Land Use Impacts of Bus Rapid Transit:

Effects of BRT Station Proximity on Property Values along the Pittsburgh Martin Luther King, Jr. East Busway

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13. ABSTRACT The development of bus rapid transit (BRT) systems is relatively recent in the United States; however, several systems are operating and many more are being planned. A more comprehensive understanding of the relationship between land use and BRT is needed, particularly in comparison to other fixed-guideway modes. This report documents an effort to quantify the impacts of BRT stations on the values of surrounding single-family homes. The hypothesis is that BRT stations have an impact on property value that is commensurate with rail transit projects considering the level and permanence of services and facilities. To test this hypothesis, a hedonic regression model was used to estimate the impact of distance to a BRT station on the fair market value of single-family homes. Because many BRT systems operating in the United States may be too new to find evidence of capitalization into property values, data from Pittsburgh's East Busway, one of the oldest operating BRT systems in the country, was used. Decreasing marginal effects were found: moving from 101 to 100 feet from a station increases property value approximately $19.00, while moving from 1001 to 1000 feet increases property value approximately $2.75. Another way to interpret this result is to say that a property 1,000 feet away from a station is valued approximately $9,745 less than a property 100 feet away, all else constant (this figure is determined by summing the marginal effects for each foot of distance).The results shown in this report are only valid for the data used in Pittsburgh's case. As more BRT systems continue operating in the United States for more years, this method should be applied to other cities and other types of properties to gain a better understanding of the general property value and land use impacts of proximity to BRT.

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	= 2.5 centimeters (cm)
1 foot (ft)	= 30 centimeters (cm)
1 yard (yd)	= 0.9 meter (m)
1 mile (mi)	= 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	= 6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	= 0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	= 0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	= 2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	= 4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	= 28 grams (gm)
1 pound (lb)	= 0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	= 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	= 5 milliliters (ml)
1 tablespoon (tbsp)	= 15 milliliters (ml)
1 fluid ounce (fl oz)	= 30 milliliters (ml)
1 cup (c)	= 0.24 liter (l)
1 pint (pt)	= 0.47 liter (l)
1 quart (qt)	= 0.96 liter (l)
1 gallon (gal)	= 3.8 liters (l)
1 cubic foot (cu ft, ft^3)	= 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	= 0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	= 0.04 inch (in)
1 centimeter (cm)	= 0.4 inch (in)
1 meter (m)	= 3.3 feet (ft)
1 meter (m)	= 1.1 yards (yd)
1 kilometer (km)	= 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	= 0.16 square inch (sq in, in^2)
1 square meter (m^2)	= 1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	= 0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	= 1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	= 0.036 ounce (oz)
1 kilogram (kg)	= 2.2 pounds (lb)
1 tonne (t)	= 1,000 kilograms (kg)
	= 1.1 short tons

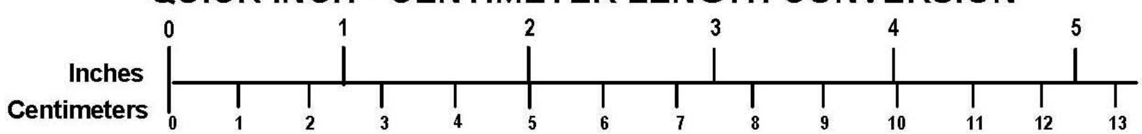
VOLUME (APPROXIMATE)

1 milliliter (ml)	= 0.03 fluid ounce (fl oz)
1 liter (l)	= 2.1 pints (pt)
1 liter (l)	= 1.06 quarts (qt)
1 liter (l)	= 0.26 gallon (gal)
1 cubic meter (m^3)	= 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	= 1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

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EXECUTIVE SUMMARY

The development of Bus Rapid Transit (BRT) systems is relatively recent in the United States; however, several systems are operating and many more are being planned. A more comprehensive understanding of the relationship between land uses and BRT systems is needed, particularly in comparison to other fixed-guideway modes such as heavy and light rail. While recognizing that existing land uses have an important and complex influence on the development costs and benefits of fixed-guideway projects, this research is focused on the impacts that BRT projects have on surrounding property values.

This research seeks to begin the understanding of the extent to which access to BRT services are considered in the location decision, whether commercial or residential. Is the availability of BRT service a factor in an investment decision such as a home purchase? With the appropriate data and methodology, the marginal effect of proximity to BRT access on property values can be estimated.

Indeed, there is a large amount of qualitative and anecdotal evidence that the implementation of BRT services can lead to economic development and increased land values (Breakthrough Technologies Institute, 2008). This work goes beyond the qualitative evidence in an attempt to find a positive, statistically-significant impact on property values from proximity to BRT access.

No recent quantitative modeling studies on the property value impacts of BRT access for systems operating in the United States are available. In 1990, a study examined some operating "busways" (including Pittsburgh), but did not find any impacts (Mullins, et al., 1990). Also, recent studies have been conducted on the BRT system operating in Bogotá, Colombia (Rodriguez and Targa, 2004; Rodriguez and Mojica, 2009). In the U.S., the studies on impacts of proximity to transit on property or land values have focused on rail modes. As described in the literature review contained in the full report, these studies attempted to isolate the effect of distance from rail transit (either the right-of-way, stations, or both) on property or land values. Most of the studies found positive impacts on property values from nearby rail transit; however, the magnitudes are relatively small. Certainly, a relatively small marginal impact would be expected from access to transit when the myriad factors that influence the price of a property are considered.

For this effort, an attempt was made to quantify the impacts of BRT stations on the values of surrounding single-family homes. The hypothesis was that BRT stations have an impact on property value that is commensurate with rail transit projects considering the level and permanence of services and facilities: does the home-buyer or other decision-maker consider BRT service to be as permanent as a rail mode? To test this hypothesis, the method of a hedonic price regression model was used to estimate the impact of distance to a BRT station on the fair market value of single-family homes. Using this regression framework, it was expected that, as the distance to a BRT station decreased, the property value would increase, all else constant.

While, as stated above, some research has been done on this subject for BRT systems that operate outside the United States, this research is among the first to study this issue for BRT systems in the U.S. Because many BRT systems operating in the U.S. may be too new to find evidence of capitalization into property values, data from Pittsburgh's Martin Luther King, Jr. East Busway, one of the oldest operating BRT systems in the country, was used. It was found that the relationship between the distance to a station and property value is inverse and decreasing as distance from a station increases. Decreasing marginal effects were found; for example, moving from 101 to 100 feet away from a station, property value increased approximately $19.00. Moving from 1,001 to 1,000 feet away from a station increased property value approximately $2.75. Another way to interpret this result is to say that a property 1,000 feet away from a station is valued approximately $9,745 less than a property 100 feet away, all else constant (this figure is determined by summing the marginal effects for each foot of distance). There may be some factors introducing upward bias in this result that could be determined and corrected for in a subsequent effort.

It must be stated that the results documented in this report are only valid for the data used in Pittsburgh's case. In the United States, as existing BRT systems continue operations and more systems are implemented in the coming years, this methodology should be applied to other cities. In addition, other types of properties, both residential and commercial, should also be examined for impacts on property values from proximity to BRT. This future work is necessary to add to the literature on this subject and to allow the industry and others to have an overall understanding of the average, or typical, expected impacts of BRT.

INTRODUCTION

The development of Bus Rapid Transit (BRT) systems is relatively recent in the United States; however, several systems are operating and many more are being planned. A more comprehensive understanding of the relationship between land uses and BRT systems is needed, particularly in comparison to other fixed-guideway modes such as heavy and light rail. While recognizing that existing land uses have an important and complex influence on the development costs and benefits of fixed-guideway projects, this research is focused on the impacts that BRT projects have on surrounding property values.

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This report is organized into several sections that describe the study effort, data used, and the results. A summary of literature on the topic is included following this introduction. Other sections describe the study area encompassing Pittsburgh's East Busway, the types of data required for the modeling effort and the variables used, the regression methodology, and a full interpretation of the model results. A concluding section summarizes the project and addresses the need for further research on this topic.

PREVIOUS LITERATURE

The following literature review contains three parts: the first part describes transit-oriented development, its importance, and the requirements for its occurrence; the second part reviews studies that attempt to quantify the development that has occurred following the installation of transit in various locations and reports describing relevant factors and indicators of development; the third part focuses on studies that use modeling in their analyses to quantify the effect of transit on property values and employment and population densification. Though the studies reviewed focus on the effects of rail transit on development, they provide the necessary background to researchers who will estimate the effect of BRT on development since these studies highlight an array of issues that should be taken into consideration.

Transit-Oriented Development

Transit-oriented development (TOD) is compact, mixed-use development near transit facilities that is generally associated with high-quality walking environments. In recent years TOD has been actively promoted by planners, practitioners, and developers in an attempt to redress a host of contemporary urban problems, including traffic congestion, affordable housing shortages, pollution, and urban sprawl. Additionally, transit-oriented development has the potential to increase the access of the poor to better labor market opportunities. By promoting transit use and by providing multiple spheres of activity where consumers can engage in the market, thereby reducing congestion, TOD will reduce commuting times. Other benefits of TOD include the revitalization of declining neighborhoods and increased profits to those who own land and businesses near transit stops.

TOD should ideally take into account public input, which can be ascertained through surveys and meetings. Strategic station-area planning should take place backed by appropriate zoning, policy incentives, and regulations. Overlay zones are commonly used to control land uses, densities, and site designs. Such zones often specify desired land uses outright, in order to prevent activity that runs counter to TOD, e.g. automobile-oriented uses.

Current widespread construction of public transit infrastructure in the U.S., both in the form of new rail or BRT systems, heightens the importance of TOD. Over 100 TOD projects currently exist in the United States and are most often found around heavy-, light-, and commuter-rail stations (Cervero, et al., TCRP 102, 2004). In recent years, as BRT has emerged as a potential lower cost alternative to light-rail, attention has increased regarding TOD surrounding BRT stations. Though BRT is still relatively young in comparison with rail, it is generally thought to have comparable development potential.

A report by the non-profit Transportation and Land Use Coalition (TALC) promotes BRT in San Francisco and Oakland using the argument that BRT can promote smart growth like rail does, based on three rail-like characteristics: high ridership, fewer stations, and infrastructure permanence (TALC, 2003). Importantly, TALC also emphasizes that there must be appropriate design and supportive land use policies in order for BRT, or any transit project, to support TOD. In promoting TOD for BRT, TALC cites an Alameda- Contra Costa Transit staff study evaluating BRT and light-rail transit (LRT) in Pittsburg's East Corridor. AC Transit concluded that "BRT and LRT have a large fixed infrastructure component that helps attract development. Bus systems with little or no fixed infrastructure do not appear to have the same development potential." However, they report that "transit alone will not create development." Their literature review, like this one, indicates that in order for TOD to occur, there must be additional governmental investments and coordinated transportation and land use policies in place (Cervero, et al., TCRP 102, 2004).

Since Pittsburgh was one of the first cities to adopt BRT, TOD along its busways has attracted considerable attention. One study indicates that there has been significant development surrounding Pittsburgh's East Busway, which is comparable in magnitude to the amount that one would expect surrounding rail (Wohlwill, 1996). Though much of the development that has occurred cannot be considered TOD, Wohlwill's analysis concludes that, between 1983 and 1996, 54 developments were constructed that have a total fair market value of $302 million. Wohlwill estimates that another $203 million of development has occurred since 1996, and that an estimated additional $300 million has occurred since 2004 (Wohlwill, 2004; Wohlwill, 2009). Further construction is underway or planned. According to Wohlwill, this corridor has not fully realized its TOD potential. The Martin Luther King, Jr. East Busway (the focus of this study) and the new landscaping that accompanied it were, however, major improvements that helped spur development. These elements, along with stations that were rebuilt along the busway and design treatments that enhance the appearance of guideways, serve to improve the image of the transit area: a critical step leading to development.

In another study, the authors also emphasize the development potential of BRT by stating that "reported land development benefits with full-featured BRT are similar to those experienced along rail transit lines" (Levinson, et al., TCRP 90, 2003). The authors support this statement by citing the $302 million in new and improved development near Pittsburgh's East Busway described above, 80 percent of which was clustered at stations, $675 million in new construction around transit stations that followed the construction of the Ottawa Transitway, and the fact that property values near Brisbane's South East Busway grew 20 percent, which is largely attributed to the busway construction. In addition, the authors cite Adelaide and Curitiba as examples of cities where BRT has had land use benefits similar to those resulting from rail transit.

Despite the success of the cited cases above, it has not always been clear that BRT will foster development of the magnitude that one might expect as a result of rail. Indeed, the degree of development may vary from place to place and with the circumstances characterizing its location. Currie wrote an article comparing TOD associated with bus versus rail that may also apply to TOD associated with BRT versus rail (Currie, 2006). The elements he focuses on therefore may determine whether BRT may be as effective as rail in attracting developer dollars. After conducting a literature review of TOD related to bus and rail Currie comes to some conclusions regarding the relative strengths and challenges of bus in relation to TOD. Characteristics that TOD studies claim make rail superior to bus, and that may be shared by BRT systems, include permanence, newness (if dedicated BRT buses are used), frequency of service, choice customers, parking availability, urban density, and scale dilution. Challenges that are common to bus and BRT are bus stigmatization, noise, pollution, lack of TOD expertise at the respective agencies, and a poor track record of each with respect to TOD. Currie identifies some advantages of BRT over rail as being flexibility and cost effectiveness. (All of these elements should be taken into account, to the extent that it is possible, in the analysis that follows this review.)

When evaluating two potential BRT station areas for TOD opportunities, another study concludes that BRT can be an effective transit option for promoting TOD if appropriate policies are put in place (Yildirim, 2004). He states that it is essential for transit agency and city officials to work together. They must also have the support of land developers, financiers, and regulators. He cites density bonuses and tax abatement as key policies. Additionally, he

recommends that a Transit Overlay District exist one half-mile around potential station locations to ensure appropriate development before BRT stations are built. The Transit Overlay Districts are zones in which city officials control and guide the use and development of all land in an effort to promote TOD. Finally, he specifically recommends that one of the stations he is focusing on shift its development pattern from auto-oriented to transit-oriented development.
Another study analyzes whether BRT appears to provide similar incentives to developers as light rail (Kaplowitz, 2005). He concludes that BRT does attract development as a result of its substantial investment in 'permanent-seeming' infrastructure. The author argues that when stations are attractive, up-scale developers are more likely to view the stations as permanent. This assertion seems to echo the necessity for newness stated by Currie above. This author, however, argues that neither dedicated right-of-way nor flashy vehicles are needed to stimulate developer interest. He bases his conclusions on development data from Cleveland's Euclid Corridor (which has since seen the implementation of the Healthline BRT service), Boston's Silver Line, the Orlando LYMMO system, Pittsburgh's busways, and FTA's *Characteristics of Bus Rapid Transit* document. Nonetheless, he seems to draw strong conclusions based on limited evidence and does not appear to have interviewed developers about why they invested in these corridors. A 2008 study by Breakthrough Technologies Institute, *Bus Rapid Transit and Transit Oriented Development: Case Studies on Transit Oriented Development Around Bus Rapid Transit Systems in North America and Australia*, does include interviews with developers.

