THE ECONOMIC DEVELOPMENT IMPACTS OF LIGHT RAIL TRANSIT: A CASE STUDY OF THE BALTIMORE CENTRAL LIGHT RAIL

A Thesis
Submitted to the Faculty of the
Graduate School of Arts Sciences
of Georgetown University
in partial fulfillment of the requirements for the
degree of Master of Public Policy
in Public Policy

By

Kyle A. Barry, B.A.

Washington, D.C.
April 13, 2012
THE ECONOMIC DEVELOPMENT IMPACTS OF LIGHT RAIL TRANSIT:
A CASE STUDY OF THE BALTIMORE CENTRAL LIGHT RAIL

Kyle A. Barry, B.A.

Thesis Advisor: Dr. Ward Kay, PH.D

ABSTRACT

This study uses a multivariate hedonic regression model to estimate the economic development impacts of the Baltimore Central Light Rail. Given that the state of Maryland and the City of Baltimore are planning to construct a new light rail line in the coming years (known as the Baltimore Red Line), it is important to confirm the predicted benefits of light rail on a pre-existing system. This analysis uses data from the 2005-2009 5-Year American Community Survey to test the impact of light rail station proximity on census tract level property values. Past studies have shown that proximity to a light rail station may have either positive or negative effects on property values. This is due to either, respectively, what is known as the “accessibility effect”, or the increased ease of moving around the city due to increased access to public transportation, or the “nuisance effect”, or the annoyance of living so close to the light rail station, due increased noise and the potential for increased crime in a given area. Presumably, these effects will be capitalized into the demand for local property values. The hedonic regression models showed a significant effect of light rail station proximity on property values only when locational variables were taken into account. When a more comprehensive model was incorporated or other variables were added to the locational model, the significant effect of station proximity disappeared. From this analysis, it can be inferred that the city of Baltimore must be quite careful in calculating full costs and benefits of the coming Red Line, and should promote the line as only one piece of a broader economic development program for the city, not as the central component.
TABLE OF CONTENTS

Chapter I: Introduction and Motivation................................................. 1
  The Baltimore Red Line............................................................. 1
  Light Rail Systems and Transit-Oriented Development.................... 3
  Economic Development and the Baltimore Red Line....................... 4
  The Baltimore Central Light Rail............................................... 6
  Theory and Hypothesis............................................................. 7

Chapter II: Literature Review............................................................. 8
  Light Rail System Impacts on Property Values.............................. 9
  Broad Impacts of Light Rail..................................................... 15

Chapter III: Data and Methodology.................................................... 16
  Sample Data.............................................................................. 18
  Methodology............................................................................. 19

Chapter IV: Regression Results........................................................... 23

Chapter V: Policy Implications............................................................. 25

Bibliography.................................................................................... 31
LIST OF TABLES AND FIGURES

Figure 1: Baltimore Red Line Study Area................................. 17

Figure 2: Central Light Rail Study Area................................. 17

Graph 1: Histogram of Property Values................................. 20

Table 1: Tabulation of Dummy Variables................................. 22

Regression Table 1: Regression Models 1-3............................. 23

Table 2: Correlation Coefficients............................................. 24
I. INTRODUCTION AND MOTIVATION

The Maryland Transit Authority is proposing a $2.12 billion new light-rail transit line in Baltimore City and Baltimore County, known as the Red Line, which in addition to reducing traffic congestion is expected to spur economic development and community revitalization.\(^1\) Theory holds that residential property values in close proximity to light rail stations should be higher than those further away from light rail stations, a sign of increased economic activity and higher demand for property. However, given other variables present within Baltimore which may have a significant effect economic development, will the Baltimore Red Line light rail have a positive impact on property values? This thesis will use data from the 2005-2009 American Community Survey to test whether or not proximity to a station serving the currently operating Baltimore Central Light Rail has had a significant impact on residential property values within the City of Baltimore, relative to residential property values further away from a light rail station. Despite the potential for economic impacts to be mitigated or lessened by other social or economic factors, it is likely that properties near the light rail station with the city of Baltimore will be more highly valued than properties further away from a light rail station.

The Baltimore Red Line

The Baltimore Red Line is a proposed 14-mile east-west light rail system in Baltimore City and Baltimore County, Maryland. The project is currently in the Preliminary Engineering phase of its review process. The Red Line is designed to be part of the Baltimore Regional Rail System Plan, a proposed regional rail transit system connecting riders to jobs, education, shopping, and medical services in the Baltimore metropolitan area. The eventual system will be composed of six lines and 122 stations, covering 109 miles in the Baltimore area.\(^2\) The east-west Red Line will serve as an integral part of this plan, as it runs through three major economic centers in the
Baltimore region: CMS services in Woodlawn, MD, the Central Business District (CBD) within the City of Baltimore, and the Johns Hopkins Bayview Medical Campus in East Baltimore. The rail will connect with or be in close proximity to Oriole Park at Camden Yards, M&T Bank Stadium, Lexington Market, the University of Baltimore, the University of Maryland – Baltimore, the University of Maryland Biotechnology and Medical Center, the Inner Harbor (the city’s most popular tourist attraction), the historic Fells Point and Canton neighborhoods, as well as many of the city’s major employers in downtown Baltimore.⁴

The Red Line will be a two-track light rail system, and “will run mostly as a dedicated surface transitway in the median of existing roads.”⁴ 9.8 miles of the track will be aboveground on designated right-of-way designated railways. 3.9 miles of the system will be run underground through tunnels, in areas of high-congestion or limited right-of-way. There will be approximately 38 light rail vehicles that operate along the track, with 19 planned stations along the route.

