Capitalization of BRT network effects into land prices

Daniel A. Rodríguez PhD, Carlos H. Mojica, MST

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Abstract

A generalized before-and-after evaluation relying on hedonic models is used to value the network and the local access effects of an extension to Bogotá's BRT system. Properties already served by the BRT but benefiting from the enhanced regional access provided by the extension are used to assess the network effects of the investment, relative to properties in a control area. Similarly, properties previously without walking access to the BRT but now served by the extension are used to determine the local effects relative to their control counterparts. Results suggest that properties offered during the year the extension was inaugurated and in subsequent years had higher asking prices ranging between 15% and 20% relative to properties in the control area. For the local access effect, asking prices did not appear consistently higher after the BRT service was introduced. Limitations of the study and implications of the findings are discussed.

About the Authors

Dr. Rodriguez is the Director of the Carolina Transportation Program (ctp.unc.edu) and Associate Professor in the Department of City and Regional Planning at UNC-Chapel Hill. His research focuses on the connection between transportation systems and land development and on understanding the relationship between the urban environment and behavior. His work has been funded by the Robert Wood Johnson Foundation, the Environmental Protection Agency and the NC Department of Transportation among others. He is the author of more than 35-peer reviewed publications in the transportation area and a co-author of the 5th edition of the book *Urban Land Use Planning* (University of Illinois Press).

Dr. Rodríguez is currently appointed to three standing committees of the National Academies' Transportation Research Board. Professor Rodríguez has been the recipient of the Transportation Research Board's Fred Burggraff Award (2000) and the Eno Foundation Fellowship (1998). He has worked internationally for the World Bank and the Universidad de los Andes, Bogotá, Colombia. Dr. Rodríguez is also an Eno Transportation Foundation Leadership Fellow and a Fellow at NYU's Institute for Civil Infrastructure Systems. He serves in the editorial board of prestigious journals like the Journal of the American Planning Association, Journal of Transport and Land Use, Journal of Architectural Planning and Research and Landscape & Urban Planning.

Carlos Mojica received a BS degree in Civil Engineering from Universidad de Los Andes (Colombia) in 2004, and is currently a dual-degree candidate for a Master's in Urban Studies and Transportation Science from the Massachusetts Institute of Technology (M.I.T.). Since 2005 he has participated as a research assistant and teaching assistant with the Department of Urban Studies and Planning and the Civil and Environmental Engineering Department (CEE). His research interests include public transportation, interaction of land use and transportation systems, and transportation finance. He has also worked for the Inter American Development Bank in the Finance and Infrastructure Division and for the Chicago Transit Authority in the Strategic Planning Department. He participated in Colombia in the planning and development of transportation and housing projects as a civil engineering practitioner.

Daniel A. Rodríguez PhD
Department of City and Regional Planning
University of North Carolina, Chapel Hill
CB 3140, Room 319
Chapel Hill, NC 27599-3140
Phone: 919-962-4763
e-mail: danrod@unc.edu

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Table of Contents

Capitalization of BRT network effects into land prices

1. Introduction

Planners and policy-makers continue to show renewed interest in coordinating transportation investments and land development in order to provide alternatives to automobile commuting, and to decrease its negative effects. Terms such as "smart growth," "transit-oriented development" and "livable communities" embody the belief that the accessibility advantages provided by public transportation can be coordinated with compact land development. This development, in turn, is expected to support and reinforce the viability of public transit and other non-automobile transportation modes.

Simultaneously, the re-emergence of high service level bus systems is revolutionizing transit systems around the world. Bus rapid transit (BRT) is a bus-based mass transportation system that delivers comfortable, cost-effective mobility emulating rail transit (Wright and Hook 2007; p. 11). It relies on coordinated improvements in technology, infrastructure and equipment to deliver a high quality level of treatment for buses (US General Accounting Office 2001). Twelve Latin-American cities in Brazil, Chile, Colombia, Ecuador, Guatemala and Mexico, three Australian cities, seven US cities, eight Asian cities and eighteen European cities have BRT systems in place. BRT systems actively under construction span the globe: From Dar es Salaam in Tanzania, Jinan in China, Bologna in Italy, Mérida in Venezuela to Auckland in New Zealand. GTZ estimates that as of March 2007, there are at least 27 cities with active planning processes for building a BRT system and another 14 systems that are considering expansions (Wright and Hook 2007).

The dramatic success of BRT is partly due to the cost-effectiveness and relative flexibility of the investments required. BRTs often can mobilize as many passengers as most conventional light rail systems at a fraction of the cost. BRTs also compare well with heavy rail systems, except under circumstances of very high passenger demand exceeding 50 000 passengers per hour per direction on a line. As rail systems, however, the cost-effectiveness of BRT hinges on the ability to have supportive land uses that concentrate demand along system corridors. Therefore, in most cases BRTs have been built in corridors with proven demand. Yet, it is plausible that BRTs also attract dense development that will in turn benefit the BRT system in the future. This reciprocal connection between BRT investments and land development has been a cornerstone of Curitiba's development. Despite the importance of this connection for the future viability and cost-effectiveness of BRTs, however, there is limited empirical evidence to support or dismiss the relationship between BRT investments and changes in development. Although this relationship is critical to the potential of BRT as a catalyst for urban growth and redevelopment, a recent World Bank (2000) study observed, 'the impacts of busways on land use and city structure have been little researched'.

The present study addresses practical and conceptual gaps in the previous literature to investigate the relationship between accessibility to BRT and its capitalization into residential home values using a generalized before and after evaluation. In a market economy, changes in land values are a first step in instigating investment decisions by land developers. We rely on geographic information systems to measure accessibility to BRT lines and distance to the right-of-way as a proxy for its deleterious effects.

The study has two aims. First is to quantify, for properties already served by BRT, the land value changes resulting from BRT network expansions occurring elsewhere in the city. In other words, the intent is to measure how the network effects of BRT expansions are capitalized onto land values of properties already served by BRT. To our knowledge, this effect has never been examined for BRT systems, yet BRT network expansions are actively planned for many cities worldwide. The second aim is to determine the capitalization of BRT investments into land values when BRT system extensions directly serve properties that were previously not served by the system.

In the next section, we review the literature regarding the expected impacts of transportation investments, generally, and BRT in particular. The third and fourth sections discuss the hedonic analysis methodology employed and the data collected. Results of the empirical analysis and conclusions are provided in the last two sections of the report.