TCRP 90 (Levinson, et al, 2003) enumerates specific requirements for implementing successful BRT service. Among these, and with specific regard to the likelihood that BRT will lead to prolific development, is the recommendation that BRT and land use planning in station areas should be integrated as soon as possible. Part 2 of TCRP 102 (Cervero et al., 2004) describes appropriate policies for implementing TOD; Case Studies described in Part 4 provide detailed descriptions of various cities' experiences with TOD. Additionally, TCRP H-1 (Parsons Brinkerhoff Quade & Douglas, et al., 1996) summarizes the principles for integrating transit and land use that were recognized by evaluating detailed case studies. In Chapter 6 of TCRP A-23A (Kittelson and Associates, Inc. et al., 2006), the Urban Land Institute identifies ten principles for TOD success. Though these will not be discussed individually, the importance of provisions for parking is highlighted, as it has not been emphasized previously. The location, supply, and pricing of parking will influence development opportunities, property values, urban form, and travel behavior (Evans and Pratt, TCRP 95, 2007). This being the case, often cities have set a required maximum number of parking spaces per establishment within various distances of a BRT line. Requirements such as these will have important implications for TOD and will be discussed in further detail in another section of this report. In addition, in Chapter 6 of TCRP A-23A, case studies of TOD further describe the requirements and incentives that cities have put in place to encourage TOD. In Ottawa, for example, 'new regional shopping centers must be located on the rapid transit network'. Similarly, the City has outlined that 'high-density residential uses should occur close to a BRT station, and medium-density residential uses should occur in locations where it can act as a transition to nearby low-density residential neighborhoods.' The City of Pittsburgh has done this along a portion of its East Busway known as the Baum-Centre Corridor. The City's strategy for corridor, which consists of 1.6 miles of Baum Boulevard and Centre Avenue, emphasizes development around busway stations (Wohlwill, 2006).

Chapter 6 of TCRP A-23A (Kittelson and Associates, Inc., et al., 2006) offers insight into developer decisions as well. Developers were surveyed in both Ottawa and Boston about the factors that influence them to locate different types of development within walking distance of BRT stations in different areas. Of particular concern to developers in Boston was the issue of the permanence of BRT; some developers expressed a preference for rail. In general, there appeared to be a lot of frustration over the timetable for the transit line construction and the amount of right-of-way that developers are required to dedicate to transit routes. Important factors underlying development decisions in Boston included supportive zoning, land availability and cost, provisions of real-time information, proximity to the Silver Line, and infrastructure investment, such as the widening of sidewalks and the installation of amenities. In Ottawa, developers were involved in the planning of the rapid transit network due to efforts made by the City to ensure an extensive public involvement process. The City observed that developer interest is site-specific, developers support proximity to rapid transit when promoting sales and rentals, and developers are less interested in development if there are additional costs associated with BRT components. Additionally, developers generally feel that BRT contributes to the station-area development market.

Impacts of Transit on Development

Above, gross figures were quoted for the impact a given city's BRT system has had in terms of economic development. In assessing the impact of BRT on TOD, various approaches have been used. Several reports, briefs, and journal articles were reviewed to obtain a perspective of previous work undertaken to determine the impact of transit on development. The types of work reviewed range from less developed, anecdotal items to highly developed statistical models. While reviewing the literature described below, an effort was made to identify items that could be improved upon as well as to note items highlighted by previous researchers that should be taken into account in conducting the analysis that follows.

The Voorhees Transportation Center (VTC) at Rutgers University was hired by the New Jersey Department of Transportation (NJDOT) to study the state's Transit Village Initiative from September 2002 to October 2003. The Transit Village Initiative is a program that seeks to revitalize and grow selected communities with transit as an anchor. The Transit Village is defined as the half-mile area around a transit facility; this is usually referred to as a TOD area. The Alan M. Voorhees Transportation Center (2003) summarizes the success factors, obstacles, and recommendations of the Transit Village Initiative based on the findings of in-depth interviews with stakeholders, including state officials, municipal officials, and private developers. VTC notes that, as stated in TCRP 102 (Cervero, et al., 2004), "most TODs in the United States are so new that adequate data have not yet been collected to evaluate their success." The report also noted that, pertinent to the case at hand, data about what was happening in the half-mile radius around the transit station was not being kept and/or reported to NJDOT in a consistent manner. Improvements in this domain would be very helpful in later evaluations.

Another study, improving upon a previous attempt by the VTC to measure changes in economic activity in the fourteen Transit Villages, includes a table of required monitoring data that can be found in the building permits issued or in the Town/Transit Village Applications (Wells and Renne, 2004). Data from the building permits describe and enumerate the net increases in dwelling units, total construction activity, residential construction, non-residential construction, and affordable housing. Data in the Town/Transit Village Applications describe and enumerate the total businesses in the Transit Village, number of auto-dependent establishments, transit supportive shops, parking spaces, and acres of brownfield reclaimed. The VTC Center also reviewed tax maps for the Transit Villages. Using these tax maps, it could collect information for properties on blocks within one half of a mile of the transit stations on the value of construction, whether the construction was residential or commercial, whether the construction was new or rehabilitative, the number of housing units, and the distance to the transit station (within one quarter mile, one half mile, or at the fringe). Using before and after comparisons, this report found a substantial increase in development, mostly within one half mile of the transit stations. There was substantially more non-residential construction, most noticeably within one quarter mile of the stations. The report recommends including property values in the data in the future as well as making use of tax tables. The VTC also noted that its methodology does not distinguish between public and private sector investment. The latter will be taken into account when constructing the model that follows this literature review.

Like the Alan M. Voorhees Transportation Center's study, the National Cooperative Highway Research Program's (NCHRP) Research Results Digest 294 (2005) summarizes work by Renne, Wells, and Bloustein and describes a strategy to systematically evaluate the potential success of transit-oriented development based on various indicators. The authors first summarized existing research to determine TOD outputs and benefits. Then they drew up a list of 56 indicators of TOD effects and divided them into five groups: travel behavior, economic, environmental, built environment, and social diversity/quality indicators. The authors then surveyed transportation professionals about the usefulness of each indicator, the difficulty of collecting the data, and the frequency with which each indicator should be monitored. Based on their research the authors determined the most useful indicators of TOD success to be: transit ridership, density, the quality of streetscape, the quantity of mixed-use structures, pedestrian activity and safety, the amount of increase in property value and tax revenue, public perception, the number of mode connections at the transit stations, and parking configuration. Another study similarly identifies important indicators of economic and community impacts of Hiawatha LRT in Minneapolis (Poindexter and O'Connell, 2006).

TCRP Reports 95 (Evans and Pratt, 2007), 102 (Cervero, et al., 2004), and 35 (Cambridge Systematics, Inc., et al., 1998) describe other factors that should be taken into consideration when attempting to measure impact. TCRP 95 emphasizes that the scheduling and frequency of transit affect transit service quality, and, in turn, ridership; thereby, these factors indirectly affect the impact of transit on land use. Indeed, TCRP 102 states that residential property values may rise with proximity to transit, but the size of the effect is very dependent on service quality and neighborhood location. In regard to the latter factor, greater proximity to transit lowers property values in higher income neighborhoods (possibly due to greater differential noise impacts and other negative factors such as crime), while it increases property values in other neighborhoods. Therefore, in attempting to assess the impact of transit on land use, efforts should be made to take scheduling and frequency, neighborhood, and potential negative impacts into consideration. TCRP 95 also describes the direct and indirect effects of density, design, and diversity on mode choice. If transit is a viable option, for example, the spatial separation from the transit stop (in part determined by density) will affect whether the rider chooses transit and whether the rider walks or drives to the stop. Likewise the opportunities for trip-chaining affect the likelihood that transit will be used, as well as its design. Higher ridership likely leads to larger economic impacts. TCRP 102 stresses that transit alone seems unlikely to affect property values. A strong regional economy is a key factor. Second, public policy is crucial. Areas with counterproductive zoning and taxations policies, for example, will not see benefits from transit. Hence, these factors should also be taken into account in the analysis that follows. TCRP 35 advises that when considering undertaking an impact analysis one must be sure that the period for which data can be collected is long enough for all impacts to materialize. This consideration is of particular importance for this research, since the breadth of the impact from transit is not generally thought to take place until 15 to 20 years after its installation. Last, TCRPs 102 and 35 emphasize that the impact of transit may be redistributive in nature. The economic gains that may take place are not independent from other regions, and hence they should not be regarded as such, i.e. it may be that the economic gains experienced in one region as a result of the installation of a transit line may coincide with a decline in economic activity in a nearby region as a result of it being less accessible by comparison. In addition, the Federal Transit Administration (FTA) offers a comprehensive set of guidelines for assessing transit-supportive land use (FTA, 2004). Case studies on economic development and "smart growth" are also described in a report from the International Economic Development Council (IEDC, 2006).

One study examines how proximity to a Dallas Area Rapid Transit (DART) light rail transit station affects taxable property values (Weinstein and Clower, 2003). They use Dallas County Appraisal District data to identify property values for properties within a quarter mile radius of 20 light rail stations and control properties that share similar location and market characteristics, outside of the central business district (CBD), for 1997 and 2001. For each property type (commercial, industrial, retail, and residential), they compare the median property value in 1997 to that in 2001. They find that residential property values near DART stations increased faster than those of the control group. Retail properties showed no significant difference in value for the two groups, while industrial property values increased faster in the control groups. Interestingly, the authors eliminated properties within the CBD from the analysis because they believed it would be impossible to separate the effect of LRT stations from the tax incentives available to the developers in the CBD.

In a later paper, Weinstein and Clower attempt to estimate the value of total new investments or re-investments in properties adjacent to or near DART LRT stations occurring between 1999 and 2005 (Weinstein and Clower, 2005). The authors gathered all newspaper articles on these investments, and estimated the dollar value of each project. Weinstein and Clower used either the estimate provided in the article or based their estimate of a dollar amount on the value of similar properties that were appraised in the Dallas Central Appraisal District. They found that new investments completed, underway, or planned near LRT stations since 1999 totaled more than $3.3 billion. The study, however, controlled only for location and market characteristics; additional variables would have to have been controlled for in order to test for the causal effect of proximity to transit.

Another report quantifies development trends before and after the commitment to build the Portland streetcar service was made in 1997 (E.D. Hovee & Co., 2005). The authors evaluate development between 1997 and 2004 in terms of density (floor area ratio- FAR) and annual percentage growth in an area's building stock; data were collected on a tax lot basis. The study differentiates between areas according to whether they are one, two, three, or more than three blocks away from the streetcar line. The report finds that, from 1997 through 2004, the density of new construction (i.e. the percentage of a site's allowable development capacity) increased with proximity to the streetcar. Tax lots within one block of the streetcar also increased their percentage of the entire area's development, and overall, they experienced average annual growth rates more than three times that of any other location. A shortcoming of this report is that it only examines new development and not re-development and reinvestment in existing buildings. The authors focused on new development because data was more readily available to track new development; additionally, the project scope did not cover determining changes in building occupancy or use. The authors indicate that, in some cases, these changes would indicate significant new development activity. Therefore, they believe their estimate of development correlated with the streetcar is conservative. The authors recommend implementing a hedonic analysis, which would determine how net development/rehabilitated space can be understood as a function of streetcar proximity, other transit proximity, public-private partnership status, and years from streetcar opening. The authors discuss some of the difficulties involved in data collection. According to the authors, existing public agency information on land tax lots would only indicate new development, so rehabilitative development would have to be determined by survey. Likewise, it would be necessary to rely on surveys to determine the amount of public-private partnership development (By using appraiser parcel data in this analysis, researchers will automatically take into account both redevelopment and re-investment in the existing buildings since the property appraisal values should reflect these improvements, thereby overcoming some of the concerns of the authors of this assessment.).

One study conducted by the Rappaport Institute used Geographic Information Systems (GIS) data to analyze land use changes in the areas surrounding all current and former commuter rail stations in the greater Boston area between 1970 and 1999 (Beaton, 2006). Essentially, the author compares land use patterns in all commuter rail station areas (current and former) between 1970 and 1999 to land use patterns in the Boston region as a whole. The stations were categorized by whether they were continuously open, opened in the 1970's, 1980's, or 1990's, or closed in these decades. The author used two data sources. Data from Mass GIS describes the land use of a location in 1971, 1985, and 1999. This information comes from an analysis of aerial photos of the state and categorizes each location as a certain kind of land use for each of these three years. This author's methodology is unique in terms of the way he defined station areas. Likely to reflect the greater relative dependence of commuter rail on park-and-ride lots, he defined them as areas within 5 and 10 minute drives of a station, rather than simply considering the radius around a station. Beaton reasoned that his method took into account actual land use patterns. He also used Census data to obtain data on population, transit use, and household income.

For both the region of Boston and the areas of commuter rail stations, about 90 percent of the land had the same land use in 1999 that it did in 1971. Beaton compares changes in land use for the remaining 10 percent of the land for both the commuter rail station areas and Boston to draw his conclusions. Beaton concludes that commuter rail service had only a modest impact on the land uses in the areas of commuter rail stations. Interestingly, he also found that pre–existing land use patterns seemed to have had a bigger effect in some areas than any changes in rail station status after 1970; some areas that lost rail stations showed greater development than the overall region. He carries out similar comparative analyses to evaluate the impact of commuter rail service on transit ridership, population density, and income.

Statistical Models

The remainder of the literature discussed in this summary deals with the development of economic models. A total of thirteen research papers including modeling were reviewed. In contrast to the studies described above, modeling allows the researcher to control for many variables that affect property values. These analyses are, therefore, more sophisticated since they permit the researcher to estimate a causal effect for the distance from transit. Essentially, researchers can isolate the effect of the distance from transit, at the means of the other variables included in the regression model. Of the thirteen papers using modeling, five focus on the effects on commercial property values. These papers shall be discussed after those focusing on the effects of residential property values.

The research reviewed for this effort generally attributes impacts of rail transit on property values to two sets of factors: one set that increases property values and one that leads to decreases. Rail transit, particularly near stations, can lead to increases in property values if the rail system is a more favorable alternative than driving. It seems logical that commuters and developers or employers would be willing to pay more for property near rail transit if it resulted in reduced commuting time and less stressful (and perhaps more productive) commutes. Property values might also be positively impacted if rail stations attract additional commercial and retail establishments that serve nearby residents or workers. Alternatively, property values may be adversely affected by rail stations' potential negative externalities, such as noise, pollution, and a general unattractiveness of the area. Perception of crime associated with transit stations is another significant negative externality. For policymakers, it is important to understand these factors when evaluating the benefits of expensive public investments such as transit.

An early paper, published in 1993, examines the impact of Miami Metrorail stations on the value of nearby residential properties (Gatzlaff and Smith, 1993). The authors of this paper note that access to a downtown area, market, or other central location is a key determinant of property values. Miami's Metrorail is a "heavy rail" system that opened in 1984. The 21-mile north-south rail line, which has 21 stations, bisects downtown Miami. The stations to the south of downtown are in relatively affluent areas characterized by single-family and multi-family residences and significant commercial and retail activity. Stations to the north of downtown are generally located in areas of economic decline. Eight stations, distributed along the entire line, were selected for the analysis. Data for this study were from the Florida Department of Revenue's 1990 Dade County Property Tax Records.