The Red Line is designed to serve multiple purposes and needs in the Baltimore area, including:⁵

- Increasing transit choices for riders in West Baltimore and the Central Business District
- Promoting economic development
- Improve efficiency in the current transit system
- Improve air quality by reducing traffic congestion and automobile use
- Encouraging community revitalization, particularly in Baltimore City
- Promoting transit-oriented development

Total construction costs of the Red Line are projected at approximately $2.12 billion.⁶ Guide-way and track costs make up approximately 40% of total construction costs, estimated at $698 million.⁷ Stations, stops, and terminals are projected to cost approximately $198 million. The
project, despite its high cost, is estimated to be relatively cost-effective: cost-benefit analysis estimates that the benefits of the transit line outweigh the costs by approximately $21.17 per hour.\textsuperscript{8} This estimate was derived by dividing the incremental annualized cost by annualized user benefits, measured in dollars per hour. Estimated costs to the project have actually increased over the last few years, although this is primarily due to calculation differences between the FTA and the MTA. The price tag through construction and initial operation and maintenance increased from $1.8 billion to $2.12 billion in 2011.

**Light Rail Systems and Transit Oriented Development**

Light rail systems may serve as an example of what city planners refer to as “transit-oriented development.” Transit-oriented development is defined as “a type of community development that includes a mixture of housing, office, retail and/or other amenities integrated into a walkable neighborhood located within close proximity to quality public transportation systems.”\textsuperscript{9} In this type of system, light rail stations are designed to serve as a hub for economic development. Presumably, communities surrounding light rail stations should receive economic benefits as a result of increased commuter access to the area. This may include increased commercial activity, including an increase in the number of permanent jobs as employers relocate into areas that might be easily accessed by transit. In addition, light rail may also bring increased benefit to a given area’s residents, in the form of new residential buildings or increased property values for older buildings.

In addition to economic development impacts, light rail systems may provide significant environmental benefits, primarily by reducing traffic congestion, reducing the number of trips by car individuals make every year, improving air quality, and increasing population density around
light rail stations. These benefits can be substantial, particularly in heavily-congested urban areas.

Each of these potential benefits – increased commercial activity, increased commuter traffic, increased employment opportunities around the light rail station, as well as residential benefits like reduced congestion and improved air quality – should all increase the attractiveness of the area near a light rail station, manifested in a direct rise in local property values. Theoretically, both residential and commercial property values should increase as a result of these transit-related benefits. However, the impacts of light rail stations on property values are mixed at best. Other factors besides light rail stations may play an important role in increasing economic development around light rail stations.

**Economic Development and the Baltimore Red Line**

As stated above, one of the proposed Red Line’s primary purposes is to promote economic development within the City of Baltimore. This is particularly true for West Baltimore, one of the poorer areas of the city. Today, this portion of the city is one of the least served by transit – neither the Central Light rail line nor the Baltimore Metro Subway pass within the area of West Baltimore. In addition, the area is heavily congested by automobiles traveling into the city’s Central Business District from Baltimore County, as major highways I-70 and I-695 empty out onto a two-lane road traveling through West Baltimore. Apart from West Baltimore, the Red Line is designed to encourage further investment and development in the Fells Point and Camden neighborhoods, former industrial centers that had declined significantly over the last few decades.
The various partners involved in building the Baltimore Red Line – the Federal Highway Administration, the Maryland Department of Transportation, the Baltimore Metropolitan Council, and the City of Baltimore – have all touted the lucrative potential of the Baltimore Red Line. The Environmental Impact Statement produced by the project’s developers offers the following as reasons the Red Line will improve the economic development prospects for the proposed area:  

- Increased commercial activity in areas surrounding station
- Increased commuter traffic to and from the city
- Economic development impacts related to reduced congestion
- More attractive residential options due to increased transit options

However, whether or not the Red Line will have the projected economic impacts is debatable, for a number of reasons. First, an interesting component of the relatively short rail line (14 miles) is that the majority of the line will pass through areas of high-poverty, high crime areas. This may discourage riders traveling from the western edge into the Central Business District, and vice-versa from actually riding the rail line. Second, unlike the Washington DC Metro, the Red Line will be running above ground for the majority of its route (exceptions include the Central Business District and the western edge of the city line). These above-ground tracks may actually serve as an unnatural barrier to development along the rail line. In addition, stations themselves will be aboveground, taking up substantial space that could be used for redevelopment and community investment. Third, Baltimore is not a city that has proven truly adaptable to intra-city transit. Although there are currently two rail transit systems running through the city, ridership has been relatively low and the systems go relatively unused by wealthier areas of the city. Baltimore, especially the areas built since the 1960’s, has been built for the automobile.
Given the high cost of the system, and the risks associated with this form of development, it is important to analyze the true economic potential of the Red Line.

**The Baltimore Central Light Rail**

Baltimore currently has a light rail system in operation. The Baltimore Central Light Rail came into service in 1992, and was originally a 22.5 mile line that ran from Timonium in Baltimore County to Glen Burnie in Anne Arundel County. The line was built “fairly quickly and cheaply,” and did not receive any funding from the federal government. The primary purpose of the line was to promote economic development in the city of Baltimore, mainly by allowing commuters from North of the city to venture to the newly built Camden Yards. The line has since been extended twice, with the final extension completed in 2005. The system now covers a 30-mile corridor, extending from Hunt Valley in northern Baltimore County to the Baltimore-Washington International Airport. There are 28 stations along the main corridor line. Daily ridership is approximately 36,300, with the majority of commuters riding during rush hour.

