect[2]	Crime effect[4]	Retail effect[3]	Total effect	Direct effect[1]	Crime effect[4]	Retail effect[3]	Total effect
$10,000	2 mi	−$4,407	−$254	−$1,210	−$5,870	−$23	−$131	−$251	−$405
	7 mi	−4,888	52	422	−4,415	−3,033	105	1,124	−1,804
	12 mi	−5,364	359	2,113	−2,893	−5,846	343	2,540	−2,964
$30,000	2 mi	343	−394	−1,347	−1,398	3,845	40	−402	3,474
	7 mi	−194	−89	279	−4	583	277	968	1,828
	12 mi	−724	217	1,965	1,458	−2,466	516	2,379	428
$50,000	2 mi	5,632	−533	−1,485	3,614	8,037	212	−554	7,695
	7 mi	5,035	−210	137	4,942	4,501	450	812	5,763
	12 mi	4,445	75	1,818	6,337	1,197	689	2,218	4,104

1. Income and distance to CBD interactions with distance from MARTA significant at 10% level.
2. Only income interaction significant.
3. Only distance to CBD interaction significant.
4. Neither interaction is significant, but distance to MARTA is significant.

Distance from MARTA rail stop

(b)		0–One-quarter mile				One-quarter–one-half mile				One-half–one mile			
Tract median income	Distance to CBD	Direct effect	Crime effect^{1,5}	Retail effect^{2}	Total effect	Direct effect	Crime effect^{3,5}	Retail effect^{3,5}	Total effect	Direct effect^{1,5}	Crime effect^{3}	Retail effect	Total effect
$10,000	2 mi	−6,269	−$6,266	$701	−$11,834	−$6,18	$187	−$2,653	−$8,648	−$14,629	−$627	−$2,444	−$17,701
	7 mi	9,417	1,901	11,603	22,382	−2,756	249	14,383	11,875	−12,007	236	251	−11,519
	12 mi	31,270	1,901	23,716	56,886	962	311	39,367	40,640	−9,166	1,115	3,113	−4,937
$30,000	2 mi	−22,211	−12,438	−2,653	−37,303	−4,387	−97	−2,653	−7,137	−3,715	−162	−1,906	−5,782
	7 mi	−12,812	1,901	−2,653	−13,544	−808	−35	14,667	13,824	−184	710	824	1,349
	12 mi	331	1,901	−2,653	−421	3,078	26	39,768	42,872	3,640	1,598	3,721	8,959
$50,000	2 mi	−31,785	−17,655	−2,653	−50,093	−2,511	−378	−2,653	−5,543	10,977	308	−1,360	9,925
	7 mi	−26,128	1,901	−2,653	−27,880	1,228	−317	14,952	15,863	15,729	1,188	1,403	18,320
	12 mi	−18,248	1,901	−2,653	−19,000	5,288	−256	40,171	45,203	20,876	1,901	4,336	27,113

		One–two miles				Two–three miles			
Tract median income	Distance to CBD	Direct effect^{2}	Crime effect^{4}	Retail effect^{3}	Total effect	Direct effect^{1}	Crime effect^{4}	Retail effect^{3}	Total effect
$10,000	2 mi	−4,823	224	−$793	−$5,391	−$80	−$134	−$272	−$487
	7 mi	−5,299	533	854	−3,913	−3,086	102	1,102	−1,883
	12 mi	−5,770	843	2,560	−2,367	−5,896	339	2,517	−3,040
$30,000	2 mi	−120	83	−932	−970	3,783	37	−424	3,396
	7 mi	−651	390	710	449	525	274	946	1,744
	12 mi	−1,176	700	2,411	1,935	−2,520	512	2,356	348
$50,000	2 mi	5,116	−58	−1,071	3,988	7,970	209	−575	7,603
	7 mi	4,525	248	566	5,339	4,439	446	790	5,675
	12 mi	3,941	557	2,262	6,760	1,138	685	2,196	4,019

1. Income and distance to CBD interactions with distance from MARTA significant at 10% level.
2. Only income interaction significant.
3. Only distance to CBD interaction significant.
4. Neither interaction is significant, but distance to MARTA is significant.
5. Parking interaction with distance from MARTA is significant.

travel much beyond the already high-crime areas. As noted above, intervening opportunities might explain this result. Alternatively, a criminal may not use rail to gain access to a neighborhood farther from downtown because he feels he may be more readily targeted as an outsider when walking from the station.

VII. POLICY IMPLICATIONS

Atlanta and a number of other metropolitan areas attempting to combat sprawl have chosen residential densification around rail transit stations as part of their overall strategy. Our results suggest that densification efforts should consider both the direct and the indirect effects of transit stations on the attractiveness of nearby neighborhoods.

Without any market intervention, stations located away from downtown will attract residential development. Here, direct effects and retail effects are positive and large while crime effects are small. Increasing densification around stations located closer in, however, may require government intervention. In low-income neighborhoods, the focus should be on mitigating negative externalities emitted by the station, while in high-income neighborhoods the priority should be on reducing transit generated crime.

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