Gatzlaff and Smith used two methods to analyze the magnitude and pricing impacts of the development of Metrorail stations. First, a repeat-sales index was constructed using the pooled sample of the properties surrounding the stations, which was compared to an identically-constructed index representing the entire county. Second, a hedonic regression model was used to examine property values before and after the development of the Metrorail system. The authors acknowledge that the repeat-sales index, estimated using regression analysis, can be impacted by sampling bias; however, they note that the emphasis is on the relative price changes, not the level of the index itself. They find that, at all times over the 18-year estimate, the index for homes near Metrorail stations is within a 95 percent confidence interval of the county-wide index. Therefore, the authors cannot conclude that these two indices are significantly different during any period examined.

The hedonic regression estimated by Gatzlaff and Smith models property value as a function of various location and property-specific variables. After estimating four alternative functional forms (linear, semi-log, exponential, and double-log), the exponential form was found to be the best fit. Overall, signs of the coefficients were as expected, but not all results were statistically significant. For stations north of the downtown, property values were found to increase faster as a function of distance from the station after the announcement of the Metrorail development. This is a statistically significant finding, although small in magnitude. For stations south of the downtown, this finding was not significant. Gatzlaff and Smith also reported widely varying results for the individual stations, suggesting that residential property impacts are a function of neighborhood characteristics. One finding from the individual station results is that residential properties with higher prices near stations experienced greater increases in values than those in poorer neighborhoods.

Gatzlaff and Smith's major conclusion is that they find weak evidence of residential property impacts due to the development of the Metrorail stations in Miami. Further, greater net benefits appear to accrue to higher-income households, rather than poorer households. The authors note that there are a myriad of other reasons to expand urban rail transit; however, in this study, the benefits of increased residential property values near the stations are found to be quite small.

Another study examines the impacts of the "light rail" system (MAX) in Portland, Oregon on the values of single-family homes near the stations (Chen, et al., 1998). Unlike a heavy rail system, such as that in Miami, which is characterized by larger vehicles, a separate, often elevated guideway, and a relatively longer distance between stations, light rail is typically characterized by smaller vehicles, an at-grade guideway sometimes sharing street space with automobile traffic, and a relatively shorter distance between stations. The impacts are assessed using the distance to the stations as a proxy for accessibility and distance to the rail line itself as a proxy for "nuisance effects," or negative externalities such as noise, traffic, and pollution. Prices of single-family homes sold from 1992 to 1994, compiled from two regional databases, are used in this study. In addition, 1990 U.S. Census data are used, as well as geographic information system (GIS) mapping to determine the distance variables. A hedonic approach was used to estimate two functional forms: semi-log and double-log. The main hypothesis of the research is that the effect of accessibility (distance to the stations and its squared term) will indicate a decline in values with increasing distance, *ceteris paribus*. The "nuisance" effect (represented by the distance to the rail line and its squared term) should show increased values with increasing distance, *ceteris paribus*. Whichever effect is strongest will determine the overall impact on housing values.

Chen, Rufolo, and Dueker found the accessibility effect to be significant. The interpretation is that, as distance to the station increases, the housing price decreases, but at a decreasing rate due to the effect of the squared term. For example, at a 100 meter distance from a station, each additional meter farther away will lead to a $32.20 decline in price for an average priced home. The coefficients representing the nuisance effects have the correct signs, but are not significant. However, the authors found that removing the distance-to-line variables distorted the distance-to-station variables, implying combined effects are occurring. The results of this study confirm the hypothesis by the authors that the light rail stations in Portland have both a positive (accessibility) effect and a negative (nuisance) effect on the value of single-family homes. They find that the positive effect dominates the negative effect, implying declining prices as distance from a station increases.

Another study focused on assessing the effect of Chicago Transit Authority (CTA) and Metra stations on single-family residential property values in the Chicago metropolitan region (Gruen and Gruen Associates, 1997). The study also examines other benefits, such as improved accessibility, reduced congestion and reduced transportation costs. The study includes a literature review both on the urban economic theory on the determinants of residential property values and empirical studies that used a hedonic price modeling to estimate the effect of transit stations on property values. The assessment was primarily based on hedonic price modeling, but the regression analysis was supplemented with interviews both to facilitate interpretations of the statistical results and to suggest the effect of transit stations on multi-family uses not evaluated empirically. Based on their literature review, the authors determined the following variables to be statistically significant, and therefore collected data on each item. The sales price of single family homes provides an estimate of the property value. The living area, lot size, and property age are used to reflect structural characteristics of the property; data on the social area, median household income at block group level, household income by income category at block group level, percentage of owner-occupied homes, and percentage of the population who is African-American or Hispanic are used to describe the neighborhood. Data describing the station characteristics include data on parking, amenity and structure characteristics, and frequency of the freight service. Transportation access data include distance from the nearest station (feet), distance from the nearest freeway interchange, commuter rail travel time from the nearest station to CBD, and the average commute time where the residence is located; other data is used to account for seasonal effects. The authors selected stations which represented different service areas and station types, were generally representative of CTA or Metra service, were located on commuter rail lines where freight operations are at a minimum, were not between freeway medians, and were reasonably homogenous in terms of socio-economic characteristics.

The study by Gruen, Gruen and Associates finds that, whether a property is located in lower- or higher-income neighborhoods, proximity to CTA and Metra stations positively affects the value of single-family houses. All other factors equal, home prices decline as the distance from a station increases. Interestingly, the authors find that the perception of desirability is a dominant influence on property values, with the presence of a transit station facilitating desirability. The authors conclude that policies promoting TOD such as higher-density zoning and redevelopment financing should be encouraged.

Another study examined the impact of Atlanta's heavy rail system, MARTA, on economic development; specifically, population and employment densification around rail stations (Bollinger and Ihlanfeldt, 1997). The authors note that one benefit of urban rail transit would be increased population and/or employment density surrounding the stations resulting from increased access to those areas. They suggest that, from a public economics perspective, increased densities would be beneficial due to the resulting increased tax revenues and employment opportunities. The authors investigate the impacts of MARTA through a general equilibrium model that estimates simultaneous equations of population and employment. They theorize that population and employment densities should be greater in areas where profits and utility are higher. For households, the benefits of MARTA are assumed to be travel time and travel cost savings. For firms, MARTA's benefits are assumed to include reduced labor costs (from an increased labor supply), increased revenues due to increased accessibility by customers, and reduced land/construction costs due to the need for fewer parking spaces.

The authors used U.S. Census data and regional employment data for the seven-county Atlanta region. Changes in population and employment are measured from 1980 to 1990 for the 299 census tracts in the region. The MARTA independent variable was constructed using GIS methods to draw a quarter-mile ring, or buffer, around each station. A quarter-mile is typically considered a maximum walking distance to access transit. While the resulting coefficients have the expected signs, not all are statistically significant. Three significant results are that MARTA increases government employment and decreases transportation, communication, and utilities employment around stations categorized as mixed-use regional nodes; also, MARTA is found to reduce manufacturing employment around stations categorized as commuter stations. Joint and sum tests for employment confirm that MARTA has not impacted total employment near its stations. However, there is evidence that MARTA has impacted the mix of employment in those areas.

Overall, Bollinger and Ihlanfeldt conclude that MARTA has had no effect on total employment near its stations. In addition, MARTA has altered the employment mix in favor of the public sector. The authors use the second conclusion to support a hypothesis that public policymakers target transit station areas for government employment. They used the results of their study to conclude that the overall presumed benefits of MARTA, based on population and employment densification, were negligible.

A later paper further examines potential impacts of MARTA by focusing on residential property values (Bowes and Ihlanfeldt, 2001). Like Chen, Rufolo, and Dueker, Bowes and Ihlanfeldt acknowledge the positive effects (reduced commuting costs, increased retail activity) and negative effects (such as noise and crime) of urban rail transit on property values. The authors estimate two sets of equations: hedonic price models to investigate direct impacts of the positive and negative effects described above, and equations that relate neighborhood crime and retail employment to distance from a station to examine indirect effects. For the hedonic model, the data set included information on the sales of single-family homes in the Atlanta region from 1991 to 1994. A semi-log specification was used. Key variables include the property's physical characteristics, neighborhood characteristics, crime density of the census tract (which was found to be a better measure than the crime rate), the property's access to employment, and two transportation access variables (one for highways and one for MARTA). For the crime model, the dependent variable is the crime density in the census tract. Key variables include those that represent the tendency of the tract's residents to engage in crime, the attractiveness of the tract to criminals (based on potential "booty" and the probability of being caught), station proximity variables, and neighborhood access. The crime model uses a panel data set, and a Lagrange multiplier test was applied to compare a random effects model to ordinary least squares (OLS) estimation. The OLS model was rejected in favor of the random effects model. For the retail employment model, the dependent variable is the retail employment density in the census tract. This model is similar to the crime model in that the same panel data are used and OLS is rejected in favor of a random effects model. Key variables include the tract's proximity to retail customers, station proximity variables, and property tax rates.

Bowes and Ihlanfeldt find that the estimated coefficients in the hedonic price model are mostly significant with expected signs and reasonable magnitudes. The basic model shows that properties within one quarter-mile of a MARTA station sell for 19 percent less than those beyond three miles from a station. However, properties between one and three miles from a station have a significantly higher value compared to those farther away. These findings suggest that the houses very close to the stations are affected by the negative externalities, but those a bit farther away (but not too far) are beyond the negative effects and benefit from the access provided by the stations. For the crime model, the results support the hypothesis that rail stations contribute to crime by improving a neighborhood's access to outsiders. However, based on interaction terms, stations are found to cause less crime the farther they are from the central business district (CBD). The main finding from the retail employment model is that rail stations have a positive impact on retail activity farther from the CBD.

To summarize, Bowes and Ihlanfeldt find that MARTA rail stations have direct (positive) effects on the values of single-family homes, which vary with neighborhood income, distance to the CBD, and whether the station has parking. Results of the two auxiliary equations indicate that crime density and retail employment density are affected by station proximity. The authors suggest that, based on their findings, cities that wish to contain urban sprawl by employing strategies for densification (such as transit-oriented development) should carefully consider the negative externality effects as well as the positive effects on nearby residential housing values.

Another study used a panel data set for five major cities that implemented or expanded urban rail transit in the 1980s to examine the impacts on housing values as well as transit usage (Baum-Snow and Kahn, 2000). Specifically, they seek to measure the extent to which commuters are induced to switch modes to transit, which demographic groups benefit most from the transit improvements, and how housing prices are affected by the improvements. The authors note that cities that invest in rail transit projects are hoping to reduce traffic congestion, improve air quality, and improve quality of life (especially for low-income residents through better access to jobs). They also note that those in the transit industry are optimistic that the benefits of rail transit are quite large, and forecasts of transit usage tend to be very high while forecasts of rail project costs tend to be too low. Baum-Snow and Kahn acknowledge the criticism the transit industry has received based on such overly optimistic ridership forecasts and unrealistically low cost estimations.

The five cities included in the panel data set are Boston, Atlanta, Chicago, Portland, and Washington, D.C. Baum-Snow and Kahn believe that these cities comprise a useful dataset because generalizations can be made beyond one area, different regions of the country are represented, and "old transit" (Boston, Chicago, Washington, D.C.) as well as "new transit" (Atlanta, Portland) cities are included. While the goals for new rail service, as well as the magnitude of the service change, differed among cities, one common goal was to decrease traffic congestion. For this study, 1980 and 1990 U.S. Census tract-level data were used, as well as the 1 percent Public Use Microdata Sample (PUMS) available from the U.S. Census. When using the PUMS data, dummy variables were used for public transit use, gender, race, age, living in the central city, and household income; information was obtained on what share of a census tract's commuters use public transit as well as tract-level means of demographic and housing attributes. The authors also created a measure of each census tract's proximity to rail transit in 1980 and 1990 using GIS mapping. When no rail transit existed in 1980 (for Atlanta and Portland), access was measured from the CBD. The measure of distance was used as a proxy for the time-cost of commuting by public transit.

The authors estimate a regression of the percent of commuters who use public transit to get to work as a function of tract demographic variables and the tract's distance from public transit; next, a differenced specification was estimated. The regression results indicate that better access to transit (closer distance) induces more use; the net result of moving a tract from 3 kilometers to 1 kilometer away from transit increases average tract transit usage by 1.42 percentage points. Of this 1.42 percentage points, 1.24 percentage points are due to mode switching by those already living in the tract (incumbents). Baum-Snow and Kahn discussed the two components of potential new transit usage: tract incumbents switching from driving to transit as access improves, and Tiebout migration to areas with new transit (those that prefer to use transit will locate near enough to use it). Interestingly, the authors use 2 kilometers (approximately 1.24 miles) as a maximum walking distance to transit, while most studies use one quarter-mile. When the demographic groups were examined to see which groups benefit from new rail transit, logit model estimations indicated that blacks and youths were not served by the transit expansions, due to the expansions occurring mostly in suburban or outer-city areas.

An important result from this study by Baum-Snow and Kahn is that transit is regarded as an amenity, in terms of housing prices. The authors estimate a differenced hedonic regression of home price on tract demographic variables and the distance from transit. The authors find that the positive effects of the transit access outweigh the negative effects of noise, pollution, and crime, etc. Specifically, decreasing transit distance from 3 kilometers to 1 kilometer increases monthly rents by $19 and home values by $4,972. A key finding is that "walk-and-riders" (as opposed to those who park and ride) who are renters are the primary beneficiaries of new rail transit because they save commuting time and their rents have not increased proportionately. Baum-Snow and Kahn's major conclusion is that, in response to new urban rail transit, a small number of incumbent residents switch to the transit mode for the work commute, and small increases in housing values are achieved. These results, although statistically significant, are small in magnitude.

Another study presents an analysis of the impact of St. Louis' Metrolink, a light rail system, on residential property values in St. Louis County (Garrett, 2004). The Metrolink system opened in 1993 and is currently 38 miles long with 28 stations. Like other authors in this review, Garrett acknowledges the positive accessibility effects and negative nuisance effects of rail transit on property values. He uses data on 1,516 single-family homes in St. Louis County that were sold from 1998 to 2001 and are located within one mile of a Metrolink station. Given that economic theory provides no insight into the proper functional form, Garrett uses Box-Cox tests to determine that a log-linear model should be used. He regresses sales price on a vector of house and neighborhood characteristics, city and year dummy variables, variables accounting for spatial correlation in both home prices and the error term, and variables for distance to the track [controlling for nuisance effects as in Chen, Rufolo, and Dueker's study above] and distance to the station. Eight different regression models were estimated.