The Central Light Rail connects to other transit options within the city. The Light Rail connects to the Maryland Area Regional Commuter (MARC) train in four locations – at Penn Station in the Center of the City, in West Baltimore, at Oriole Park at Camden Yards, and at BWI Airport. The MARC train provides Baltimore residents with easy transit options to Washington DC. In addition, the Light Rail connects to the Baltimore Metro Subway at Penn Station and Lexington Market, in the Central Business District, which offers the opportunity to travel northwest to Owings Mills, MD, or to the Johns Hopkins Bayview Hospital in southeast Baltimore. The light rail thus offers different multimodal options for transit development.
Theory and Hypothesis

Given that the Central Light Rail has been in operation for some time, the potential economic development impacts of the Red Line may be estimated. By analyzing residential properties in relative proximity to light rail stations, the economic effects of light rail systems may be parceled out. The fact that both systems are within the same city will be incredibly important to this analysis. First, some of the variables that may also impact residential property values, including social and economic demographics, will be very similar between the two transit corridors in question. In addition, commuting patterns amongst residents are likely to be similar, as both systems are within the Baltimore region and both connect to other forms of transit. Finally, both systems pass through relatively similar demographic regions. The Red Line will run through both wealthy and low-income areas (particularly in West Baltimore), a component that is mirrored by the Central Light Rail Line. By studying the economic development impacts of the Baltimore Central Light Rail on property values in relative proximity to light rail stations, the potential impact of the Red Line may be predicted.

There are many factors that may play into an increase or decrease in property values. Local crime rates, local education rates, family income, race and other social demographics, as well as commuting patterns are examples. Given these variables, what has been the impact of the Baltimore Central Light Rail on property values within the City of Baltimore, given proximity to a light rail station? Purely based on visual knowledge of the area, one would believe that the system’s impact has been negligible. However, as mentioned above, given the perceived benefits of light rail – increased convenience to transit, improved environmental conditions, and increased commercial activity – one would hypothesize that properties relatively close to light rail stations have benefitted from the system’s existence. These properties likely will be valued
higher than properties further away from a station. Given the high cost of the proposed Baltimore Red Line, this study may be important for analyzing precisely how much economic benefit the system may bring.

II. LITERATURE REVIEW

Studies analyzing rail’s impact on property values have yielded mixed results, both in terms of the overall effect on property values as well as localized differences between properties located closer and further away from a station. This analysis of the Baltimore Light Rail differs from past studies in that it attempts to analyze property values within a broad regional area, in an attempt to capture the regional effect of rail transit and not its impacts on specific property values.

Most studies of rail transit systems have utilized hedonic linear regression models to estimate rail’s impact on residential and commercial property values (Parsons Brinckerhoff). In general, studies have utilized similar variables in estimating their model, normally depicting neighborhood demographics, crime rates, proximity to light rail, and local business characteristics. In addition, studies have generally utilized real estate data on home sales near a rail system within a specified time period. Properties chosen for analysis have covered a wide array of distances relative to a light rail station. Multiple studies have extended their range of study up to three miles away from a light rail station, while others have limited the range to between one-quarter and one-half miles.

Theory holds that an “accessibility bonus,” or increased accessibility to a city’s businesses and other amenities, provided by light rail should be capitalized into a property’s valuation (Bowes and Ihlanfeldt, 2001; Debrezion, et. al., 2007). Rail transit provides residents and businesses
with increased accessibility to other areas of a city, most importantly the Central Business District. This added convenience should provide benefits to properties near a light rail station, and should reflect an increase in a property’s value relative to properties further away from a station. Consumers should choose to live in and be willing to pay more for properties that exhibit this added accessibility.

However, urban economic theory also posits that there may be negative externalities associated with proximity to both light rail stations and tracks. This includes a “nuisance effect,” or a negative impact on property values associated with the increased noise and vibration from a rail system (Weinberger, 2001). In addition, some theorists believe that proximity to stations increases the likelihood of crime occurring in a given area, as individuals seeking to commit crimes not only have more freedom to move around, but also have a higher number of individuals (commuters) to prey upon (see Bowes and Ihlanfeldt, 2001; Cervero and Landis, 1996). This in turn not only has an impact on property values, but may also impact if, how, and where consumers choose to board a light rail (Kim et al., 2006).

**Light Rail System Impacts on Property Values**

As of 2007, over 100 papers had been written concerning light rail’s impacts on both residential and commercial property values. Although analyses provided by these studies have yielded mixed results, on average most studies have shown some net positive economic development benefit resulting from proximity to light rail stations. Garrett lists a number of potential reasons for the mixed results from previous studies: first, there may be measurement error in empirical modeling. Second, the specific light rail studied may have characteristics that make it difficult to detect any relative change in local property values. These may include too few stations, a fixed
route away from residential areas, or a small amount of commuters utilizing the rail compared with the percentage of commuters using automobiles. Third, an effective and efficient highway system may have already been installed within the area of study, and may both provide better accessibility to necessary services as well as discourage individuals to commuting to rail. Finally, light rail may only exist in dense, low-income urban areas, and not extend out into primarily suburban residential areas. This may have the effect of providing a benefit to small urban areas, but will not induce an economic benefit of the magnitude sought by many policymakers.