2. Literature review

Land rent theory, advanced in an urban context by Alonso (1964) and Muth (1969) is commonly used to understand the relationship between the accessibility benefits of transportation investments and land values. The core assumption is that households are willing to trade off purchases of accessibility, land area, and other attributes. As such, transportation investments are expected to provide accessibility advantages to certain parcels over others. Because the number of parcels benefiting from enhanced access is finite, and assuming that access is a scarce good, households and firms valuing such benefits in a competitive market are expected to be willing to pay more for properties with good access over other properties, all else held equal. As a result the access benefits provided by a transportation investment are expected to be capitalized into property values.

Recent evidence suggests that transportation investments are associated to higher property values. In the previous five years alone, several studies have related land values to urban transportation investments (Table 1). Access premia consistent with theory have been identified for Seoul, London, San Diego and the Massachusetts suburbs. However, other studies have failed to identify appreciable effects. Local land market characteristics, omitted variables, and the specification of access to the transportation infrastructure may contribute to explaining differences in results across studies.

For BRT, much of the discussion around the topic of the land value impacts of BRT is based on theoretical expectations (The World Bank 2000; Polzin and Baltes 2002). Aside from the case of Curitiba where BRT has been a cornerstone in the formulation of an integrated transport-land use strategy (Rabinovitch and Leitman 1996), the evidence to date regarding the relationship between BRT and land values is limited. The first study examined HOV-bus lanes in Washington, D.C., California, Seattle, and Florida (Knight and Trygg 1977) using previously published reports, interviews, aerial photos, and other secondary sources available to conclude that exclusive bus lanes incorporated into highways appear to have no land use impacts upon either residential or commercial development. Mullins et. al. (1990) found that only the BRT in Ottawa, Canada appear to have some effect upon land development in areas surrounding stations. For the rest of the cases analyzed by Mullins et al (Houston, Pittsburgh, San Francisco), the findings were consistent with the findings of Knight and Trygg (1977). More recently, a hedonic analysis applied to LA's first-year with BRT (Cervero and Duncan 2002) did not detect any evidence of benefits having accrued to nearby multi-family parcels, although the lack of exclusive right of way and the newness of the service partly explain these findings.

Considered by many as a premier example of BRT (Cain et al. 2006), Bogotá's BRT system has been the focus of at least four studies of the land value impacts of its BRT system. The first study relied on asking prices for apartment rentals to estimate spatial hedonic price models of BRT station access and land values in 2003 (Rodríguez and Targa 2004). Accounting for spatial autocorrelation, the authors detected a premium of 6.8 to 9.3% for every 5 minutes walking time closer to BRT station. In the second study, Muñoz-Raskin used data on property values provided by a local housing agency to determine that properties in the immediate walking proximity (0-5 minute walk) valued more the access to feeder lines compared to properties in a 5-10 minute walk distance (Muñoz-Raskin 2006). His findings also show that high income properties were valued if they were in close proximity to a feeder line, but in the case of trunk lines, the effect was the opposite.

The third study was completed in 2007, using assessed property values from cadastral data to examine the relationship between distance to the BRT and property values (Mendieta and Perdomo 2007). Assuming walking speeds of 4.39 km/h (Knoblauch, 1996), results show that property prices increased between 0.12% and 0.38%, depending on the distance to the BRT, for every 5 minutes walking time closer to BRT station. The fourth and final study 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% for properties with BRT access was detected at a 95% level of confidence.

Although the evidence to date of the relationship between BRT and property values provides a base to build on further research, its ability to inform policy remains limited. For example, all studies to date rely on cross-sectional data. As a result, it is impossible to isolate whether the BRT caused the land value change, or whether planners sited the station in locations that were already valued by residents. Furthermore, despite the interest of policy-makers in expanding established BRT systems and finding ways to finance them, no studies have examined whether expansions provide benefits to properties that were already served by the BRT system. The potential benefits accruing from improved connectivity to other parts of a city fall under the definition of a "network effect" (Katz and Shapiro 1994). Although such effects are pervasive in transportation networks (Garrison and Levinson 2006) their capitalization onto land values has been poorly studied. Particularly for high-quality transit service, whether regional access improvements are capitalized onto values of properties benefiting from existing service will determine the viability and extent of using value capture techniques to recoup some of the windfall capitalization enjoyed by these property owners.

In summary, although BRT is being embraced as an innovative solution for urban transport and urban redevelopment, some questions about the usefulness of BRTs for influencing urban form remain. Although the research available suggests that the land development impacts of recent BRT investments may be important, the cross-sectional designs and omitted variables remain a concern. Therefore this study is animated by the lack of existing research regarding the nature and magnitude of land value changes due to public-sector investments in BRT, and the increasing relevance of BRTs as transportation mobility solutions for several cities around the world. As a result, our hypotheses are: 1) Properties already served by BRT capitalize onto land values changes resulting from BRT network expansions occurring elsewhere in the city; and 2) properties benefiting from new access to a BRT station that before did not have such access are expected to exhibit to capitalize such access, all else held equal.

3. Methods

We apply a generalized before-and-after approach to hedonic price functions (Rosen 1974) to test the hypotheses. In a hedonic model, properties are characterized as a set of complex heterogeneous goods. Each property consists of an inseparable bundle of homogeneous goods or attributes that differ in values and characteristics. The underlying theory for the market of heterogeneous goods states that the price of the good is a function of the levels or value of each attribute in the bundle.

Hedonic price functions allow us to estimate prices of attributes that are not explicitly exchanged in observable market transactions. In the housing market, these attributes are usually structural and site characteristics of a property. Characteristics of the neighborhood area, quality of local services, and locational attributes such as accessibility to transportation systems or centers of activity are also part of the bundle of attributes. Similarly, hedonic price functions can include temporal variables that measure variations in market conditions that influence prices, including changes due transportation investments and accessibility. In our case, the transportation investment either extends BRT service to other parts of the city (Hypothesis 1) or brings BRT service (and a station) within reasonable access distance of a set of properties (Hypothesis 2).

To test our first hypothesis, we use properties that before had access to a BRT station but that now benefit from the expanded reach of a BRT system due to extensions in the network. For the second hypothesis we focus on BRT system extensions that bring service to properties previously without walking access to the system.