Garrett finds that most of his models show no relationship between the distance to the track and home prices, and he concludes that there is no general nuisance effect, and that there is only slight evidence that distance from Metrolink's track impacts home values. However, he does find evidence that distance from a Metrolink station has a significant impact on property values. Specifically, home values increase, on average, $139.92 for every 10 feet closer they are to a station, beginning at 1,460 feet. When interpreting the results, the author cautions that complete capitalization of transit accessibility into housing prices might not have occurred at the time his study was conducted. He notes that the time lag for such capitalization might be large, and a similar study conducted 10 years in the future might yield results of greater magnitudes. The significant findings are that the nuisance effect associated with Metrolink is weak, and that there is strong evidence of a relatively larger positive accessibility effect (home prices increase as the distance to a station decreases). Also, similar to other studies reviewed for this effort, this positive effect is found to outweigh the negative (nuisance) effect.

Another study assesses the impact of proximity to light rail transit stations on residential property values in Buffalo, New York (Hess and Almeida, 2007). This study is unique in that it focuses on an older American city, where the population is declining and ridership is decreasing. Buffalo's transit system has been in place for twenty years. The authors use a hedonic regression model to regress property value on vectors of independent variables measuring the proximity of properties to light rail stations, property characteristics, locational amenities, and neighborhood characteristics. They use data from the 2002 assessed value of properties from the assessor's database for the City of Buffalo, GIS data, and 1990 and 2000 Census data. The data includes 7,357 single-family and multi-family parcels located within a half mile radius of the transit stations. Besides using an all inclusive hedonic regression model for properties within a half mile of the 14 stations, the authors ran individual hedonic models for each of the 14 stations.

The authors use two methods for measuring the distance from a property to a transit station. One method uses the linear distance from a property to the nearest rail station; this method measures the perceived distance to the station. A second method uses a route along the street network from a property to the nearest rail station, and thereby measures actual walking distance. To measure housing characteristics the authors use variables for lot area, age of the house, the number of bedrooms, the number of bathrooms, the number of fireplaces, a dummy variable to indicate whether the property accommodates a single family, and a dummy variable to indicate whether the house has a basement. Accessibility and locational measures include variables indicating how far a parcel is from the CBD, proximity to the nearest park, proximity to the largest park in the city, and a dummy variable indicating whether the parcel is located in the east side of Buffalo. Neighborhood characteristics are measured by using a variable for median family income, the property crime rate, the violent crime rate, the housing occupancy rate change between 1990 and 2000, and the population growth rate change.

The all-stations model indicates that a property located within the half mile radius of a transit station is valued $2.31 higher (using the linear distance) and $0.99 higher (using the network distance) for every foot closer to a light rail station. Consequently, an average home located within the half mile radius would generally be worth between $990 and $2,310 more than the average home if it were 1,000 feet from the station. When the units of measurement of the variables in the regression are standardized to compare the relative impact of the variables the number of bathrooms, the size of the parcel area, and whether the parcel is located in the East side of Buffalo are more influential than rail proximity in predicting property values. The individual regressions indicate that contrary to the findings for other metropolitan areas (Gatzlaff and Smith, 1993; Cervero, et al., TCRP 102, 2004), the largest positive impacts in Buffalo were made in high-income neighborhoods, and the largest negative impacts were made in low-income areas. This result may be partly due to the fact that in Buffalo older and less valuable homes tend to be closer to the CBD, in contrast to cities where homes nearer to the CBD are more valuable. In any case, the author points out that this result lends support to the idea that the lack of a strong regional economy would limit the power of transit to revitalize an area. In addition, the relatively small size of Buffalo's rail system may be a factor.

Table 1 on the following page summarizes the papers described above.

TABLE 1: Summary of Literature Estimating Impacts of LRT on Residential Property Values

Study Authors and Year	Study Information	Key Findings
Gatzlaff and Smith, 1993	Dade County Property Tax Records data on sales for a pooled sample of properties surrounding Miami Metrorail stations.	No significant change in sales index of homes before and after establishing Metrorail. Overall, weak evidence of positive residential property impacts, with high-income households accruing greater net benefits than low-income households.
Chen, et al., 1998	Prices of single-family homes sold from 1992-1994 in Portland.	As distance to a MAX station increases, housing price decreases, but at a decreasing rate.
Gruen, Gruen and Associates, 1997	Data on sales price of single-family homes, structural data, social data, station and transportation access data for Chicago Transit Authority.	Home prices decrease as distance from a station increases, for both low and high income neighborhoods.
Bollinger and Ihlanfeldt, 1997	Measured changes in population and employment in Atlanta from 1980 to 1990 using U.S. Census data.	MARTA shifted the employment mix to favor the public sector, although overall the effects of MARTA on total employment were negligible.
Bowes and Ihlanfeldt, 2001	Atlanta sales of single-family homes and crime density of the census tract from 1991-94.	Proximity to MARTA stations has a positive effect on the value of single-family homes. Crime density and retail employment are affected by station proximity.
Baum-Snow and Kahn, 2000	1980 and 1990 U.S. Census tract-level data for Boston, Atlanta, Chicago, Portland, and Washington, D.C.	Decreasing transit distance from 3 to 1 km increased monthly rents by $19 and home values by $4,972.
Garrett, 2004	1,516 single-family homes in St. Louis County within one mile of a Metrolink station, sold from 1998-2001.	Home values increase an average of $139.92 for every 10 feet closer to a station, starting at 1,460 feet. The “nuisance” effect associated with the Metrolink is weak.
Hess and Almeida, 2007	City of Buffalo 2002 assessed value of properties, 1990 & 2000 U.S. Census data.	A property increases $0.99-2.31 for every foot closer to a light rail station.

The last five articles included in this summary address commercial property values. The first study examines how transit investments, including joint development, impact key indicators of office market conditions (Cervero, 1994). The author defines joint development as a "formal, legally binding agreement between a public entity and a private…organization that involves either private sector payments to the public entity or private sector sharing of capital or operating costs, in mutual recognition of the enhanced real estate development potential or higher land values created by the siting of a public transit facility."

A later study by Cervero analyzes changes in private residential and non-residential land development for a sample of stations along the BART system from 1970 to 1990 (Cervero and Landis, 1997). This study was undertaken to add to the results of an earlier study that was done only five years after BART's operation was begun. The previous study was thought to be premature, since five years is not enough time for land use impacts to be felt.

The authors use three different approaches. First, they compare the changes in population and employment for BART-served and non-BART served areas. Then, they employ a 'vintage model' which tracks historical changes in residential and non-residential building areas, land consumption, and densities by geographic location and station classes. Third, they analyze a matched pair comparison of changes in land use and densities between BART station areas and areas near a freeway interchange. The authors defined a station area as the area within a half mile radius of the station, except for downtown stations, for which they define the station area as the area within one quarter mile radius of a station. This definition of station areas is unique amongst the papers reviewed here, and is noted. The primary data source was TRW-REDI, an on-line database of property tax records from the local taxing jurisdictions. This database provided information on square footage, lot area, year of construction, and other statistics for individual privately owned parcels of land. As with others studies reviewed, one potential shortcoming of this data is the fact that land use is only defined when a building is constructed, therefore a change in a building's use would generally not be reflected in the data. Nonetheless, the authors note that residential homes are rarely converted to commercial uses. Also, apartment buildings that are torn down and rebuilt as commercial properties do need to get a new permit so this type of change would be reflected in the data. Hence, the misrepresentations of the data are minimal. The authors also used Census data for population and employment data. Finally, the authors supplemented this data with secondary sources, in-field observations, windshield surveys, local planning documents, neighborhood plans, and interviews with local planning staff, redevelopment agencies, and real estate firms. The authors find that there are significant residential effects of proximity to BART, but there are no major commercial price or rent premiums associated with proximity.

To study the impacts of urban rail transit and joint development, another study used pooled data for five rail station areas in Washington, D.C. and Atlanta where commercial development increased significantly between 1978 and 1989 (Cervero, 1994). Sixty data points were used spanning the twelve year period. Multiple regression was employed and, for most of the models, first-order autoregressive estimation was used to correct for serial correlation. Impacts were measured for all commercial and office properties with over 100,000 square feet of floor space that were located within one quarter-mile of one of the five rail transit stations used in this study. Cervero examined the impact of transit investments and joint development on office rents, vacancy rates, absorption rates, densities, and the shares of new and total office and commercial construction near transit stops. Other variables taken into consideration included those representing the transit service, regional economic and growth factors, and station-area transportation, infrastructure, and development characteristics.

Some of Cervero's statistically significant findings include that offices near terminal stations rented for approximately $3.35 less per square foot than offices near non-terminal stations, *ceteris paribus*. The author suggests that this might be due to the fact that terminal stations tend to be located farthest from the city center. He also finds that the presence of joint development projects at rail stations increases rents by approximately $3.00 per square foot. Another significant finding is that vacancy rates are approximately 11 percent lower in station areas with joint development projects. Overall, Cervero concludes that the hypothesis that rail transit investments, and joint development projects in particular, lead to measurable land value benefits is supported by the empirical evidence in this study.

A later study explored the relationship between urban rail transit and commercial land values in Santa Clara County, California (Weinberger, 2001). The first stage of Santa Clara's light rail system opened in 1987. In 1991, the southeastern spur was added and the current system is 20.8 miles in length with 30 stations. The impetus for the author's research was based on the situation of the County facing several damage claims from property owners located along the light rail line's right-of-way. These owners believed that the light rail line devalued their property. However, Santa Clara County saw the potential for the benefits of light rail.

Weinberger's research seeks to fully understand the effects on properties adjacent and close to light rail stations. The author uses a hedonic regression model, with the dependent variable as a measure of price. The dataset includes lease transactions between 1984 and 2000 collected from a large brokerage firm. Four models are estimated. Weinberger finds that the hypothesis that there is no market response to light rail is rejected. She finds a rental premium on office properties located within one half-mile of light rail stations.

Another study focused on analyzing the impacts of urban rail transit on commercial land values in Santa Clara County (Cervero and Duncan, 2002b). In addition to the effects of the light rail system, they also study the region's commuter rail systems, CalTrain and the Altamont Commuter Express. Commuter rail systems generally serve inter-city trips and often use rights-of-way shared by freight rail transportation. Commuter rail transit operates at higher speeds than heavy or light rail, and distance between stations is generally the greatest of the rail modes.

The authors note that, in the public sector, the major benefit of rail transit, and transit-oriented development as well, is to reduce automobile congestion by providing a commute alternative. In the private sector, developers and land owners hope to accrue benefits from being near rail transit in the form of increased profits.

Cervero and Duncan focus on land values rather than rents and use a hedonic price model in their research. Data for commercial, office, and light industrial properties were compiled for 1998 and 1999. The authors controlled for rail and highway proximity, accessibility and location, density and land uses, and neighborhood quality. Weighted least squares was used to correct for heteroskedasticity in OLS estimation. All variables in the model were found to be statistically significant. The key finding from this study is that being near rail transit increased commercial land values. The greatest benefits accrued to properties near commuter rail stations. Specifically, land parcels within one-quarter mile of a commuter rail station in a business district were worth more than $25 per square foot more than comparable properties away from stations. This translates to more than 120 percent above the mean property value. For the light rail stations, the capitalization benefits were $4.00 per square foot, or 23 percent above the mean property value. Cervero and Duncan note that these findings are significant in magnitude compared to previous studies.

In an earlier paper, Cervero and Duncan assess the impact of transit on land values in San Diego County (Cervero and Duncan, 2002a). They use hedonic price models to determine the land value premiums or discounts associated with land use in commuter rail and trolley (light rail) corridors. The impact of transit on four types of properties is assessed: single-family housing, multi-family housing, condominiums, and commercial properties. For each type of property a separate hedonic model was estimated. The sales price of a parcel is a function of transportation services (proximity to transit and highways, and accessibility to jobs); property characteristics (structure and size) and land use (i.e. type of commercial property); neighborhood socio-demographic characteristics (e.g. race and household income); and controls, such as municipality and times-series fixed effects. The authors' primary data source was Metroscan, a proprietary database maintained by First American Real Estate Solutions. The authors' observations included residential parcels sold in 2000 and commercial properties sold between 1999 and 2001 (the larger span for the latter was used to provide a sufficient number of observations for statistical validity). Metroscan provided data on sales price as well as descriptive information on each parcel used in the model (e.g. number of bathrooms, lot size, etc.). Data on the population, housing units, and socio-demographic attributes was obtained from the 2000 Census. SANDAG provided 1995 employment and household income data at the traffic zone (TAZ) level, as well as data on peak period highway travel times via car and transit. Many of the variables were developed using GIS tools. The authors found the greatest amenity and disamenity affects for commercial properties, though multi-family, single-family, and condominiums all showed some amenity and some disamenity effects. Prior to their analysis, the authors reviewed previous efforts to evaluate the impact of San Diego rail systems. Of note is a study done by VNI Rainbow in 1992 which used "matched pairs" analysis and examined rents as opposed to land value. The authors expressed doubt that rents are an accurate way to measure benefits since they do not represent the full array of concessions provided to tenants and, in this study, were not adjusted for occupancy levels. The latter is an interesting point to be taken into consideration when evaluating the impact on commercial properties.

These five papers are summarized in Table 2 on the following page.

TABLE 2: Summary of Literature Estimating Impacts of LRT on Commercial Property Values

Study Authors and Year	Study Information	Key Findings
Cervero and Landis, 1995	On-line database of property tax records (TRW-REDI) and U.S. Census data for population and employment statistics.	No major commercial price or rent premiums associated with proximity to BART rail stations.
Cervero 1994	Pooled data for five rail station areas, with large commercial development from 1978-1989 in Washington, D.C. and Atlanta	Overall, empirical evidence supports a measurable land value benefit from rail transit investments and joint development projects. Vacancy rates are 11% lower in station areas with joint development projects.
Weinberger 2001	Santa Clara County lease transactions from 1984-2000 collected from a large brokerage firm.	Rental premium exists on office properties located within one half-mile of light rail stations.
Cervero and Duncan, 2002b	1998-1999 Santa Clara County commercial property data.	Being near rail transit increased commercial land values. Land parcels within a quarter mile of a rail station in a business district were worth $25 per square foot more than comparable properties away from stations.
Cervero and Duncan, 2002a	San Diego County sale prices from Metroscan database (maintained by First American Real Estate Solutions), 2000 U.S. Census, GIS.	Greatest amenity and disamenity factors for commercial properties, claim rents to be an inaccurate way to measure benefits.

Summary and Other Work

The articles reviewed for this effort have largely focused on the impact of rail on real estate values in the U.S. This focus facilitates comparison with the analysis that shall be undertaken to assess the impacts of BRT on real estate values better than international assessments, since the latter reflect different political, cultural, and social environments. Nonetheless, recently there have been attempts to assess the impact of BRT on real estate values in Bogotá, Colombia, a city with very extensive BRT service. Since these are the first attempts to evaluate the effects of BRT, in particular, the results of these efforts are briefly reviewed here.