In addition, Bowes and Ihlanfeldt claim that mixed results stem from the interplay of four differing factors, two of which may cause higher property values and two of which may cause lower property values. First, light rails provide an accessibility effect, as mentioned above. Second, higher property values and increased accessibility may attract new commercial services, particularly retail establishments to an area. These may be countered by the two negative factors mentioned above, namely nuisance effects from the system itself as well as increased crime resulting from the station. The interplay of these effects, and the magnitude of one compared to another, determine the whether or not the net impact of a light rail system on property values is positive.

**Positive Impacts**

In their study of the Atlanta MARTA (Metropolitan Atlanta Rapid Transit Authority), Bowles and Ihlanfeldt (Journal of Urban Economics, 2001) found positive economic impacts resulting from light rail station proximity. Their study analyzed the economic development impacts of the MARTA by examining the system’s impact on property values, changes in the local crime rate, and increases in the number of local retail businesses. Bowes and Ihlanfeldt estimated one model
for analyzing MARTA’s impact on property values, as well as two auxiliary regression equations that estimated crime rate and retail activity given proximity to a light rail station. Their model was estimated using data from the US Census, as well as data collected from real estate sales in the years 1991-1994. A portion of their model was derived from census tract level data, and was used to calculate real estate activity and neighborhood demographics. Their estimates revealed that all three models significantly interplayed with economic development in the area near light rail stations, and that there was a net positive gain in property values resulting from proximity to light rail stations. However, they also found that the magnitude of the impact was in large part determined by the proximity of the property to the Central Business District (CBD). Properties in close proximity to stations but further away from the CBD were impacted, on average, more than properties that were of the same relative distance to the station but closer to the CBD.

Garrett (2004) also found a significant relationship between property values and proximity to St. Louis MetroLink stations. For his methodology, Garrett developed a model that included all potential variables that may affect single-family house prices, such as neighborhood and household-level characteristics. His analysis used data from local real estate sales, as well as neighborhood demographic variables from the US Census, to track the distance from a MetroLink station and neighborhood demographics, respectively. He included in his model two different sets of homes, those up to one-half mile from a MetroLink station and those properties one-half mile to one mile away from a MetroLink station. Garrett found a statistically significant relationship between distance from a MetroLink station and residential property values. However, this relationship depended on precisely how far away from a station a property was. Specifically, Garrett found that on average, home values between 1,400 and 2,300 feet increased $139.92 for every 10 feet closer they are to a MetroLink station, up to 2,300 feet. This translates
into a 31.25-32.72 percent increase in property value when averaging across the 4 models. Garrett notes, however, that although this percentage increase in property values may seem large, it is important to recognize that the homes in this area have relatively low property values. Thus, any increase in local property values was likely to have a relatively high percentage impact.

The above studies are similar to evidence shown by Weinberger (2001). Ms. Weinberger analyzed commercial property values near Bay Area Rapid Transit (BART) rail stations in Santa Clara County, California to test for any potential impacts on property values. Her study used a dataset of negotiated lease transactions for commercial office space that spanned sixteen years (1984-2000). This time period covered five years prior to BART’s opening, as well as the following ten years to test for impacts on property values. Her model included neighborhood- and building- specific factors, indicators accounting for varying economic cycles, highway access, and location factors related to distance, among them distance from light rail stations and distance from the CBD. Weinberger found that the presence of a light rail system within Santa Clara County was associated with a rental premium on office properties that lie close to a rail station. Specifically, she found that properties that lay within one-half mile of a light rail station commanded a higher lease rate than other properties within the county.

Cervero and Landis (1996), in their own study of the BART system, found positive impacts on land use changes resulting from close proximity to a rail station. Around nine BART stations, they found that the area of vacant land in a ½ mile radius surrounding a station fell sharply in the first 20 years of BART’s existence – from “27.6% of total area in 1965 to just 4.2% of area in 1990.” They also note that BART has created opportunities for attracting new development and reinvigorating stagnant areas that some communities have capitalized on.
Billings (2011) found neighborhood-level positive impacts from the light-rail system located in Charlotte, North Carolina. Billings incorporated a difference-in-difference model to test single-family homes and condominiums within 1 mile of a light rail transit station. He incorporated approximately 4,790 single family homes and 2,487 condominiums into his analysis. Billings found an aggregate benefit of approximately $10.9 million to $109 million for single-family homes, and a benefit of approximately $45.9 million to $153.9 million for condominiums. Overall, Billings sites his “preferred estimate” as $97.2 million. However, he does note that this amount is substantially lower than the $450 million in construction costs related to the light rail system. To counter this, however, he notes that his analysis does not capture the full benefits of new development along light rail corridors, nor does it capture the full benefit associated with the elimination of externalities associated with automobile use.

**Negative Impacts**

Lewis-Workman and Brod (1997), in their analysis of the BART, the New York City Transit Authority, and the Portland MAX, found positive impacts on property values associated with the NYCTA and the BART, but actually found a negative impact on property values resulting from proximity to the light rail station for the Portland MAX. Explanations for this negative effect were system specific, indicating that it was various characteristics of the Portland MAX that led to a decrease in property values. Most important among these were that the Portland MAX is located along a major arterial, specifically a highway. Lewis-Workman and Brod found a negative association between property values and proximity to highways, a fact which likely mitigated the impact of the light rail (see also Kilpatrick et. al, 2007). This may hold important
policy implications for the Baltimore Central Light Rail, as nearly one-half of the system within the city limits is located along I-83.