Following McDonald and Osuji (1995) the empirical relationship to be evaluated is the value of residential properties as a function of property attributes, of the general form:

$$V_i = c + \sum_j \beta_j \cdot X_{ij} + \varepsilon_i \qquad (1)$$

where V_i is the nominal value of the *i*th property, X_{ij} is the *j*th attribute for the *i*th property, β_j is the estimated implicit empirical marginal price for the *j*th attribute, c is the intercept constant term, and ε_i is the random error term. Equation (1) can be generalized to account for the year when properties were offered. If data are available for time periods before and after the investments were made, then changes in values associated with the BRT intervention could be detected. Thus, an equation for each year when properties were sold would be estimated.

The data used to estimate the yearly equations can be pooled to provide added flexibility in comparing parameters across years and gain efficiency. Assuming that the coefficients β_j of each attribute X_{ij} remain unchanged across time, the resulting pooled equation can be written as:

$$V_i = c + \sum_j \beta_j \cdot X_{ij} + \alpha_2 \cdot year_{i2} + \alpha_3 \cdot year_{i3} + \alpha_4 \cdot year_{i4} \ldots + \alpha_t \cdot year_{it} + \varepsilon_i \qquad (2)$$

where $year_{it}$ are dummy variables such that they take the value of one for observations offered in the *t*-th year and zero otherwise, and α_t is the estimated coefficient for each dummy variable. The dummy variable for $year_{i1}$ (the first year) is excluded from the equation. The coefficients α_t determine the yearly appreciation of land values, after controlling for all other observables. In terms of our hypotheses, a larger increase in property values is expected for years after the BRT investment.

One limitation of equation (2) is that the effect of inflation and other secular changes in the property market cannot be isolated from the appreciation caused by the BRT investments. In other words, it may be that prices increased because the overall land market in the city was improving, not because of the BRT investment. As a result, in addition to having property date for time periods before and after for the areas affected by the investment (an intervention area), we also include in our analysis properties from an area not directly contaminated or affected by the BRT investments (a control area).

The derivation of the pooled hedonic equation that includes control and intervention areas follows the same logic as the derivation of equation (2), except that we assume further that the implicit prices for each attribute X_{ij} are similar in both the control area and the intervention area. The resulting equation can be written as:

$$V_i = c + \sum_j \beta_j \cdot X_{ij} + \alpha_2 \cdot year_{i2} + \alpha_3 \cdot year_{i3} + \alpha_4 \cdot year_{i4} \ldots + \alpha_t \cdot year_{it} + \lambda_2 \cdot year_{i2} \cdot I + \lambda_3 \cdot year_{i3} \cdot I + \lambda_4 \cdot year_{i4} \cdot I \ldots + \lambda_t \cdot year_{it} \cdot I + \varepsilon_i \qquad (3)$$

where I is a dummy variable such that it takes the value of zero for observations in the control area and the value one for observations in the intervention area. The coefficients for $\lambda_2 \ldots \lambda_t$ measure the estimated appreciation of property values by year for the intervention zone after controlling for property value appreciation during the same year in the control zone. Compared to each other, the coefficients $\lambda_2 \ldots \lambda_t$ determine changes in appreciation before and after the investment, for the intervention zone.

The assumption that implicit prices for property attributes are the same across time and between intervention and control areas may be inappropriate. This assumption can be formally tested by interacting either the year dummy variables or the intervention dummy variable (or both) and the suspected property attribute(s), thereby introducing additional variables to the model.

Finally, estimation of equations (2) and (3) by means of OLS regression is optimal only when a number of assumptions are satisfied and as a result we also will account for two different forms of spatial autocorrelation that may occur. One form is related with a lag term on the dependent variable. The other one occurs when the error term follows a spatial autoregressive process. Anselin (1993) defines the former as substantive spatial dependence, and the latter as spatial error dependence. The estimated coefficients will be biased under substantive spatial effects, while for spatial error dependence the coefficients will be inefficient but remain unbiased. Our approach is therefore to diagnose the presence and type of spatial autocorrelation by means of Lagrange multiplier tests (Anselin and Getis 1992) and their robust counterparts (Anselin et al. 1996). Where spatial autocorrelation is detected, we use maximum likelihood methods to estimate a spatial hedonic price function, one that incorporates the same functional form as the OLS model, while simultaneously accounting for the specific type of spatial autocorrelation detected.

4. Study area

Data comes from a sample of properties in the Bogotá metropolitan area between 2001 and 2006. Bogotá's BRT was inaugurated in December 2000, with extensions occurring on June 2001, December 2003, July 2005 and April 2006. The December 2003 extension, along Avenida de las Americas, provides the setting for the study. To test the first hypothesis, we used a convenience sample of properties that were within 1 km of the BRT system before December 2003 and that benefited from the network effects of the system expansion. Properties along the Avenida Caracas and Calle 80 BRT lines, shown in Figure 1, satisfy this requirement. To test the second hypothesis, we relied on properties within 1 km of Avenida de las Americas. These properties did not have local BRT access prior to December 2003 and benefited from the extension BRT extension. Properties in the control area are not served, or planned to be served, by the BRT or by other major transportation infrastructure investments. Figure 1 shows the study areas for hypothesis 1, hypothesis 2 and the area that serves as a control for both areas.