In one study, a spatial hedonic model is used to determine the extent to which access to BRT stations in Bogotá is capitalized into rental asking prices (Rodriguez and Targa, 2004). They find that for every five minutes of additional walking time to a BRT station, the rental price of a property decreases by between 6.8 and 9.3 percent, after controlling for structural characteristics, neighborhood attributes, and proximity to the BRT corridor. Rodriguez and Mojica summarize the findings of Mendieta and Perdomo (2007) who found that, assuming walking speeds of 4.39 km/h, property prices increased between 0.12 percent and 0.38 percent, depending on the distance from the BRT, for every five minutes of walking time closer to a BRT station. Another study reviewed by Rodriguez and Mojica was one which used propensity score matching to compare asking prices of residential and commercial properties in two zones, one with and one without BRT access (Perdomo, et al., 2007). The results were mixed, with most comparisons yielding statistically insignificant results. In only one case a premium of 22 percent for residential properties with BRT access was detected with a 95 percent level of confidence. Rodriguez and Mojica, themselves, use a before-and-after hedonic model to value the network effects of an extension to Bogotá's BRT system. Focusing on the asking prices of residential properties, they find that properties offered during the year of the extension and in subsequent years have prices that are between 13 percent and 14 percent higher than prices for properties in the control area. In addition, the appreciation is similar for properties within 500 meters and properties between 500 meters and 1 kilometer of BRT.

Additional modeling results that are acknowledged but were not reviewed in detail and focus on the effects of LRT on property values include those shown in Table 3 on the following page:

TABLE 3: Summary of Other Literature Estimating Impacts of LRT on Property Values

Study Authors and Year	Study Information	Key Findings
Dueker and Bianco, 1999	Population Census' median house value in Portland between 1980 and 1990.	Premium of $2,300 for properties within 0.06 km of a MAX station.
Lewis-Workmann and Brod, 1997	Cadastral information for all properties (4,170) within 1.7 km of three MAX stations in Portland.	Premium of $75 per 0.03 km closer to the station.
Forrest et al., 1995	795 house sales in Manchester (UK) during 1990.	Premium ranging from 2.1- 8.1% depending on distance from station.
Landis et al., 1995	134 single-family sales in San Diego during 1990.	Premium of $272 for every 0.1 km closer to station.
Dabinett, 1998	Sheffield (UK) Supertram.	No evidence of appreciable effects.
Al-Mosaind et al., 1993	235 single-family home sales in Portland during 1988.	Premium of $663 per 0.03 km closer to station.

Source: TCRP A23A, 2006

Overall, 12 of the 13 papers reviewed using modeling find positive impacts on property values from nearby rail transit; however, the magnitudes vary. Seven of these studies focus on residential property values, while five emphasize commercial properties. Most impacts are found to be statistically significant, yet relatively small in magnitude. The thirteenth paper does not specifically address impacts on property values, but rather the issue of population and employment densification around transit stations. This paper found no impact on total population or employment density around stations, but did find an impact on the mix of employment.

The majority of the studies reviewed, whether including statistical modeling in their analyses or not, found small but positive effects of transit on development. Though most of these studies focus on the impact of rail transit on development, they provide a valuable framework of reference for research attempting to quantify the impact of BRT on development.

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STUDY AREA DESCRIPTION

For this research, the impact of distance to the nearest BRT station along the Martin Luther King, Jr. East Busway in Pittsburgh is estimated on the assessed property values for single-family residences located near the transit stations. The focus is on the impact of proximity to stations along Pittsburgh's East Busway because this service represents one of the oldest BRT corridors in the U.S., having opened in 1983. The effects of proximity to transit have accrued over a period of more than 25 years. Figure 1 below depicts a bus on the East Busway leaving the Pittsburgh Central Business District (CBD).

Source: Port Authority of Allegheny County

FIGURE 1: East Busway Bus Leaving the CBD

The city of Pittsburgh is located where the Allegheny and Monongahela Rivers meet, forming the Ohio River at the head of Pittsburgh's Golden Triangle. The city is surrounded by hills that lend to its appeal, but cause the city to be somewhat difficult to navigate, since roads must often veer off at strange angles to adapt to the topography of the city.

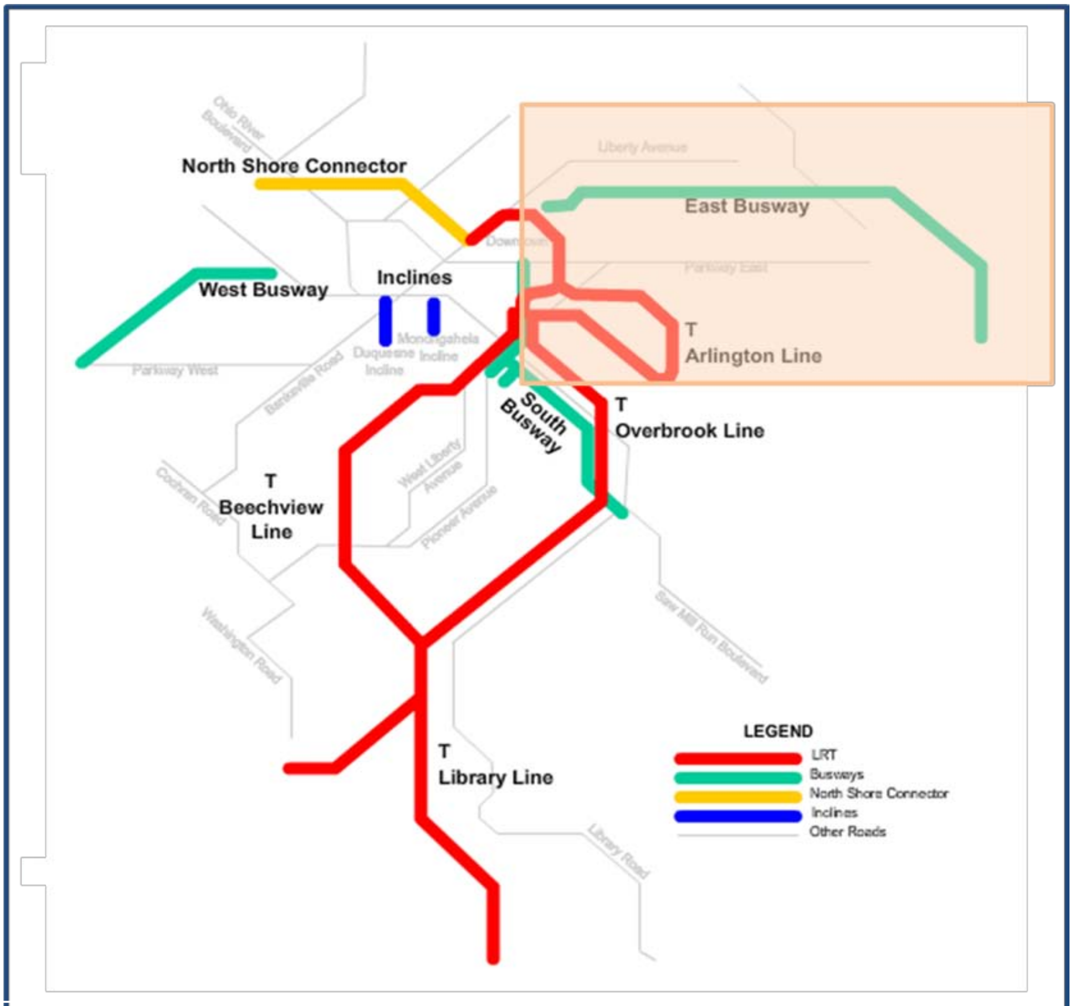
Pittsburgh is known as an industrial city because its heritage and development were heavily influenced by the development of the steel industry. Since the decline of the steel industry in the 1980s, the city has been adapting to changing conditions. Today, Pittsburgh's economy is considerably more service-oriented, comprising services including medicine, higher education, tourism, banking, and corporate headquarters. Pittsburgh is home to several universities and colleges and a vast medical research center and hospital complex. Likewise, Pittsburgh is home to several professional and university sports teams.

The U.S. Census Bureau estimates that the city of Pittsburgh's population was 312,819 in 2006 (down from 334,563 in 2000). The population of the urbanized area was approximately 2.3 million in 2008; a decrease from 2.4 million in 2000. The Pittsburgh Urban Area is the 22nd largest in the U.S., and ranks between those of Cleveland, Ohio and Portland, Oregon. There are three important factors that influence the demand for transit in the area: 1) Downtown Pittsburgh has a higher percentage of total regional employment than CBDs in other cities of similar size; 2) Downtown Pittsburgh's density of development along with its compact size limits the amount of land available for parking; and 3) Pittsburgh has a relatively limited highway network, without a beltway system as in many other metropolitan areas (Wohlwill, 2009).

The Port Authority of Allegheny County operates a bus system, light rail transit (the T), and three dedicated busways, as well as paratransit service for senior citizens and persons with disabilities. Approximately 220,000 trips are taken on Pittsburgh's public transportation services each weekday (http://www.portauthority.org).

According to the Port Authority's website, the impetus for the development of busways began in the 1960s in response to growing traffic congestion. During the 1970s, Pittsburgh became one of the first cities in the U.S. to operate service on busway facilities. The Port Authority appropriately names itself an "international pioneer in the development and advancement of bus rapid transit facilities, technology, and service" (http://www.portauthority.org). The first of the three busways, the South Busway, opened in 1977. The Martin Luther King, Jr. East Busway was next to open in 1983; an extension opened in June 2003. The West Busway began operations in September 2000.

In addition to the busways, the Port Authority also operates a light rail system, the T, which first began service in April 1984. Figure 2 presents a map of the Port Authority's fixed guideway system, including the busways, the T, the North Shore Connector (extension to the T), and the two inclines, the Monongahela Incline and the Duquesne Incline. On Figure 2, the approximate study area for this effort is highlighted in the light orange box.



Source: Port Authority of Allegheny County

FIGURE 2: Port Authority of Allegheny County's Fixed Guideway System (highlighted box represents approximate study area)

As the focus of this study, the Martin Luther King, Jr. East Busway extends from Penn Station in downtown Pittsburgh to Swissvale, covering 9.1 miles in length. Below, Figure 3 shows a photo of the East Busway and adjacent rail corridor and Figure 4 provides a photo of a former industrial building along the East Busway corridor that has been renovated for other uses.

The East Busway was constructed in a railroad corridor first established by the Pennsylvania Railroad. The rail line is now owned by Norfolk Southern, and is an important corridor in the area, linking Pittsburgh with Harrisburg and other points east. Norfolk Southern operates freight trains as well as Amtrak's Pennsylvanian. Traffic volume on the line varies considerably by day of week and time of day (Wohlwill, 2009).

Source: Port Authority of Allegheny County

FIGURE 3: East Busway and Adjacent Rail Corridor

Source: Port Authority of Allegheny County

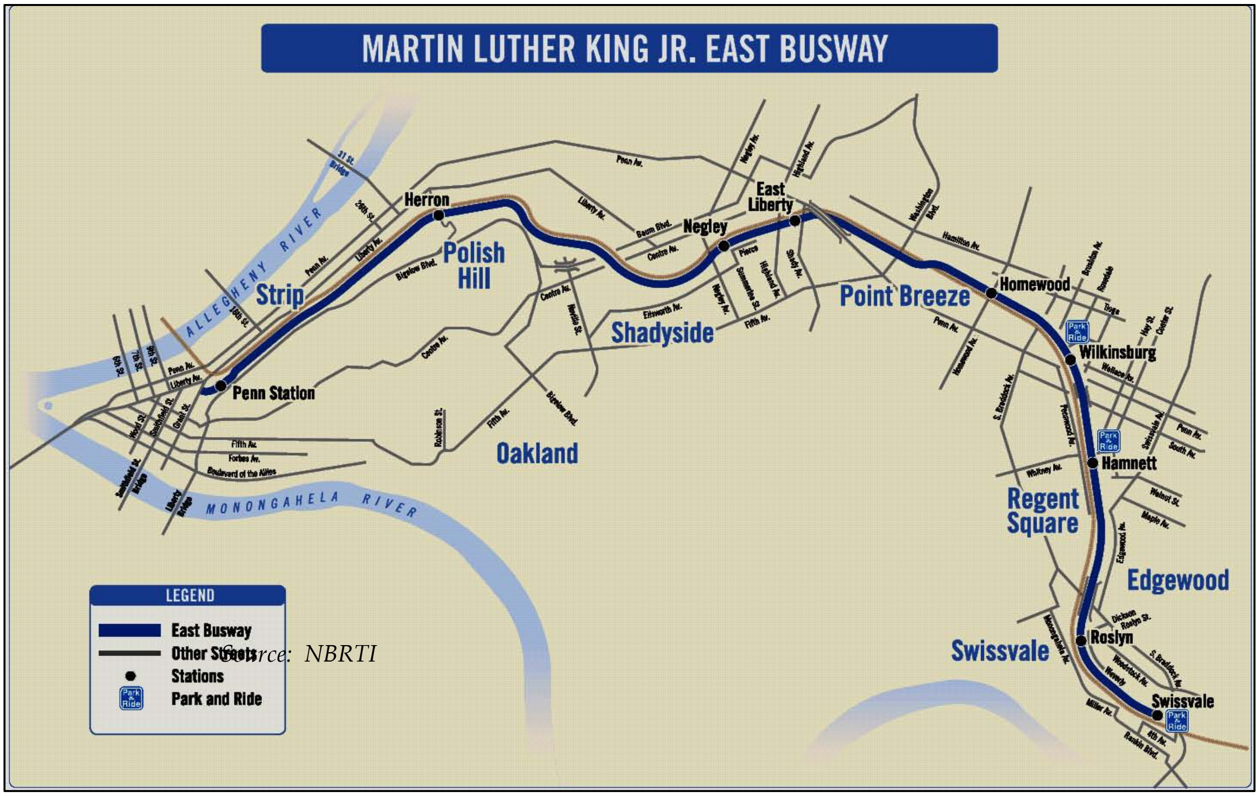
FIGURE 4: Office Redevelopment along the East Busway Corridor

Given the size of its ridership, the East Busway has been important for easing traffic congestion on major roadways. The original East Busway, which linked Downtown Pittsburgh and Wilkinsburg opened in February 1983 and had a length of 6.8 miles. The original East Busway also provided access to Oakland via the Neville Ramp. In June 2003, a 2.3 mile extension of the busway was opened, extending the service from Wilkinsburg to Swissvale. Over time, many different routes have been developed that operate both on the busway and feed into the service.

According to the Port Authority, the eastern corridor accounts for 40 percent of all trips taken on public transit in Allegheny County and is an area of significant and continuing growth (http://www.portauthority.org/PAAC/CustomerInfo/BuswaysandT/MartinLutherKingJrEastBusway). The corridor's development, relatively long history, and high level of ridership make it an ideal BRT site for a study on how proximity to BRT stations affects property values.

The Martin Luther King Jr. East Busway, alone, has an average weekday ridership ranging from 25,000 to 28,000, exceeding the average daily ridership of 9,000 on both the South and West Busways individually. Ridership on the East Busway has been comparable to, and sometimes is greater than, ridership on the light rail system (Wohlwill, 2009). Figure 5 provides a map of the East Busway. As of 2009, a total of 32 bus routes operate on the East Busway; additionally several community buses feed into the BRT service. Besides the East Busway -All Stops service (EBA), three express bus routes run along the busway, facilitating faster and more convenient commutes for individuals traveling to high traffic areas, such as to Oakland, for example, where many of Pittsburgh's universities are located as well as the city's medical research center and hospital complex. In addition to the EBA service, the East Busway-Oakland (EBO) service provides trips directly to Oakland and serves all of the stations between Swissvale and Negley. The East Busway-Short (EBS) serves all of the busway stations from Downtown Pittsburgh to Wilkinsburg.