Similarly, Forrest et. al. (1996) found that property values near Manchester, England’s Metrolink station were negatively impacted by close proximity to the station.\textsuperscript{25} They list a number of possible explanations for why a negative effect may have occurred, including negative externalities (like the nuisance effect), possible omitted variables (most notably plot size – builders may have responded to the building of the train, thus correlating plot size with both value and station proximity). In addition, their study attributes measurement error, particularly inadequate data on surrounding neighborhoods, as one possible reason for the results of their study.

In addition, a study of Atlanta’s MARTA system by Nelson (1994), in contrast to the above mentioned study by Bowes and Ihlanfeldt, revealed both positive and negative effects for high- and low-income residents, respectively.\textsuperscript{26} Along the system’s East Line, neighborhoods to the North and to the South of the tracks are dramatically different, with high-income residents residing to the north and low-income residents residing to the south. The rapid transit system was not constructed to reflect these differences in neighborhoods, but instead was built along old freight rail tracks. Nelson found differing effects for properties located near MARTA station tracks in both the north and south. In the lower-income neighborhoods to the south, Nelson observed a positive effect on property values. Property values increased $1045 for every 100 feet closer a property was to the station. However, on the north side of the line, Nelson observed that for every 100 feet closer a property was to the line, the value of that property dropped by $965. Nelson reasoned that this occurred given differing utility preferences related to nuisance and
accessibility. In the south, accessibility was weighted more heavily than nuisance, while the opposite was true in the north. Such an effect may impact the Central Light Rail, particularly heading south of Penn Station.

**Broad Impacts of Light Rail**

Although the economic development impacts on localized areas have been noted, analysis by Winston and Maheshri (2006) has shown that from a social surplus perspective, nearly every rail transit system has failed to provide social benefits over and above the full cost of the system. In their model, they establish two demand and cost models to estimate the amount of social surplus generated by rail systems. Control variable were derived primarily from the Department of Transportation and the US Census, and included system size, average fare, ridership numbers, commute times, and metropolitan demographic information, among others. Their sample consisted of 25 urban rail transit systems, with data collected between 1993 and 2000. With the exception of the BART line in California, Winston and Maheshri estimate that “every system in the country actually reduces welfare and is unable to become socially desirable even with optimal pricing or physical restructuring of its network.” Models were estimated that both left out and included positive externalities, related to reduced traffic congestion, environmental benefits, etc. Even with these externalities included in the equation, the BART system remained the only rail system that provided net societal benefits. The Baltimore rail line, which was included in their estimation, was particularly inefficient. According to the study’s authors, the line produced $6 million in consumer surplus, but net costs to taxpayers led to an overall net social benefit of $-177.1 million. Such costs versus benefits will of course have to be weighed when designing a system, over and above the perceived economic development impacts to a specific area or neighborhood.
III. DATA AND METHODOLOGY

To estimate the impact of the Baltimore Central Light Rail, a study corridor similar to the one shown in the Environmental Impact Statement provided by the Maryland Department of Transportation (MDOT) was developed. This corridor is shown in Figure 2 below (along with, for comparison, the Red Line study corridor provided by MDOT in Figure 1). The map was drawn approximately such that the Baltimore Central Light Rail runs approximately down the center of the study area. Given that the light rail began service into this area 10-15 years prior to the completion of the American Community Survey data used in the study, the data should significantly capture any potential benefits derived from light rail proximity.
Figure 1: Baltimore Red Line Study Corridor

Figure 2: Baltimore Central Light Rail Study Corridor
Sample Data

This study uses data from the 2005-2009 American Community Survey (ACS) to test for the economic development impacts of the Baltimore Central Light Rail. The ACS is an ongoing survey conducted by the US Census that provides annual data on community social, economic, and housing demographics. It is the largest survey conducted by the Census Bureau other than the decennial census. Generally, the ACS samples approximately 3.5 million addresses per year. The data is used by federal, state, and local governments for many purposes, including tracking population patterns, evaluating welfare and other social programs, and implementing community investment programs, including investments in local transportation systems. The estimates used in this study were taken over a period of 5 years, from 2005-2009. These estimates are constructed as period estimates and “reflect average characteristics over the 5 year period.” The Census Bureau advises using the 5 year estimates when analyzing very small populations, and when precision is more important than currency, such as in the analysis of census tract level data. Research by the Census Bureau has shown that the 5-year estimates “generally have larger variances than estimates derived from the decennial census long form, due in large part to smaller realized samples in the ACS.”

The Maryland Department of Planning has made the 5-Year ACS estimates for the state of Maryland available for public use through the Maryland State Data Center. Useful data for this study were census tract level data within the City of Baltimore, and further specified variables for all census tracts within the study corridor. From the ACS, data on economic, social, locational, and housing variables were collected. This includes information on race, income, education, job-type, commuting patterns, welfare, structural and building characteristics, and housing values. In addition to the ACS data, variables were added on number of census tracts...
away from a light rail station, distance from the Central Business District, and whether or not a census tract contained a highway entrance or exit ramp.