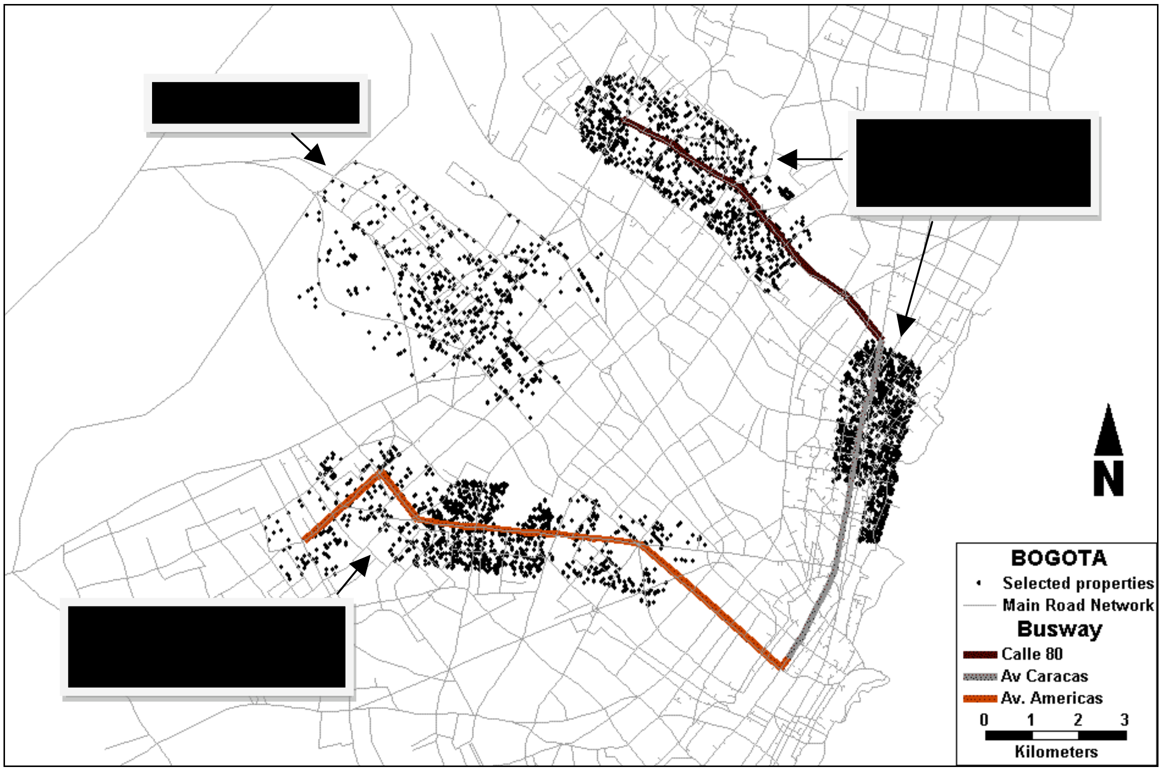

Figure 1. Selected properties in the land market (2001-2006)

Property data come from a web portal in which real estate agents in Bogotá list properties for sale and rent (www.metrocuadrado.com). We focus exclusively on all residential properties listed in the database: single-family (attached and detached) and units in multi-family apartments. Data include the property latitude and longitude, property attributes (age, type of property, floor area, number of rooms, number of garages and number of bathrooms) and asking price. Latitude and longitude allowed for the calculation of distance to the BRT right of way, relevant land uses, and related situational characteristics of each property.

4.1 Dependent variable

The dependent variable is the natural logarithm of the nominal advertised selling price. The use of log transformed dependent variable is helpful in reducing heteroscedasticity as frequently it compresses the scale in which the dependent variable is measured. One limitation of using the price at which the owner or manager is offering the property for sale as a dependent variable is that is not directly linked to an equilibrium price, where supply and demand for properties have cleared. Although we explored ways of gathering information on actual selling price or actual rental prices, privacy and security concerns prevented us from collecting it. This, however, is not the only study where asking prices are used as a dependent variable in a hedonic analysis. Other studies using hedonic price models to relate transit station accessibility to residential land values (Cheshire and Sheppard 1998; Henneberry 1998; Benjamin and Sirmans 1996; Du and Mulley 2007; Rodriguez and Targa 2004) or to commercial property land values (Cervero and

Susantono 1999) have also relied on asking prices. The approach assumes that the same influences on asking prices will apply to actual or market prices; that is, the former is a good proxy for the latter.

4.2 Independent variables

Because properties included in this study were offered between January 2001 and December of 2006, five dummy variables, one per year, were included in the model, with the year 2001 as the reference category. As presented in the methods section, the variables of interest are the year variables interacted with a dummy variable indicating whether the property belongs to the intervention area. Six interactions were included in the model, one per year beginning with year 2001 (*INTX2001, INTX2002, INTX2003, INTX2004, INTX2005* and *INTX2006*). To reiterate, the estimated coefficients for these variables measure the asking price increase by year for the intervention zone relative to the control zone. Compared to each other, the coefficients also determine changes in appreciation before and after the BRT investments.

We controlled for several structural attributes of the property like the type of property (house or apartment), its approximate age coded as a set of dummy variables (new – reference category, 0-10 years old, 10-20 years old, or more than 20 years old), number of rooms, number of bathrooms, number of garages (if any), the floor area (square meters) and, if an apartment, the floor in which the unit is located. The original data was notoriously incomplete for type of property and age attributes, so these values were imputed by best-subset regression, and dummy variables taking the value of one were created for each observation with imputed data and zero when the observation had full data.

For a property's access to regional activity centers, we measure the road distance to Bogotá's Central Business District (CBD), defined as the downtown BRT station located in Calle 13. Although a second extended business district exists further north, a variable measuring access to this second center was highly collinear with the first measure, and thus the first measure was the only regional access measure used.

In addition to property information we used contemporaneous information (before and after the BRT extension) on demographic, social, land use, housing, homicides (per thousand residents), and transportation services of the neighborhood in which the property is located, as available. This required that data be collected from a variety of public and private organizations, including the DANE, the Centro Interdisciplinario de Estudios Regionales at Universidad de los Andes, TransMilenio, and Bogotá's Planning and Police Departments. The process of linking and calculating neighborhood variables relied on a definition of neighborhood as the 250m circle around each property. Since the resulting buffer can cut through one or more boundaries, each neighborhood attribute was calculated as the average value of the boundaries intersected by the buffer, weighed by area of each boundary contained in the buffer.

Neighborhood variables include socio economic stratum (SES), which is a direct measure of tax payments, utilities and related charges. SES was specified as a continuous variable, ranging from 1 (low) to 6 (high). We also control for population density, along with the land uses in the neighborhood measured as percentage of all area devoted to commercial, industrial, institutional, park/open space uses and vacant or abandoned lots. Personal safety was measured by linking each property's data with the number of homicides per 100 residents.

Two final types of variables were included to account for the effect of proximity to roads on property values. The first (*PROX150M*) is a dummy variable that accounts for the potential negative effects of proximity to the BRT right of way. Properties located too close to the right of way can expect lower sale prices because of high noise and pollution levels (Rodríguez and Targa, 2004). The second type of variable was created to control for the relative access to non-BRT competing bus services operated on other major roads. For such properties, changes in accessibility brought by the BRT may not be as valued as in properties with limited access to other public transportation choices. Hence, six dummy variables (*CRA7, CLL72, AV_CCALI, AVBOYACA, AV68, CRA50* and *AV_LONG*) indicating whether a property is within a 500m buffer of a major road with competing public transportation were included in the model. Table 2 provides a summary of all variables used in the analysis and their sources.