As shown in Figure 5, the East Busway corridor is enveloped by the two rivers, the Allegheny to the north and the Monongahela to the south. The position of the East Busway alignment in relation to these two rivers is significant for purposes of this study. Preliminary results for this research were obtained by using properties (parcels) at given distances from the stations without regard to the rivers; however, early comments from individuals very familiar with the area led to the decision to only focus on properties (parcels) that are located in between the rivers for the remainder of the study, due to issues with ease of access to the corridor. For much of the corridor, there is a hillside along the south side of the busway and, in certain sections, there are steep slopes along both sides of the busway (Wohlwill, 2009).



Source: Port Authority of Allegheny County

FIGURE 5: East Busway Map

The East Busway includes nine stations as listed below:

- Penn (Pittsburgh CBD)
- Herron
- Negley
- East Liberty
- Homewood
- Wilkinsburg
- Hamnett
- Roslyn
- Swissvale

In addition to the stations noted above, there is a stop at the end of the Neville Ramp that serves the North Oakland neighborhood. Three of the East Busway stations have park-and-ride lots: Wilkinsburg (748 spaces), Hamnett (128 spaces), and Swissvale (163 spaces) for a total of 1,039 spaces. There are 14 other remote park-and-ride lots with access to routes that serve the East Busway, for an additional 2,146 spaces. The stations are all ADA-accessible and include amenities such as passenger information, emergency phone connections to Port Authority Police, benches, bike racks, and public phones. Banks, day care centers, schools, parks, grocery stores, pharmacies, community centers, restaurants, bars, convenience stores, art galleries, boutiques, dry cleaners, municipal buildings, and residential areas are all within short walking distance from the stations. Figures 6 and 7 depict passenger activity at Wilkinsburg Stations and Figure 8 shows offices near Negley Station.

Source: Port Authority of Allegheny County

FIGURE 6: Passengers Alighting at Wilkinsburg Station on the East Busway

Source: Port Authority of Allegheny County

FIGURE 7: Wilkinsburg Station on the East Busway

Source: Port Authority of Allegheny County

FIGURE 8: Negley Station on the East Busway

METHODOLOGY

At the beginning of this study, a significant amount of time and effort was spent in determining the appropriate quantitative methodology to use in attributing land use impacts to BRT. As first discussed in the Introduction section, many qualitative and anecdotal studies and other information are available on the impacts of BRT, much of which describe the myriad types and amounts of development that have occurred along BRT corridors and near BRT stations. Although this information is tremendously useful to the industry and to policymakers and others in communities that have implemented or are considering BRT investments, it is quite difficult to place into a modeling framework. Economic impact studies are one method for gauging the relative success of an investment by measuring the economic benefits (if any) that accrue to the community that made the investment. Such studies are quite complex and necessitate large amounts of detailed data and can sometimes require specialized software to complete. While economic impact studies of BRT investments may be quite useful endeavors, they do not address the needs of this study, which focuses on land use impacts.

The literature reviewed for this study included several papers that described the use of hedonic price regression models to determine the marginal impact of distance to a rail transit station on property values. It was thus determined that a similar methodology would be appropriate as an application to BRT stations. To date, there have been no hedonic regression models estimated for impacts of BRT stations on property values for services operating in the U.S.

Therefore, the methodology applied for this effort is a hedonic price regression model. This type of analysis estimates a price, in this case a housing value, based on a number of variables believed to influence that price.

To properly attribute causation between proximity to BRT stations and surrounding property values, the ideal method would comprise a before-and-after scenario to estimate the marginal change in value after a new BRT service is implemented. However, in this case, data for Pittsburgh and Allegheny County were not available in digitized form for the years prior to the East Busway's implementation in 1983. As an alternative, this report presents the results of a cross-section analysis to isolate the marginal effect of distance to a BRT station on property values at one point in time. It is hoped that future research in other U.S. cities with BRT will be able to comprise a before-and-after setting.

Hypothesis

It is assumed that accessibility benefits accrue for properties with proximity to a transit station. These benefits, in turn, are hypothesized to capitalize into land values. Therefore, this research aims to show that, as the distance to a transit station decreases, the accessibility benefits accrued by homeowners will be greater, resulting in a higher property value. The null hypothesis is that, as the distance to the transit station increases, there will be no impact on property values; this implies that proximity to a transit station accrues insignificant accessibility benefits for nearby properties.

Given that Pittsburgh's Martin Luther King, Jr. East Busway has been operating since 1983, it is assumed that adjustments in people's travel behavior to BRT service and the transformation in land use near transit stations have already been made. Likewise, though real estate development effects from transport improvements are generally expected to take place over a long period of time, this effort estimates the property value response to date.

The Model

As in much of the previous research reviewed, in this effort a hedonic price model was used to estimate the mean effect of distance to the nearest transit station on property value. Using such a model allows the researchers to control for the other variables that affect property values and thereby allows for the isolation of the effect of distance.

Property value was regressed on vectors of variables controlling for distance, property characteristics, locational amenities, and neighborhood characteristics. The conceptual hedonic model is:

$$P = f(\boldsymbol{D}, \boldsymbol{H}, \boldsymbol{L}, \boldsymbol{N})$$

where the dependent variable, P, is the appraised property value in dollars, which is a function of four vectors of independent variables. The four vectors are $\boldsymbol{D}$, a vector of variables that measures the distance of parcels to transit stations; $\boldsymbol{H}$, a vector of variables that describes housing characteristics; $\boldsymbol{L}$, a vector of variables that describes locational amenities; and $\boldsymbol{N}$, a vector of variables that describes neighborhood characteristics. Each of the variables included in these categories shall be discussed further below.

Economic theory does not indicate an appropriate functional form for the model. This being the case, a levels model is estimated to determine the mean effect on appraised values of a residence being one additional foot closer to a BRT station. A levels model will measure the dependent variable, price, in unit dollars, and the coefficients on the independent variables (representing slopes) will measure the change in price in dollars in response to a one unit change in the given independent variable.

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DATA

This section describes the data that were used to estimate the hedonic regression models, as well as the geographic information systems (GIS) processes that were applied to prepare the data for use in the model estimation. Also included in this section is a description of the variables included in the final models. Finally, it must be noted that this analysis focuses exclusively on single-family home values. Future research could include multi-family residences such as apartments, townhomes, and condominiums, as well as commercial properties.

Initially observations were taken from within given distances to East Busway stations without regard to the geographic location of the Allegheny and Monongahela Rivers. Results based on this initial dataset are presented in the Results section, along with results from a cut of the data suggested by individuals who are very familiar with the study area. Data in this second cut for the model are only for residences located in between the Allegheny and Monongahela Rivers. Restricting the dataset to these observations is beneficial for two reasons. First, a significant portion of this analysis focuses on residences located within one half-mile from the nearest station on the East Busway. The rivers provide a natural boundary for activity in the eastern part of Pittsburgh; the downtown and most of the surrounding suburban area is located in between the rivers. On the outer sides of both rivers there are steep hills which prevent convenient access to transit. Hence, one cannot expect accessibility benefits to accrue for properties outside of the rivers; these observations are systematically different from the other observations located within one half-mile from the nearest station on the East Busway. Second, even when focusing on observations within three-quarters of a mile from transit stations, relatively few observations are located outside of the rivers. Not only are these observations systematically different from the others in the analysis, as stated above, but they may potentially be located nearer to the West or South Busways, than to the East Busway itself, and hence there would have had to be a control for nearness to the two alternative busways to adequately control for all important determinants affecting these residences' property values.

The data consist of all properties within the specified distance limit from the nearest station on the East Busway, and that had an assessed property value of at least $10,000 and no more than $750,000. Properties with values higher or lower than these limits were determined to be outliers in the analysis. In addition, properties with a condition of "unsound," and with a value of zero for lot area, living area, bedrooms, and bathrooms, were eliminated from the analysis due to reasonableness.

Sources

Allegheny County Property Assessor data for 2007 are used to obtain the appraised (fair market) values of all parcels, or properties, located in the Pittsburgh area and the county. These data also contain information describing the characteristics of each parcel as well as information on the borough, city ward, or neighborhood within which a parcel is located. These Assessor data are used in combination with geographic information systems (GIS) data, the latter of which provides measures of the distances between each parcel and the nine coded stations along the Martin Luther King, Jr. East Busway. In the analysis, the distance from each parcel to the nearest transit station is used as the measure of distance, and is the key variable of interest in this effort. Other variables measuring various distances were also obtained using GIS. The U.S. Census data for 2000 provides information on neighborhood characteristics. In addition, Pittsburgh Police Department's crime data for 2006 were used in combination with the Pennsylvania Uniform Crime Reporting System data from the State Police Crime Statistics Division. The latter source was used for cases in which there were gaps in the Pittsburgh Police Department's data and for areas located outside the city boundaries. Further information on these data is provided below.

Use of GIS

The development of a model to assess the impact of bus rapid transit on property values requires a variety of data resources. Demographic, real estate, and crime statistics were collected for the purposes of this analysis. Additionally, geo-spatial analyses were conducted to add further value to the data. The demographic data are based on the 2000 Summary File 3 U.S Census. Real estate data such as retail values and property characteristics are based on data from the Allegheny County Property Assessor's Office. The crime statistics were gathered from the Pennsylvania State Police Crime Statistics Division and, where possible, from the local law enforcement agency. Additionally, transportation facilities such as stop and route locations, interstate access points, and light rail facilities were identified and coded in to geographic information systems (GIS).

There were several objectives with these data:

- Assign Census variable statistics to parcel data.
- Assign crime rates to parcel data.
- Calculate the distance between the parcel data and bus rapid transit facilities.
- Calculate the distance between the parcel data and other transportation facilities.

Census Data Analysis

Census data consists of two different data products; descriptive and geographic data. The descriptive data consists of all the demographic statistics of the study area and the geographic data consist of the physical elements of the study area. All the census data was acquired from the Census.gov web site and imported into geographic information system software (ESRI's ArcGIS). From the list of the descriptive data below, acquired from the U.S. Census Bureau website, variables were selected for inclusion in the model:

- Total Population
- Under Age 18 Population
- Over Age 60 Population
- Over Age 65 Population
- Minority Population
- Total Households
- Households with Income Below $10,000
- Household Median Income
- Poverty Status
- Household Availability of Automobiles
- Commute time
- Public Transportation utilization
- Carpool Utilization

The descriptive data variables were integrated with the geographic data elements for the county. In this analysis, the geographic data element used was the Census Tract. Allegheny County has 419 census tracts. This resulted in a GIS database that contained all of the descriptive and geographic data. All of the census data were assigned to the parcel information. Each parcel that fell within the boundary of the census tract was assigned the demographic data. However, because the parcel data and the census data do not share boundaries (topology), geographic analysis was performed to assign the census tract descriptive value to any parcel with its center point (centroid) within the census tract boundary. In an effort to normalize the data and to address the distribution of the census demographic data to each parcel, the data were normalized by using rates and density calculations.

Distance Calculations

The Allegheny County Property Assessor's Office 2007 parcel data served as the most significant data resource. Its robust data elements provides a high level of detail on every parcel in the county and includes; the last purchase price and purchase date, current taxable assessment (fair market value), property size, age of the house, and household characteristics, such as number of bedrooms, baths, and square footage. Additionally, given the geographic elements of the parcel data, the distance between each parcel and several transportation facilities were calculated and served as a distance variable for each parcel. The facilities included the bus rapid transit facilities as well as on-ramps to major roadways, and distance to light rail lines and light rail stations. Using ESRI's ArcGIS 9.2 software, two types of distance calculations were conducted: 1) distance of each parcel to the nearest transportation facility and 2) distance of each parcel to each transportation facility. The Near command and the Point Distance command were used, respectively, to compute these distances.

Bus Rapid Transit Facilities

A distance calculation for every parcel to its nearest station on the East Busway was performed. Additionally, to accommodate for when parcels are close to more than one BRT station, the distance of each parcel to all the stations was calculated. This resulted in multiple (the total number of BRT stations: nine) distance values for each parcel. Finally, three buffers, 0.1 mile, 0.2 mile and 0.3 mile, were created around the East Busway corridor. Parcels with their center within the buffer were assigned the value of the buffer distance. These buffer variables were then transformed into dummy variables (i.e., taking a value of 1 if within the given buffer; 0 otherwise) for use in the regression model.

Highway Facilities and On-Ramps

Similarly, the interstates and the on-ramps for Interstates 376, 279, and 579 were coded into the GIS. Two different distance calculations were made for these data. The first distance was calculated using the Near command in ESRI's ArcToolBox. This computed the nearest on-ramp to every parcel in Allegheny County. The second distance value was based on the interstate alignment. As with the bus rapid transit facilities, three buffers, 0.1 mile, 0.2 mile and 0.3 mile, were created around the interstate rights-of-way. Parcels with their center within the buffer were assigned the value of the buffer distance. Again, these buffer variables were transformed into dummy variables (i.e., taking a value of 1 if within the given buffer; 0 otherwise) for use in the regression model.

Light-Rail Facilities

The light rail stations for the T were coded into the GIS using Google Map's representation of the station facilities. The location of these data was verified against the data from the North American Transportation Atlas. Using the Near command again, the distance to the light rail station from every parcel was calculated.

Crime Calculations

The crime statistics were gathered from two sources: the City of Pittsburgh Police Department and the State of Pennsylvania's Crime Statistics Division. The City of Pittsburgh's police department tracks crime statistics by census tracts. These data were joined with the demographic census data and, similar to the distance calculations described above, the crime statistics were assigned to each parcel if its center (centroid) was within the boundaries of the tract. To normalize the data, the per-capita crime rate was calculated for each of the census tracts. For the rest of the data in the Allegheny County, the information was stored at a central web-based repository, organized by municipalities. Using Census geography data, the boundaries for each of the municipalities were imported into the GIS software. For each tract with its center inside the municipality boundary of the city or borough, the per-capita crime rate for the municipality was assigned. For census tracts that were within municipalities with no crime statistics, the overall per-capita crime rate for the Allegheny County was assigned. Once the per-capita crime rate was calculated for every tract in Allegheny County, the same technique, described previously, to assign the crime statistics to the parcels was performed. For every parcel with its center (centroid) within the census tract boundary, the per-capita crime rate was assigned to the parcel.