**Methodology**

Although there are many potential variables which may serve as an indicator of economic development, in the case of transit systems property values are most often used by researchers as a proxy to test for economic impacts. Theoretically, demand for property will rise and fall depending on services available within a given area. This includes access to public transportation services. Within the study corridor outlined above, there are 73 census tracts and 15 light rail stations. However, median property values were only provided for 68 census tracts, which may stem from the presence of parks within the city, the presence of a large prison in the heart of downtown, and two large professional sport stadiums (Camden Yards and M&T Bank Stadium). Those tracts without useful property value data were dropped from the sample data. Given population density within the study area, particularly within the central city of Baltimore (the area most similar to the residential area that will be impacted by the Baltimore Red Line), the study corridor as drawn should provide a good estimate of the Baltimore Central Light Rail’s impact on property values. As this study is concerned only with the light rail’s broad economic development impacts, the delineation of the data into census tract level units should be adequate. Using Baltimore CityView, a mapping tool provided by the city of Baltimore, the maximum distance between a light rail station and the furthest border of a census tract is approximately 1.5 miles. This distance is consistent with many of the studies outlined above, and should provide for a relatively wide variation in property values. At its widest point, the study area is approximately 3 miles wide; at its narrowest point (near the Baltimore Inner Harbor), the study area is approximately 1 mile wide.
A histogram of property values shows outlier observations, right-skewing the data. This makes sense, as many of the property values in the Roland Park / Cold Spring Lane section of northern Baltimore are some of the most expensive properties in the city. Given that many of the properties within the City are relatively poor, and that the particular methodology used in this study is unable to take into account the number of houses surveyed by the ACS, it is plausible that these outliers located in the wealthier sections of the city will skew the results of the final model. Logging the median property value variable should provide a more accurate estimate of the effect of proximity to light rail on property values, as seen in Graph 1.

**Graph 1: A Histogram of Property Values**

In general, hedonic regression analysis is used to test for revealed preferences by separating a variable into its component parts. In the case of property values, this will include local economic, social, and locational components, which may include: building characteristics, local income demographics, local unemployment rates, local education quality or attainment, and access to public transportation, among others. Using the hedonic regression model will reveal how the various components which make up property values impact demand for property in a particular census tract.
The variable of interest in this model is distance from a light rail station, defined as the number of census tracts away from a light rail station. To measure this distance, three dummy variables were constructed, measuring whether a census tract was one tract (station contained within or immediately adjacent to census tract), two tracts, or three or more census tracts away from a light rail station. Dummy variables were also developed regarding proximity to the nearest major highway and proximity to the Central Business District.

Using the above variables, a multivariate linear regression will be used to estimate the impact of the Baltimore Central Light Rail line on economic development within the city of Baltimore, as measured by census tract median property values. The model will take the following form:

\[
\text{Log Median Property Value} = \alpha + \beta(\text{Light Rail Station}) + \beta(\text{Light Rail Station 2}) + \beta(\text{Highway}) + \beta(\text{Unemployment Rate}) + \beta(\text{Distance to CBD}) + \beta(\text{Vacancy Rate}) + \beta(\text{Med # of Rooms}) + \beta(\% \text{ HS Grad})
\]

Based on past analyses, we would expect that the Baltimore Light Rail will have some moderate positive impact on property values within the study area. Properties located closer to light rail stations should see a positive impact of higher magnitude than those located further away from light rail stations. Controlling for other variables, it seems reasonable to believe that in the fifteen years in which the light rail has been in operation, some economic development impacts will have been realized as a result of light rail implementation.

Proximity to rail station is coded as a 1-0 categorical variable, measuring immediate proximity or one census tract away from a station, two census tracts away from a station, and three or more
census tracts away from a station. The study tract area corresponds similarly to the distances used for residences by previous studies, with homes within census tracts in close proximity to rail stations being approximately \( \frac{1}{4} \) miles away, contrasted with homes that may be up to 1.5 miles away at the border of the study area. Proximities to a light rail station, as well as distance to the CBD and nearest highway, were assigned by the author, and relative distances were measured using the Baltimore City View mapping software (see Table 1 for tabulation of dummy variables). Although there is no net distance from a light rail station attached to the median home value, it can be shown from the study area that the smaller tracts located within the city limits (primarily within the relatively dense downtown area) are relatively similar in size and distance. Using a hedonic regression for median property value entails deconstructing the various components that make up property value.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Railstation 1</th>
<th>Railstation 2</th>
<th>Railstation 3</th>
<th>Dist. to CBD</th>
<th>Dist. to HWY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>0</td>
<td>49</td>
<td>47</td>
<td>46</td>
<td>45</td>
<td>40</td>
</tr>
</tbody>
</table>
IV. REGRESSION RESULTS

Regression Table 1: Median Property Values by Proximity to Rail Station

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station</td>
<td>0.0202 (0.13)</td>
<td>0.446* (2.29)</td>
<td>0.216 (1.14)</td>
</tr>
<tr>
<td>2 from Station</td>
<td>0.0240 (0.20)</td>
<td>0.123 (0.73)</td>
<td>0.0390 (0.25)</td>
</tr>
<tr>
<td>Tract Contains HWY</td>
<td>0.169 (1.38)</td>
<td>0.238 (1.41)</td>
<td>0.119 (0.75)</td>
</tr>
<tr>
<td>CBD</td>
<td>0.139 (1.09)</td>
<td>0.383* (2.56)</td>
<td>0.324* (2.34)</td>
</tr>
<tr>
<td>% Vacant Houses</td>
<td>-0.00565 (-1.15)</td>
<td>-0.0203* (-3.59)</td>
<td></td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>-0.0124 (-1.57)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Med. # of Rooms</td>
<td>-0.0425 (-0.63)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% HS Grad</td>
<td>-0.0256* (-4.55)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>12.98* (31.71)</td>
<td>11.47* (95.94)</td>
<td>12.15* (56.34)</td>
</tr>
<tr>
<td>Observations</td>
<td>67</td>
<td>68</td>
<td>67</td>
</tr>
</tbody>
</table>

In all, 3 hedonic regression models were estimated to test the effects of rail station proximity on property values. In Model 1, log median property values were regressed on particular economic, social, and demographic variables. Interestingly, only one of the eight variables specified in the model, the percentage of high school graduates living within the census tract, was significant at the 0.1 level. Strangely, this variable went against its expected outcome. Model 1 estimates that a one percent increase in the number of high school grads within a given census tract will decrease
property values by approximately 2.56%, all else equal. These seemingly strange estimates for Model 1 may be resulting from the fact that the methodology used in this analysis contains only 68 observations. Variation in census-tract level data likely contributed to relatively high multicollinearity between the independent variables. As a result, increased standard errors may have magnified bias already present in the model. Table 2 attempts to explore this possibility.