5. Results

Table 3 summarizes selected characteristics of properties used to test the two hypotheses. Properties are divided in three groups: Properties in the control area, properties expect to benefit from the network effects of the system expansion (hypothesis 1) and properties expected to benefit from the local access effects of the extension (hypothesis 2). Properties are also divided in two time groups based on the date the property was offered for sale, before or after the Dec 2003 intervention. This spatial and temporal comparison is important for examining differences among the real estate submarkets.

Properties in the network effects area are more expensive than those of the other two areas before and after ($p>0.00$), but properties in the local access area had similar prices to the control area before ($p= 0.60$) and after ($p= 0.67$). Asking prices increased at different rates across the three areas. Properties in the control area appreciated an average of 7.7% between the before and after periods, whereas properties in the network effects area appreciated 5.1% and properties appreciated 9.5% for the local access effects area for the same period. The hedonic models will determine the degree to which these changes in prices reflect overall price increase sin the real estate market or the impact of new public amenities such as the BRT expansion, or other secular trends.

Price differences across areas may be the result of differences in the structural and neighborhood attributes of properties. Table 3 shows that properties in the three areas have similar number of rooms and bathrooms. However, the network effects area has larger properties than the other two areas. Properties in the local access area appear newer than properties in the other two areas, although some of these data are imputed.

For neighborhood attributes all areas have similar neighborhood SES. The control area has significant amounts of industrial uses (22.7%) and vacant lots (14.1%), relative to the other two areas (network effects area: 0.5% industrial and 0.8% vacant; local access area: 13.7% industrial and 7.0% vacant), even though population densities are similar. The control and local access areas have little or no commercial uses, while the network effect area has a more balanced mix of residential and commercial land uses. In terms of homicides, the network effects area has a rate of 72.8 homicides per 1000 residents, whereas rates the local access area (198.5) and the control area (155.9) have substantially higher rates. Finally, Table 3 shows that properties in the three areas are an average of 8.1 to 9.3 km from the CBD (Calle 13 Station), while 18% of properties in the network effects are and 25% in the local access area are within 150 m of the BRT right of way.

5.1 Price changes due to network effects of BRT system extensions

Results from four different models are presented in Table 4. The first is an ordinary least squares model with robust standard errors, while the second one is a weighted least squares (WLS) model. The OLS model showed significant spatial dependence in the form of both a spatial lag and spatial error, according the robust Lagrange Multiplier tests ($p<0.00$). Hence, the third and fourth models control for spatial dependence in the forms of lag and error, respectively. The spatial weights matrix for the last two models was created using a row-standardized spatial weights matrix defined on observations within a 0.5 km distance of each individual property. The *W_LOGPRICE* variable in Table 4 is the spatial lag of the dependent variable. The variable *LAMBDA* represents the instrumental variable that accounts for the spatially depending error.

Beginning with the variables measuring price changes per year (*YR_2002* to *YR_2006*) with respect to the baseline year 2001, we find little evidence of price changes until 2005. By contrast, for 2005 the WLS model suggests an appreciation of 8.8%, and for 2006 the WLS and the spatial lag model show an appreciation of 12.2% and 10.3% relative to 2001 prices, respectively. The price variations shown appear to be a good representation of Bogotá's market at the beginning of the decade, when the country was experiencing a strong economic recession. Figure 2 shows the variation of Bogotá's real estate consumer price index as published by the National Statistical Department (DANE). For comparison, price changes are shown in percentage terms relative to the first trimester of 2001. Consistent with our results, only by 2004 there is evidence of city-wide appreciation of real estate property.

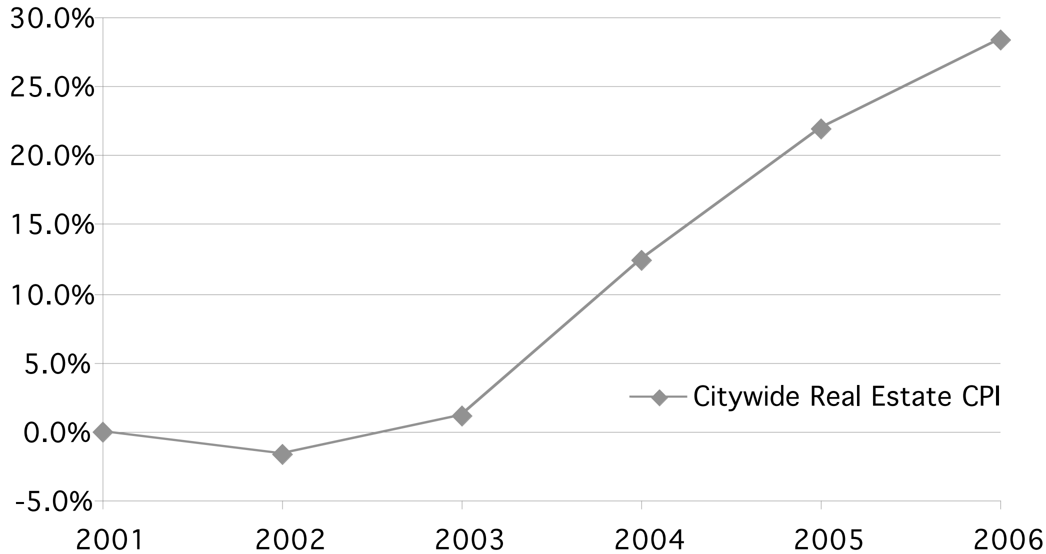

Figure 2 Changes in citywide property prices (source: DANE)

To test whether the BRT expansion caused price changes due to the network effects, we turn to the variables *INTXYR_2001* to *INTXYR_2006*. These coefficients measure the asking price changes by year for the intervention zone relative to the control zone, all else held equal. Table 4 shows that prices for 2001 and 2002 were similar between the intervention and the control zones, with no appreciation occurring. However, a consistent positive appreciation in the intervention area is seen from 2003 onwards. This appreciation is detected with the OLS, WLS and spatial lag models, with the spatial error models showing similar results that but with lower levels of confidence.

The resulting asking prices from model coefficients for the intervention area relative to the control area are shown in Figure 3. Figure 3 was constructed with Clarify, a statistical program that uses stochastic simulation techniques to help interpret and present statistical results (King, Wittenberg, and Tomz 2000; King, Tomz, and Wittenberg 2000). In the case of the OLS model estimated, we used Clarify to draw 1000 simulations of the main parameters from an asymptotic multivariate normal distribution with mean equal to the estimated coefficients and variance equal to the estimates' variance-covariance matrix. To calculate predicted values for each draw, we assumed that a property was between 10 and 20 years old and set all other variables to their median values, while changing the value of the year variable of interest (2001-2006) to 1.