Integration for Model

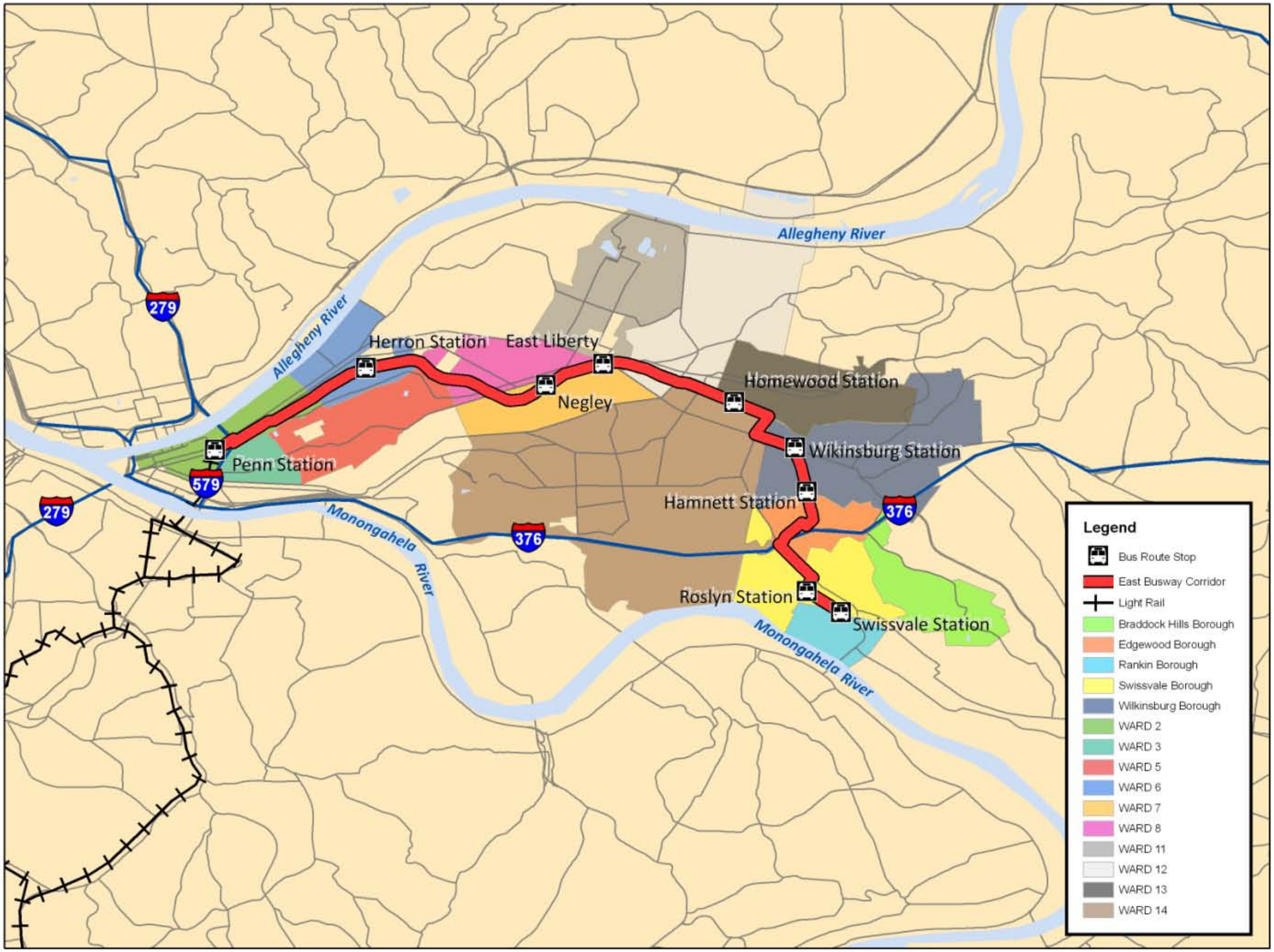
Once all of the data for each variable were created in the GIS, it became apparent that GIS, while capable of analyzing the data, was not the ideal application for managing the data. From the GIS application, the data were exported into a text (comma-separated values) for additional manipulation. The data were imported into MySQL database for exporting and formatting, to be used by SPSS (Statistical Package for the Social Sciences) and STATA statistical software. Using MySQL relational database, the data were formatted and exported into an SPSS-friendly format and used for the final model estimation. Once in the SPSS-friendly format, the data could also easily be imported into the STATA software. Figure 9 presents another map of the study area including the East Busway corridor, other transit facilities (light rail) and highway facilities.

Variables

Tables 4 and 5 provide descriptive statistics on each variable included in the analysis for each cut of the data. Two analyses were performed on the initial dataset: one with a buffer of five miles from the nearest BRT station and one with a buffer of one-half mile. For the selection of data between the rivers, analyses were conducted for all observations between the rivers and also for those observations between the rivers that are within a half-mile buffer of the stations. Information shown in the tables includes the variable minimums, maximums, means, and standard deviations. Table 6 shows the number of parcels in the data set that are contained in each of the listed boroughs, city wards, and neighborhoods for each selection of data. The percentage of the total is also shown for each area.

As described in the Methodology section above, the dependent variable in this analysis is the appraised value (fair market value) of a parcel. Commonly, the appraised value is referred to as property value (*P*). Unless otherwise indicated, property value refers to the sum of the appraised value of the land and the appraised value of the structure situated on the land.

The best indicator of market value is the price that results in a market transaction. For the five-mile cut of data, correlation was +0.71 (significant at the 0.01 level) between sale prices for the years 2006 and 2007 and the 2007 assessed fair market value. For the cut of data between the rivers, this same correlation was +0.61 (significant at the 0.01 level). Due to the relatively high correlation between sale price and assessed value, it was determined that the latter would be used as the dependent variable in this analysis. The use of the fair market value as the dependent variable has the advantage of increasing the number of observations used in the model estimation and also of avoiding any pricing issues resulting from the recent housing market downturn. However, it is acknowledged that future efforts should attempt to include satisfactory data on sales prices.



Source: NBRTI

FIGURE 9: Martin Luther King, Jr. East Busway Corridor

There are two variables in the vector of distance variables (***D***). The distance (DIST) between a property and the nearest bus rapid transit station is measured as the straight-line, or linear, distance between the two. This method of measuring distance measures the perceived distance (Hess and Almeida, 2006). An alternative distance network method measures the route along the street network from the property to the nearest transit station. This method measures the actual walking distance. If one were to use the network distance method, the resulting estimate of the effect of distance on property value would be more conservative. The straight-line distance method is used because it is the only method that was readily available to the researchers in this effort. It allows the researchers to estimate an upper-bound measure for the effect of distance. A variable for the squared distance (DISTSQ) is included in the model to control for possible increasing or decreasing marginal effects of distance on property value.

The property characteristics (***H***) include variables indicating the square footage of the lot area (LOTAREA) and the square footage of the living area (LIVINGAREA). The living area, as the phrase suggests, refers to the square footage of a home, not including outside areas such as porches. Variables are also included indicating the number of bedrooms (BEDRMS), bathrooms (BATHRMS), and half-bathrooms (HALFBATHS) in a home. An interaction variable of bedrooms and living area (BED*LIVA) is used to allow the living area premium to vary with the number of bedrooms. A likert-scale variable indicating the condition of the home as assessed by the Allegheny County Property Assessor (HOMECOND) and a variable for the year the property was built (YRBUILT) are used to further describe the properties.

The locational amenities vector (***L***) includes variables that describe access to amenities as well as disamenities. In general, accessibility to transit and transportation is considered an amenity. Nonetheless, noise, pollution, and/or aesthetics can comprise disamenities associated with proximity to transit. The distance to the nearest exit (EXITDIST) measures the distance to access the nearest interstate highway, as an alternative form of transportation. Likewise, the distance to the nearest light rail access (LRTDIST) indicates another amenity associated with a parcel's location. To account for potential non-linearities in the way either of these variables affect property values, as discussed above, squared terms are included in the model (LRTDISTSQ and EXITDISTSQ). The distance from the parcel to the Pittsburgh CBD, (CBDDIST and CBDDISTSQ), provides a measure of proximity to downtown Pittsburgh. To control for disamenities such as noise, pollution, or aesthetics, variables are included to indicate whether a property is located within one-tenth of a mile of the BRT corridor or nearby interstate highway, (BRTBUFZN) and (HWYBUFZN), respectively. By including these variables in the analysis, an attempt is made to control for the negative effects (noise, pollution, even aesthetics) of living very close to these transportation arterials, in particular. Both BRTBUFZN and HWYBUFZN are dummy variables that take the value of one (1) if the parcel is within one-tenth of a mile of the BRT runningway or interstate right-of-way, respectively, and take the value of zero (0) otherwise.

The neighborhood characteristics (***N***) include variables that describe individual communities, and thereby may affect property values. The median household income (MDHHINC), the percentage of the population that is minority (MIN_POP), and the population density (POP_DENS), together provide effective information to describe a census tract. The population density of a census tract is calculated as the population of the tract divided by the area of the tract. Given that certain neighborhoods are more appealing than others in the real estate market, thus affecting property values, a dummy variable is included for each of the boroughs, city wards, and neighborhoods (MUN#) that is included in the study area, as coded in the Assessor data. For each area, the variable takes the value of one (1) if the parcel is within the particular area, and takes the value of zero (0) otherwise. Finally, the number of crimes per capita in a census tract (CRIMERT) provides effective information on another disamenity. Specifically, the crime rate is calculated by dividing the number of crimes that occurred in a census tract by the population of the census tract.

The data described in this section were used to run a series of hedonic regression models to estimate the marginal effect of distance to the nearest BRT station on property values. Key results from this effort are described in the following section.

TABLE 4: Descriptive Statistics – Initial Dataset

Variable Name	Description	5-Mile Buffer (n=128,717)				Half-Mile Buffer (n=5,162)			
		Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation
FAIRMKT	Assessed value of residence; in U.S. dollars	$25,000	$750,000	$82,255	$64,654	$25,000	$500,000	$87,648	$78,398
DIST	Distance (in feet) of parcel to nearest BRT station	49.71	26,400	14,818	7,247	49.71	2,640	1,807	617
LOTAREA	Size of lot in square feet	120	1,304,143	8,107	16,157	400	155,683	4,310	3,817
LIVINGAREA	Size of living area in square feet	233	11,547	1,552	628	414	7,480	1,927	749
BEDRMS	Number of bedrooms	1	7	2.95	0.80	1	7	3.39	1.05
BATHRMS	Number of full bathrooms	1	6	1.24	0.50	1	5	1.36	0.60
HALFBATHS	Number of half-bathrooms	0	5	0.36	0.52	0	3	0.33	0.51
YRBUILT	Year structure was built; represents age of the residence	n/a	n/a	n/a	n/a	1824	2008	1938	31.32
LRTDIST	Distance (in feet) from parcel to nearest light rail station	25.7	57,496	23,331	15,625	1,714.8	33,830	25,486	6,867
MDHHINC	Median household income for census tract within which the parcel is located	$7,417	$147,298	$37,806	$13,855	$13,391	$56,467	$31,406	$11,409
MIN_POP	Percent minority population for the census tract within which the parcel is located	0.6%	99.5%	18.9%	23.7%	10.8%	99.5%	44.0%	30.9%
POP_DENS	Population density (persons per square mile) of the census tract within which the parcel is located	71.6	23,734	5,538	3,525	2,113.6	19,257	9,358	3,829

TABLE 5: Descriptive Statistics – Between the Rivers Dataset

Variable Name	Description	Between the Rivers (n=44,893)				Between the Rivers Half-Mile Buffer (n=6,654)			
		Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation
FAIRMKT	Assessed value of residence; in U.S. dollars	$10,000	$750,000	$87,037	$86,180	$10,000	$750,000	$78,223	$84,251
DIST	Distance (in feet) of parcel to nearest BRT station	49.71	17,811.2	6,936.57	3,957.3	49.71	2,639.96	1,793.18	622.70
LOTAREA	Size of lot in square feet	350	570,680	5,918.5	8,272.3	400	155,683	4,156.72	3,895.76
LIVINGAREA	Size of living area in square feet	240	11,547	1,697	768	240	8,332	1,870.45	766.81
BEDRMS	Number of bedrooms	1	12	3.11	0.95	1	12	3.32	1.08
BATHRMS	Number of full bathrooms	1	6	1.29	0.58	1	6	1.33	0.59
HALFBATHS	Number of half-bathrooms	0	5	0.36	0.53	0	4	0.31	0.51
YRBUILT	Year structure was built; represents age of the residence	1826	2008	1928	25.21	1826	2006	1917.74	21.89
LRTDIST	Distance (in feet) from parcel to nearest light rail station	3710.21	86,035.01	29,627.80	9,997.00	3,710.21	71,415.53	27,681.21	7,690.91
MDHHINC	Median household income for census tract within which the parcel is located	$7,417	$90,615	$36,147	$15,766	$8,955	$56,467	$29,436.26	$11,645.55
MIN_POP	Percent minority population for the census tract within which the parcel is located	0.6%	99.5%	38.83%	32.88%	0.6%	99.5%	47.62%	31.69%
POP_DENS	Population density (persons per square mile) of the census tract within which the parcel is located	432.34	23,734.06	6,774.42	3,807.55	2,113.61	19,256.86	8,891.75	3,730.48

TABLE 6: City of Pittsburgh Wards, Boroughs, and Neighborhoods in the Study Area

Area Name	Initial Dataset		Between the Rivers Dataset			
	Half-Mile Buffer		All Observations		Half-Mile Buffer	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Swissvale	1400	27.1	2424	5.3	1548	23.3
Wilkinsburg	923	17.9	3765	8.2	1151	17.3
13th Ward (Pittsburgh)	462	9.0	2193	4.8	675	10.1
7th Ward (Pittsburgh)	601	11.6	899	2.0	649	9.8
Edgewood	523	10.1	1033	2.3	577	8.7
6th Ward (Pittsburgh)	225	4.4	535	1.2	506	7.6
14th Ward (Pittsburgh)	460	8.9	6660	14.5	504	7.6
Rankin	44	0.9	387	0.8	345	5.2
5th Ward (Pittsburgh)	155	3.0	957	2.1	217	3.3
8th Ward (Pittsburgh)	167	3.2	1120	2.4	180	2.6
12th Ward (Pittsburgh)	71	1.4	1992	4.3	149	2.2
11th Ward (Pittsburgh)	57	1.1	1820	4.0	73	1.1
3rd Ward (Pittsburgh)	63	1.2	161	0.4	66	1.0
Braddock Hills	9	0.2	654	1.4	12	0.2
2nd Ward (Pittsburgh)	2	0.0	14	0.0	2	0.0
Braddock	--	--	654	1.4	--	--
Chalfant	--	--	321	0.7	--	--
Churchill	--	--	1353	3.0	--	--
E. Pittsburgh	--	--	377	0.8	--	--
Forest Hills	--	--	2605	5.7	--	--
N. Braddock	--	--	1792	3.9	--	--
Penn Hills	--	--	4756	10.4	--	--
Wilkins	--	--	749	1.6	--	--
1st Ward (Pittsburgh)	--	--	32	0.1	--	--
4th Ward (Pittsburgh)	--	--	800	1.7	--	--
9th Ward (Pittsburgh)	--	--	573	1.2	--	--
10th Ward (Pittsburgh)	--	--	2576	7.8	--	--
15th Ward (Pittsburgh)	--	--	3691	8.0	--	--
TOTAL	5,162	100.0	44,893	100.0	6,654	100.0

NOTE: Municipality data for the 5-mile buffer in the initial data set are not included in Table 4.