Table 2: Correlation Coefficients

<table>
<thead>
<tr>
<th>Variable</th>
<th>log_me-e</th>
<th>railst-1</th>
<th>railst-2</th>
<th>hwy</th>
<th>CBD</th>
<th>ho-acpct</th>
<th>UnN</th>
<th>rooms_-d</th>
<th>edu-dpct</th>
</tr>
</thead>
<tbody>
<tr>
<td>log_medvalue</td>
<td>1.000</td>
<td>0.392</td>
<td>-0.005</td>
<td>0.287</td>
<td>0.285</td>
<td>-0.540</td>
<td>-0.624</td>
<td>-0.296</td>
<td>-0.761</td>
</tr>
<tr>
<td>railstation_1</td>
<td>0.392</td>
<td>1.000</td>
<td>-0.392</td>
<td>0.378</td>
<td>0.098</td>
<td>-0.440</td>
<td>-0.226</td>
<td>-0.274</td>
<td>-0.388</td>
</tr>
<tr>
<td>railstation_2</td>
<td>-0.005</td>
<td>-0.392</td>
<td>1.000</td>
<td>0.132</td>
<td>-0.014</td>
<td>0.013</td>
<td>0.026</td>
<td>0.137</td>
<td>0.055</td>
</tr>
<tr>
<td>hwy</td>
<td>0.287</td>
<td>0.378</td>
<td>0.132</td>
<td>1.000</td>
<td>-0.164</td>
<td>-0.349</td>
<td>-0.170</td>
<td>-0.029</td>
<td>-0.176</td>
</tr>
<tr>
<td>CBD</td>
<td>0.285</td>
<td>0.098</td>
<td>-0.014</td>
<td>-0.164</td>
<td>1.000</td>
<td>-0.095</td>
<td>-0.186</td>
<td>-0.564</td>
<td>-0.238</td>
</tr>
<tr>
<td>housing_vacpct</td>
<td>-0.540</td>
<td>-0.440</td>
<td>0.013</td>
<td>-0.349</td>
<td>-0.095</td>
<td>1.000</td>
<td>0.405</td>
<td>0.252</td>
<td>0.517</td>
</tr>
<tr>
<td>UnN</td>
<td>-0.624</td>
<td>-0.226</td>
<td>0.026</td>
<td>-0.170</td>
<td>-0.186</td>
<td>0.405</td>
<td>1.000</td>
<td>0.141</td>
<td>0.634</td>
</tr>
<tr>
<td>rooms_med</td>
<td>-0.296</td>
<td>-0.274</td>
<td>0.137</td>
<td>-0.029</td>
<td>-0.564</td>
<td>0.252</td>
<td>0.141</td>
<td>1.000</td>
<td>0.208</td>
</tr>
<tr>
<td>educ_hsgdpct</td>
<td>-0.761</td>
<td>-0.388</td>
<td>0.055</td>
<td>-0.176</td>
<td>-0.238</td>
<td>0.517</td>
<td>0.634</td>
<td>0.208</td>
<td>1.000</td>
</tr>
</tbody>
</table>

As can be seen from Table 2, nearly all non-locational variables were highly correlated with the other independent variables in the model, to the degree that high standards likely biased the coefficients. A potential remedy for this problem was sought in Model 2, by dropping all but location-related variables from the hedonic regression model. Model 2 regresses only these location-specific variables on median property values. These include proximity to railstation, proximity to the nearest highway (Observation = 1 for immediate proximity, observation = 0 for two or more census tracts away from nearest highway), and distance from the Central Business District (measured as a 0-1 variable, 1 = three or fewer census tracts away from the CBD).

As can be seen from Model 2 in Regression Table 1, when using these location specific
variables relatively close proximity to a rail station is significant at the 0.1 level. According to the model, properties located within these census tracts are projected to be valued 44% higher than properties located three or more census tracts away from a light rail station, holding all else constant. Although properties located two tracts away from a station did not have a significant value, the effect was in the correct direction. Distance to the Central Business District was also significant at the 0.1 level. All else equal, properties in relatively close proximity to the central business district are estimated to be valued 38.3% higher than properties located further away from the CBD.

Despite its significance, it is likely that the estimated coefficients in Model 2 are biased, given the lack of sufficient hedonic descriptive variables measuring property values, introducing omitted variable bias into the model. An additional variable, percent vacant residences in census tract, was added to the model in model 3. Adding this variable decreased the effects of proximity to a railstation on log median property values, all else equal. In addition, the variable for census tracts containing or immediately adjacent to one railstation is no longer significant at the 0.1 level. As expected, a one percent increase in the number of vacant houses corresponded to a 2% decrease in median property values. In addition, the variable for CBD remained significant at the 0.1 level. Properties located in close proximity to the CBD were projected to be valued 32.8% higher than properties located further away from the CBD.