Figure 3 shows that properties in the intervention area appreciated earlier and more than properties in the control area. However, standard errors of each estimate (not shown) are high partly due to the semi-log model specification, making prices in each area statistically indistinguishable from each other. Figure 4 shows changes differences in prices between the intervention and the control areas in percentage terms. The 2003 spike in prices in the intervention are may be the result of owner anticipation of the BRT extension opening or other real estate submarket changes not accounted for in our variables. Although similar anticipation effects for mass transit extensions have been documented elsewhere (Knaap, Ding, and Hopkins 2001), none have been examined or documented for the network effects that such extensions create.

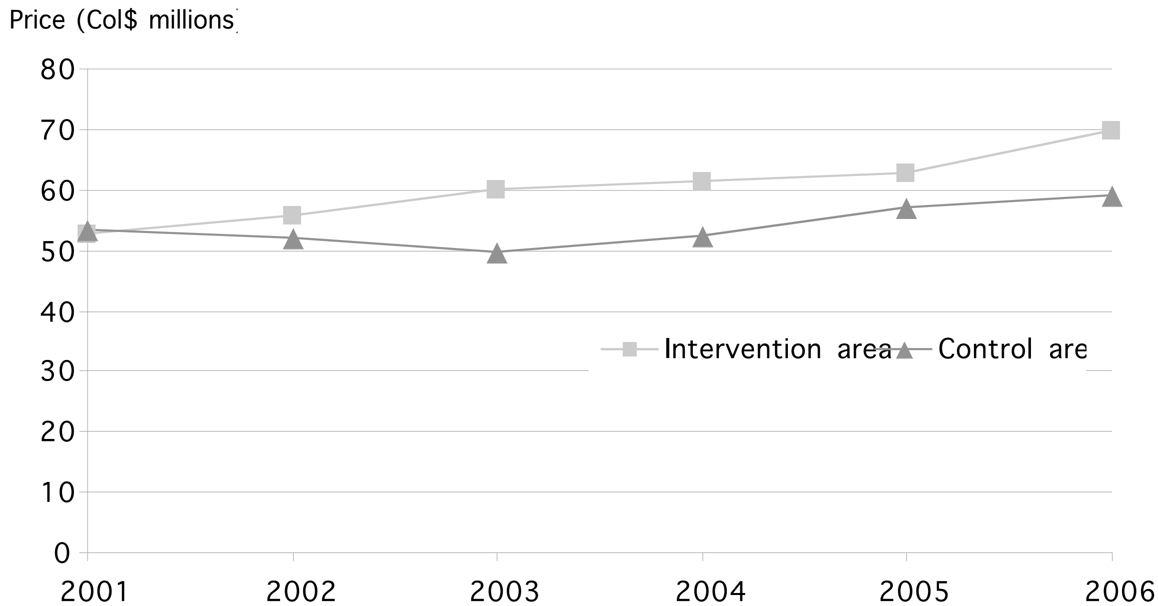

Figure 3 Estimated yearly changes prices for properties in intervention and control areas based on estimated OLS coefficients

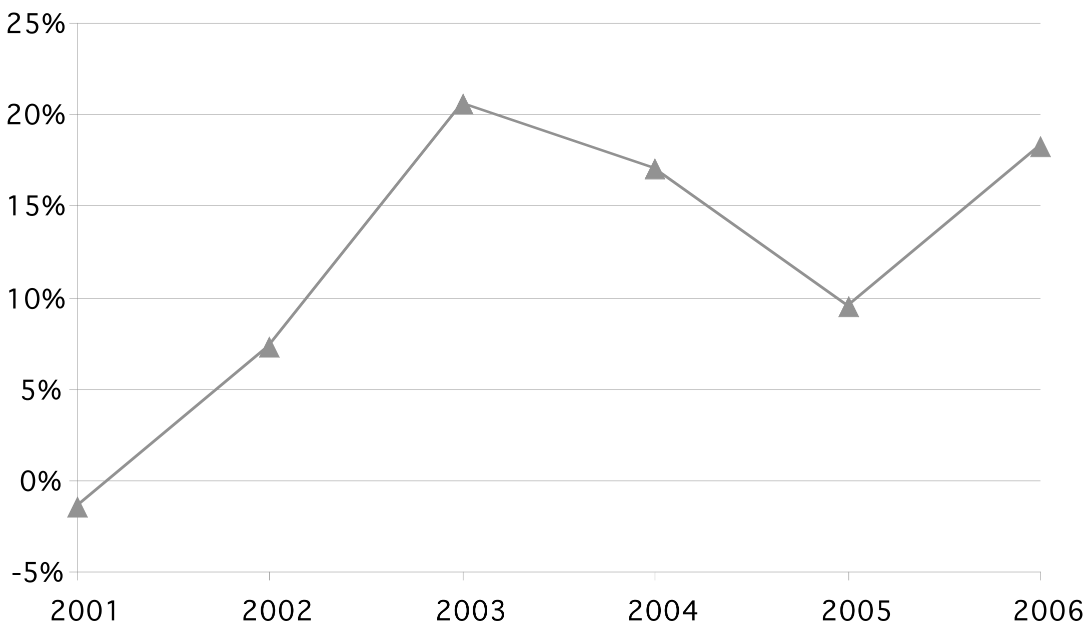

Figure 4 Estimated yearly percent difference in prices for properties in intervention and control areas, based on estimated OLS coefficients

Although our interest was in examining the changes in property values over time for the intervention zone, other coefficients examined lend credence to our results. The coefficient of proximity to the right of way is negative at a 95% level of confidence in the spatial lag model only. The coefficient suggests a price discount of 3.6% compared to properties not located within 150 m of the right of way. Similarly, the effect of distance to the CBD is negative, but significant only for the OLS and WLS models. As expected, an increase of 1 km from the CBD is related to a decrease of 0.8% to 0.9%. The coefficients for the dummy variables measuring access to major roads (Carrera 7a, Calle 72, Avenida Boyaca and Avenida 68) are either statistically insignificant or show a positive effect on prices. This is expected, as it shows that properties value access to different transportation options via different routes.