RESULTS

Tables 7 and 8 present regression results from models estimated on the initial data set and the data set restricted to between the Allegheny and Monongahela Rivers. This section describes and interprets the regression results for only the final result for this effort, shown in Table 8: the half-mile buffer in the data set restricted to observations between the rivers.

Using the data set restricted to between the two rivers, it was found that the relationship between the distance to a station and property value is inverse and decreasing as distance from a station increases. Decreasing marginal effects were found; for example, moving from 101 to 100 feet away from a BRT station, property value of a single-family home increases approximately $19.00 [=-20.737+0.018(100), at a distance of 100 feet]. Moving from 1,001 to 1,000 feet away from a station increases property value approximately $2.75 [=-20.737+0.018(1000)]. Another way to interpret this result is to say that a property 1,000 feet away from a station is valued approximately $9,745 less than a property 100 feet away, all else constant (this figure is determined by summing the marginal effects for each foot of distance). This result, an interpretation of the key variable of interest in the model, is relatively large in comparison with the findings of previous literature assessing the impact of proximity to light rail transit. Factors such as spatial autocorrelation may be introducing upward bias in this result. Identifying and correcting for spatial autocorrelation, which violates the assumption of independence among observations, is a complex procedure and, while not addressed in this effort, should be addressed in subsequent efforts.

The adjusted R-squared measure indicates that approximately 80 percent of the variation in property values is explained by the independent variables; the linear model fits the data relatively well. The overall significance of the model is shown by the measure of F=845.55. With the exception of the percentage of the population in a tract that is minority, all of the variables are significant at the five percent level of significance. As noted previously, Table 7 summarizes the regression coefficients and respective heteroskedastic-robust standard errors.

As is common in hedonic housing price models, the initial results were affected by heteroskedasticity. This condition violates one of the assumptions of the classical linear regression model, known as the constant variance assumption. The constant variance assumption is also referred to as homoskedasticity and states that the variance on the unobservable error, conditional on the independent variables, is constant. Heteroskedasticity will be present if, for example, the variance of the unobserved factors affecting home values increases or decreases with one or more of the independent variables (see Wooldridge, 2003). The problem of heteroskedasticity does not bias the regression coefficients, but it does affect the standard errors, thus making it possible to declare a coefficient statistically significant when, in fact, it is not. Plots of the regression residuals, as well as tests such as the White test and the Breusch-Pagan test, indicated the presence of heteroskedasticity in the regression models estimated for this effort. Common methods such as log transformations of the variables, and procedures including weighted least squares and feasible generalized least squares, failed to correct for the heteroskedasticity. Therefore, the regressions were estimated using heteroskedastic-robust procedures which adjust the standard errors when the form of heteroskedasticity is unknown.

To further explore the accuracy of the model, the magnitudes of the coefficients of the other determinants of property values are observed and interpreted. At the mean distance from a light-rail station, 5.24 miles, if a residence is located 100 feet closer to light rail, then its property value increases by $1,261. There is a statistically significant, yet very small in magnitude, decreasing marginal effect with increasing distance from a station. As mentioned above, variables were included measuring the distance to the CBD and the distance to the nearest access to an interstate. These variables were highly correlated with distance to light rail transit, and were hence dropped from the regression model. Nonetheless, the coefficient on light rail distance can be understood as signifying the increase in the property value coinciding with being located 100 feet closer to downtown Pittsburgh, since the light rail transit is located in the heart of the CBD. Figure 9, shown previously, illustrates where the East Busway corridor lies in relation to the Pittsburgh CBD, the T light rail system, and the area interstates.

If a residence is located within one-tenth of a mile of the nearest interstate right-of-way its property value falls by $6,379.77 on average. This finding corresponds with the expectation that there is a negative impact on a property's value if it is located very near the highway due to the effect of disamenities such as noise and pollution. Similarly, if a residence is located within one-tenth of a mile of the East Busway runningway, on average, its property value is $5,904.79 less than if it were located elsewhere. This result is likely influenced by the presence of the Norfolk Southern railroad adjacent to the busway corridor; although, it should be noted that the rail line is completely grade-separated within the corridor and there is no noise from train horns at crossings (Wohlwill, 2009).

Regarding some of the neighborhood characteristics, an increase of one dollar in the median income of a census tract results in an increase in property value of $1.66, on average. The variable controlling for the percentage of the population that is minority is insignificant in this model; as such, its magnitude shall not be discussed herein. In assessing the effect of population density, according to the model results, an increase of one additional person per square mile reduces property value by $1.44, on average. Because crime data were not available for all of the tracts/municipalities and state average data were used to fill in the gaps, the resulting coefficient for the crime rate per capita was dropped from the model due to the data problems.

For the variables associated with the property itself, it was found that, an increase of one additional square foot of living area increases a home's value by $33.87, on average. This result was obtained by taking the derivative of the property value with respect to living area [=19.718 + 4.264(3.32)], where 3.32 is the mean number of bedrooms in the data. There is a much smaller increase in property value associated with an increase of one additional square foot of lot area, as might be expected: one additional square foot of lot area yields an increase in property value.

Similar to the example above, it can be estimated that, at the means of the data, an additional bedroom reduces the property value by $4,649.31, holding living area constant. [By taking the derivative of the property value with respect to the number of bedrooms this value is computed (=-12,624.90+4.264(1870.45)), where the mean living area is 1,870.45 square feet.]. It was expected that, by allowing the number of bedrooms to vary with square feet of living area, property value would increase with additional bedrooms. The data are characterized by many smaller, older homes with a relatively large number of (smaller) rooms. Even when controlling for age of the structure and neighborhood, the result persists. For these data, this result cannot be further explained.

Having an additional full bathroom increases property values by $15,494.32. This result is very reasonable given that most residences in the data have only one full bathroom. Similarly, having an half bathroom is associated with an increase in property value of $11,737.23.

The typical single-family residence in this dataset is in either average or fair condition. A unit increase in the likert-scale increases property value by $18,069.89, on average. This result is quite reasonable since a unit increase would allow the typical home to be reclassified as being in either good or average condition. Most residences in the data are fairly old since the mean year a residence was built is 1918. If a residence were built one year later, its property value would increase by $347.35, all else equal.

The remainder of the variables in the model control for borough, city ward, or neighborhood. It was found that they are jointly significant (at the five percent level of significance) indicating that, as a group, they are statistically significant determinants of property value. Generally, these coefficients are interpreted in relation to a base category, in this case Pittsburgh's 13th Ward. For example, the fair market value of a single-family home in Pittsburgh's 14th Ward would be about $13,181 less than a single-family home in the City's 13th Ward, all else constant.

TABLE 7: Initial Regression Model Results

Variable	Description	Initial Dataset	
		5-Mile Buffer	Half-Mile Buffer
		Coefficient *Standard Error*	Coefficient *Standard Error*
Constant	Constant term in regression equation	-89,933.256* *1,194.532*	-30,315.91* *10,455.34*
DIST	**Distance (in feet) of parcel to nearest BRT station**	**-0.836*** ***0.071***	**-10.125*** ***4.038***
DIST_SQ	Distance (in feet) of parcel to nearest BRT station squared	+2.730E-5* *0.000*	+0.00567* *0.00128*
LOTAREA	Size of lot in square feet	+0.234* *0.007*	+1.577* *0.630*
LIVINGAREA	Size of living area in square feet	+8.806* *0.456*	+20.403* *3.419*
BEDRMS	Number of bedrooms	-24,764.738* *239.798*	-7,561.027* *1,875.338*
BED*LIVA	Interaction term multiplying the number of bedrooms by the living area	+11.060* *0.104*	+2.328* *0.922*
BATHRMS	Number of full bathrooms	+22,169.376* *256.487*	+18,351.820* *1,376.817*
HALFBATHS	Number of half-bathrooms	+14,248.354* *213.642*	+13,184.660* *1,323.291*
YRBUILT	Year structure was built; represents age of the residence	n/a	+24.780 *20.532*
LRTDIST	Distance (in feet) from parcel to nearest light rail station	-.311* *0.026*	-7.571* *2.352*
LRTDIST_SQ	Distance (in feet) from parcel to nearest light rail station squared	-4.782E-6* *0.000*	+0.00004 *0.00004*
HOMECOND	Condition of home ranked from very poor to excellent	+18,943.451* *147.413*	+20,186.160* *790.773*
BRTBUFZN	Takes value of 1 if parcel is within 0.1 mile of BRT right-of-way; 0 otherwise	n/a	n/a
HWYBUFZN	Takes value of 1 if parcel is within 0.1 mile of interstate right-of-way; 0 otherwise	-1,458.587* *339.827*	-18,889.200* *2,548.395*

*Significant at the 5 percent level of significance with robust standard errors.

TABLE 7: Regression Model Results, continued

Variable	Description	Initial Dataset	
		5-Mile Buffer	Half-Mile Buffer
		Coefficient *Standard Error*	Coefficient *Standard Error*
MDHHINC	Median household income for census tract that includes the parcel	+1.898* *0.009*	+2.163* *0.119*
POP_DENS	Population density (persons per sq. mile) of the census tract that includes the parcel	+0.174* *0.038*	-1.193* *0.304*
MIN_POP	Percentage of minority residents in the census tract within which the parcel is located	n/a	n/a
Braddock Hills	Takes value of 1 if parcel is located in the listed area; 0 otherwise	n/a**	+106,338.4* *30,370.08*
Edgewood			+93,307.81* *30,543.96*
Rankin			+126.055.8* *30,617.43*
Swissvale			+98,553.96* *30,133.44*
Wilkinsburg			+96,795.32* *30,048.03*
2nd Ward			-43,826.99* *4,530.992*
3rd ward			n/a (base)
5th Ward			-46,338.68* *14,792.83*
6th Ward			-32,128.51* *15,778.82*
7th Ward			+123,762.8* *24,875.13*
8th Ward			+35,983.71 *23,675.02*
11th Ward			+47,723.29 *26,764.67*
12th Ward			+56,719.85* *28,788.54*
13th Ward			+88,897.23* *29,805.48*
14th Ward			+67,760.02* *29,820.15*

*Significant at the 5 percent level of significance with robust standard errors.
**Wards and neighborhoods were included in this regression; coefficients are not shown in the table due to the high number of dummy variables in this larger data set.

TABLE 8: Final Regression Model Results: Between the Rivers (1/2-Mile Buffer)

Variable	Description	Between the Rivers Dataset: Half-Mile Buffer Coefficient *Standard Error*
Constant	Constant term in regression equation	-482,388.740* *52.380.763*
DIST	**Distance (in feet) of parcel to nearest BRT station**	**-20.737*** ***4.441***
DIST_SQ	Distance (in feet) of parcel to nearest BRT station squared	+0.009* *0.001*
LOTAREA	Size of lot in square feet	+1.342* *0.134*
LIVINGAREA	Size of living area in square feet	+19.718* *1.769*
BEDRMS	Number of bedrooms	-12,624.904* *994.668*
BED*LIVA	Interaction term multiplying the number of bedrooms by the living area	+4.264* *0.390*
BATHRMS	Number of full bathrooms	+15,494.318* *1,012.086*
HALFBATHS	Number of half-bathrooms	+11,737.230* *1,021.793*
YRBUILT	Year structure was built; represents age of the residence	+347.353* *25.317*
LRTDIST	Distance (in feet) from parcel to nearest light rail station	-12.610* *1.036*
LRTDIST_SQ	Distance (in feet) from parcel to nearest light rail station squared	0.000* *0.000*
HOMECOND	Condition of home ranked from very poor to excellent	+18,069.891* *603.436*
BRTBUFZN	Takes value of 1 if parcel is within 0.1 mile of BRT right-of-way; 0 otherwise	-5,904.787* *1,582.798*
HWYBUFZN	Takes value of 1 if parcel is within 0.1 mile of interstate right-of-way; 0 otherwise	-6,379.786* *2,768.706*

*Significant at the 5 percent level of significance with robust standard errors.

TABLE 8: Final Regression Model Results: Between the Rivers (1/2-Mile Buffer), cont'd

Variable	**Description**	**Between the Rivers Dataset: Half-Mile Buffer** Coefficient *Standard Error*
MDHHINC	Median household income for census tract that includes the parcel	+1.663* *0.140*
POP_DENS	Population density (persons per sq. mile) of the census tract that includes the parcel	-1.435* *0.246*
MIN_POP	Percentage of minority residents in the census tract within which the parcel is located	-1,387.205 *4,873.580*
Braddock Hills	Takes value of 1 if parcel is located in the listed area; 0 otherwise	+13,236.827 *11,990.851*
Edgewood		+16,335.519* *3,962.432*
Rankin		+35,731.414* *4,277.901*
Swissvale		+16,195.273* *3,452.937*
Wilkinsburg		+9,867.706* *2,340.902*
2nd Ward		-174,520.963* *30,604.315*
3rd ward		-167,216.098* *15,912.107*
5th Ward		-154,407.454* *10,385.292*
6th Ward		-132,826.396* *8,646.573*
7th Ward		+51,606.962* *4,975.952*
8th Ward		-60,452.493* *5,558.286*
11th Ward		-47,381.226* *5,395.659*
12th Ward		-26,976.920* *4,049.375*
13th Ward		n/a (base)
14th Ward		-12,969.511* *4,122.652*

*Significant at the 5 percent level of significance with robust standard errors.

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CONCLUSION

This report describes an effort to quantify the impacts of BRT stations along the Pittsburgh Martin Luther King, Jr. East Busway on the values of surrounding single-family homes. The hypothesis was that BRT stations have an impact on property value that is commensurate with rail transit projects considering the level and permanence of services and facilities. It was found that the relationship between the distance to a station and property value is inverse and decreasing as distance from a station increases. Decreasing marginal effects were found; for example, moving from 101 to 100 feet away from a station, property value increases approximately $19.00, while moving from 1,001 to 1,000 feet away from a station increases property value approximately $2.75. Another way to interpret this result is to say that a property 1,000 feet away from a station is valued approximately $9,745 less than a property 100 feet away, all else constant (this figure is determined by summing the marginal effects for each foot of distance). This result is somewhat large in comparison with the findings of previous literature assessing the impact of proximity to light-rail transit. There may be some factors introducing upward bias in this key result which could be identified and accounted for in a subsequent effort. Future research should explore a refined methodology and include applications to other U.S. cities with BRT.

The results described in this report are only valid for the data used in Pittsburgh's case, and represent one of the first studies of the impacts of BRT stations on property values in recent years in the United States. Results from quantitative modeling efforts such as those generated from this effort can be used along with other types of studies as well as anecdotal evidence to develop overall assessments of BRT's impacts on land uses and property values. As more BRT systems continue operating over time in the United States, the methodology used for this effort needs to be applied to other cities, as well as to other types of properties (both residential and commercial). Further applications will grow the body of literature and help policymakers and those in the transit industry gain a better understanding of the overall impacts of proximity to BRT stations on property values, land uses, and economic development.

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