V. POLICY IMPLICATIONS

This analysis estimated only a slightly positive impact on property values resulting from proximity to stations of the Baltimore Central Light Rail. A hedonic regression model was used to test for social, economic, and locational variables on property values. In models where all
three categories of variables were included in the estimation, proximity to light rail stations was not shown to impact property values significantly. It was only when location values alone were included in the model that proximity to a rail station had a moderately significant effect. This includes proximity to the nearest highway (in this case the central artery serving downtown Baltimore, I-83), and proximity to the Central Business District. In this model, properties located within or immediately adjacent to a census tract containing a rail station were shown to be valued approximately 44% higher than properties located three or more census tracts away from a rail station, all else equal. However, this value is likely inflated by bias introduced by the omission of other variables from the original model.

Admittedly, flaws in the original model may have contributed to insignificant coefficients on railstation variables. As can be seen in Models 1 and 3, only two variables in each model are significant - per capita income and the percentage of high school graduates in a census tract. This may be a direct result of this analysis’s attempt to view broad economic development impacts from a macro level, by looking primarily at census tract level data. The reasons behind the use of census tract level median property values was to gain a “big picture” view of the economic development impacts of the light rail, a unique technique not normally used in the literature. This form of methodology resulted in far fewer observations than in most analyses, contributing to issues related to statistical power, most prominent among them multicollinearity. This may have influenced the model in such a way as to detract from the broad variation in individual property level data, and may have biased coefficients due to high standard errors.

Although one may conclude from these estimates that the proposed east-west Baltimore Red Line will have little positive effect on Baltimore city, this analysis examines only one potential
benefit of light rail transit in Baltimore, that of economic development. There are multiple positive impacts that may be realized from the construction of a new rail transit line, including increased environmental benefits, reduced traffic congestion, and new transportation service provided to areas of the city traditionally underserved by public transportation. How these factors have impacted the city broadly is beyond the scope of this analysis. Consideration of these impacts must be taken into account in any overall cost-benefit analysis of a light rail system.

This analysis has shown that positive economic development impacts resulting from construction of the Central Light Rail have not significantly materialized. As perhaps the most important measure of a system’s success, finding a significant impact on economic development would be a serious justification for future projects included in Baltimore’s long term rail plan, including the Baltimore Red Line. This analysis now casts doubt on the capabilities of a light rail system to serve as a primary catalyst for economic development. Planners and policymakers within the city of Baltimore may wish to reexamine the costs and benefits of the new Red Line in lieu of these findings, and how they choose to message the benefits of the line in discussions with the public. The Red Line is a significantly expensive undertaking, one that will cost the city and its taxpayers a great deal of time and money in construction, operation, and maintenance costs. Given these results, the use of light rail for economic and community development may not equal the overall cost of the system, and thus may not prove a wise policy for Baltimore.

However, as Garrett acknowledges, light rail systems should not be constructed as the sole catalyst for economic development. Therefore, the question of whether or not the Baltimore Central Light Rail has itself positively impacted economic development as justification for the new line may not be the correct one. Rather, Garrett claims that policymakers should consider
light rail systems only as one piece of a broader economic development plan, not as the single facilitator of economic revitalization and community redevelopment. Such plans may include broad education reforms, substantial regulatory reform regarding new business startups, and providing a more livable area for citizens by reducing crime, decreasing the number of vacant houses (an epidemic in Baltimore), and aggressive reforms of burdensome tax policies. From this assumption, we may presume that the insignificant effects of the Baltimore Central Light Rail to promote economic development may be attributable to the failure of city and state policymakers to produce concurrent, pro-business, and pro-economic development policies that would have increased property values within the city. Analysis of such a broad economic development plan that includes mass transit may be necessary to understand the true impacts of the light rail. However, in the absence of such analysis, this paper argues that the Baltimore Central Light Rail has not had a significant positive impact on economic development near rail stations, and care must be taken to understand the limits of light rail development in spurring commercial activity and generating value in the community.

**End Notes**

1 Red Line Corridor Transit Study AA/DEIS Executive Summary –

2 Ibid

3 Ibid


5 Red Line Corridor Transit Study AA/DEIS Chapter 1 – Purpose and Need


7 Red Line Corridor Transit Study AA/DEIS Chapter 5 –
8 Ibid


10 Red Line Corridor Transit Study AA/DEIS Executive Summary –


13 Baltimore County Webpage
http://www.baltimorecountymd.gov/Agencies/economicdev/gateway/transportation/index.html


doi:10.1006/juec.2001.2214

DOI 10.1007/s11146-007-9032-z


doi:10.1016/S0965-8564(96)00027-4

DOI:10.1016/j.tra.2006.11.001


21 Ibid at 18


29 US Census Bureau. “When to Use 1-Year, 3-Year, and 5-Year Estimates.”
   http://www.census.gov/acs/www/guidance_for_data_users/estimates/


31 Maryland State Data Center. http://www.mdp.state.md.us/msdc/

BIBLIOGRAPHY


doi:10.1006_juec.2001.2214

doi:10.1016/S0965-8564(96)00027-4

DOI 10.1007/s11146-007-9032-z


DOI:10.1016/j.tra.2006.11.001


http://www.roadstothefuture.com/Balt_Light_Rail.html


http://www.census.gov/acs/www/guidance_for_data_users/estimates/

DOI: 10.1016/j.jue.2006.07.02