Neighborhood attributes such as socioeconomic stratum, percent of open space/parks and perecent of industrial uses have positive and significant coefficients. Neighborhood residential density was only significant for the spatial error model, having a negative sign. Finally, structural attributes are highly significant in the expect direction in all models. Variables such as the number of rooms, bathrooms and garages are positive at a 99% level of confidence. Similarly, the built area variable also correlates positively with the price of the property and its coefficient is also highly significant.

5.2 Price changes due to local or direct access effects of BRT system extensions

The four models presented in section 5.1 (OLS, WLS, spatial lag and spatial error models) are presented in Table 5 to examine the asking price changes due to the availability of a local BRT station. The coefficients of variables measuring price changes per year (*YR_2002* to *YR_2006*) with respect to the baseline year 2001 show statistically significant price increases for 2005 and 2006 in all four models. The two spatial models also show a price decrease in 2003. The values of the coefficients estimated are also fairly similar to those reported in section 5.1. In 2006, properties were estimated to be between 10.9% and 15.4% more expensive than properties offered in 2001.

To test whether prices increased as the BRT extension was inaugurated, we examine coefficients for the variables *INTXYR_2001* to *INTXYR_2006*. Table 5 shows mixed evidence, with the coefficients estimated via WLS being significant for 2001, 2003, 2004 and 2006 and the coefficients for 2002 and 2003 being significant for the spatial lag model, at standard levels of confidence. Furthermore, the hypothesis that the coefficients for 2004 and 2006 are equal to the coefficients in 2002 and 2003 cannot be rejected. Thus, we find little evidence of consistent property appreciation in the sample studied.

The coefficient of proximity to the right of way is negative at a 95% level of confidence in the spatial error model and at 90% level of confidence for the OLS model. A discount between 2.8 and 4.4% is estimated for properties within 150 m of the BRT right of way relative to those further away from it. The effect of distance to the CBD is negative and significant for all models except the spatial lag model. As expected, an increase of 1 km from the CBD is related to a decrease of between 3.3% and 5.1%, which is a much higher impact than what was found in section 5.1. The coefficients for the dummy variables measuring access to major roads (Avenida Boyaca, Avenida 68, Avenida Longitudinal and Avenida Ciudad de Cali) show a positive and statistically significant effect on prices for all models.

As with the analysis for hypothesis 1, neighborhood attributes such as socioeconomic stratum, % of open space/parks and % of industrial uses have residential density has a positive sign. Structural attributes are also highly significant in all models. Variables such as the number of rooms, built area, bathrooms and garages are positive and significant at a 99% level.

5.3 Discussion

Our results paint a mixed picture about the appreciation of prices due to BRT extensions. On the one hand, the evidence is supportive of our first hypothesis of price appreciation due to the network benefits of mass transit extensions. This is significant, given that prior studies had not examined or quantified the magnitude of these effects. The evidence is not conclusive, however, because such appreciation may be the result of local real estate submarket fluctuations related to earlier BRT investments made in 2000. For example, the study time period coincides with the market's recovery from a citywide recession of the early 2000s. It is possible that the housing market in the intervention area appreciated more than the market in the control area for reasons related to this recession. This speaks to broader research design concerns including the potential bias that unobserved differences between the intervention and control zone can introduce.

On the other hand, and contrary to our second hypothesis, we find limited evidence of asking price increases for properties along a corridor that previously did not have a local BRT station, but that now is served by the BRT extension. There are many possible explanations for our results. First, the capitalization of benefits of the extension may take time to occur. Our estimates of the price impacts cover only up to three years after the extension was inaugurated, but the development impacts of transportation projects tend to take time to realize. A second related explanation is that properties appreciated in anticipation of the BRT investment, rather than when the extension was inaugurated. However, we this should have been captured by our time variables for the intervention area, which date to 2001. A third explanation is that our study areas are fairly large, containing several neighborhoods and varying degrees of access to BRT stations. Although we attempted to estimated average effects, it is possible that prices increased but only for a subset of properties (for example those within 300 m of the station). Even for our analysis of hypothesis 1, it is possible that a subset of properties may be behind the average effects measured.

A fourth concern that applies to both of our analyses is that the control area may not be directly comparable to our interventions areas due to observed or unobserved characteristics. To explore this further, for each hypothesis we estimated a before-and-after model excluding the control area. The results were largely consistent with our findings, suggesting that even if the control area is not directly comparable, it is not biasing the findings of the study.

Other concerns included the high colinearity among many of the variables and the model heteroskedasticity. Variance inflation factors (VIF) are included in Tables 4 and 5. A high VIF suggests high colinearity. For example, the year dummy variables (*YR_2002* to *YR_2006*) have VIFs ranging between 10 and 14, which suggest that between 7% (1/14) and 10% (1/10) of their variance cannot be explained by other independent variables. Thus, it may be that the high colinearity is inflating the standard errors of the coefficients estimated. This is less of a concern for the product of the intervention and year dummy variables (*INTXYR_2001* to *INTXYR_2006*), having VIFs < 10.

The functional specification of the regression equation also may influence the results. Some evidence suggests simple functional forms such as linear, semi-log, double-log, and linear Box-Cox forms perform better than more complex ones (Cropper et al. 1988). Other empirical evidence regarding access to transportation facilities and land values concludes that the best specification for the functional form is a semi-log (Garrod and Willis 1992, Forrest et al. 1996). For those that have used various functional specifications, better results tend to be produced by the semi-log specification (Damm et al. 1980, Bajic 1983, Laasko 1992, Forrest et al. 1996, Henneberry 1998, Rodriguez and Targa, 2004).

All spatial models have significant heteroskedasticity (see Breusch-Pagan test statistic at the bottom of Tables 4 and 5), even after accounting for spatial dependence of the data. This suggests that standard errors can be underestimated. Visual inspection of residual plots suggested that the variables (*INTXYR_2001* to *INTXYR_2006*) were partly responsible for this. We included several polynomial terms for other variables associated with the dummy variables to remediate the problem but high heteroskedasticity remained. In the interest of model parsimony, those terms were removed from the final model.

6. Conclusions

This study used a generalized before and after methodology to examine two effects of BRT extensions in Bogotá, Colombia. The first effect examined was the network effect resulting from the enhanced accessibility that residential properties already served by the BRT experience when the BRT system expanded to other parts of the city. The second effect is the more traditional local access improvement resulting from a system extension on properties that previously did not have a BRT station within walking distance and now they do.

The results provide a mixed picture of the effects of BRT extensions on property values. For the network effect we found property premia of between 15 and 20%, although the appreciation began 1 year before the extension was inaugurated. For the local access effects, we find no consistent evidence of appreciation over time. We also estimate that asking prices for properties within 150 m of the BRT right of way are between 3% and 4.4% lower than other properties. This change measures the deleterious effects of proximity to the road, regardless of whether it was used by the BRT or by mixed traffic. Future research can examine changes over time in these deleterious effects.

Although our results cannot be generalized to other cities or time periods, they paint a cautious picture of the land value impacts of BRT extensions. For the City of Bogotá in particular, how to finance future extensions becomes a more difficult question since the evidence presented here does not strongly support the usefulness of value capture techniques.

There are several possible reasons for why our results were not as anticipated. First, there can be a plethora of omitted variables. For example, variations in local public services like police coverage and, in neighborhood environmental conditions like air quality, are possible. Second, our measures of land use are cross-sectional. As such, it is possible that the anticipation of the BRT extension induced changes to development patterns that could affect property values. Third, it is possible that certain submarkets appreciate considerably more than others. To the degree that such heterogeneity is not captured by our research design, bias will be introduced into our models.

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Tables

Table 1 Selected studies of the relationships between transportation investment and land values, 2002-present

Authors	Data Source	Selected Results
Heavy Rail Rapid Transit		
(Du and Mulley 2007)	Asking prices of properties within 500 m of Sunderland Metro extension stations relative to properties at least 1000 m from stations 1 year after opening.	No changes in property values detected (using ANOVA)
(Armstrong and Rodriguez 2006)	1,860 single-family residential properties from four municipalities with commuter rail service and three municipalities without commuter rail service	Premium of 9.6% and 10.1% for municipalities with commuter rail
(Gibbons and Machin 2005)	7474 housing transactions from the Nationwide building society in London and a wider area of South East England between 1997 and 2001.	House prices rose over the period by 9.3 percentage points more in places affected by these transport infrastructure changes.
(McMillen and MacDonald 2004)	17,034 single-family house transactions and 4,056 repeat sales observations from the Illinois Department of Revenue	Premium of 3% for every .25 miles closer to transit station
(Bae, Jun, and Hyeon 2003)	Budongsan Bank data of 241 properties over four years data in Seoul	Premium of 8.9% within 1000 m of station due to station opening
(Cervero and Duncan 2002)	3803 sales of properties in multi-family housing in Los Angeles in 2000.	No evidence of appreciable effects
Light Rail Transit/Trolley Service		
(Cervero and Duncan 2002)	1495 sales of properties in multi-family housing in San Diego in 2000.	Premium for multi-family units ranging from 2 to 6%
BRT		
(Munoz-Raskin 2006)	130,692 properties registered by the Bogotá Department of Housing control between 2001 and 2004	Premium for properties less than five minutes walking from Transmilenio's feeder lines.
(Perdomo et al. 2007)	304 residential properties and 40 commercial properties with or without access to Bogotá's TransMilenio system	No premium was detected in 5 out of 6 tests. When significant, a 22% premium for properties with BRT access was detected.
(Rodriguez and Targa 2004)	494 multifamily residential properties in a 1.5-km area around two corridors of Bogotá's TransMilenio system	Premium of 6.8 to 9.3% for every 5 minutes walking time closer to BRT station
(Cervero and Duncan 2002)	3803 sales of properties in multi-family housing in Los Angeles during 2000.	No evidence of appreciable effects

Note: Results apply to area and properties studied only. Refer to each particular study for details.

Table 2 Variable descriptions and data sources

Variable	Description	Source
PRICE	Asking price ($Col thousand pesos) [a]	www.metrocuadrado.com
Structural attributes		
APT	=1 if property is an apartment	www.metrocuadrado.com or imputation
FLOOR	Floor number	www.metrocuadrado.com
AGE_1-10	=1 if 1-10 years old	www.metrocuadrado.com or imputation
AGE_10-20	=1 if 10-20 years old	www.metrocuadrado.com or imputation
AGE_20-30	=1 if >= 20 years old	www.metrocuadrado.com or imputation
BEDROOM	Number of bedrooms	www.metrocuadrado.com
BATH	Number of bathrooms	www.metrocuadrado.com
GARAGE	Number of garage spaces	www.metrocuadrado.com
AREA	Floor area (square meters)	www.metrocuadrado.com
Neighborhood attributes		
SES	Neighborhood socio-economic stratum 1-6 (1=lowest)	www.metrocuadrado.com
POP_DENS	Population density (residents per sq km)	DANE
PCNT_INDU	% of neighborhood area in industrial uses, 1998	DANE
PCNT_COMM	% of neighborhood area in commercial uses, 1998	DANE
PCNT_INSTIT	% of neighborhood area in institutional uses, 1998	DANE
PCNT_VACANT	% of neighborhood area empty or vacant, 1998	DANE
PCNT_GREEN	% of neighborhood area of parks/open spaces, 1998	DANE
HOMICIDES	Homicides per 100 000 residents in neighborhood, 2001 & 2004	DAPD
Accessibility		
PROX_150M	=1 if within a 150 m of BRT right of way	GIS
CLL13	Distance between property and Calle 13 station (km)	GIS
CRA7	=1 if within 500 m of Cra 7a	GIS
CLLE72	=1 if within 500 m of Calle 72	GIS
CCALI	=1 if within 500 m of Av Ciudad de Cali	GIS
AVBOYACA	=1 if within 500 m of Av Boyaca	GIS
AV68	=1 if within 500 m of Av 68	GIS
CRA50	=1 if within 500 m of Cra 50	GIS
AVLONG	=1 if within 500 m of Avenida Longitudinal	GIS

[a] $US 1 = $Col 1,980 as of May 2007.

Table 3 Descriptive summaries of property characteristics by area and time period

	Control area				Network effects area (hypothesis 1)				Local effects area (hypothesis 2)			
	Before (n=267)		After (n=732)		Before (n=1407)		After (n=1570)		Before (n=1055)		After (n=874)	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Price (thousands)	76,517.63	77040.87	82,387.20	73135.49	95,222.23	72,526.76	100,053.90	77,995.21	73,931.77	44,465.33	80,990.11	55,113.80
APT	0.76	0.43	0.84	0.36	0.55	0.50	0.70	0.46	0.53	0.50	0.59	0.49
FLOOR	2.31	1.95	2.65	1.89	1.87	2.37	2.66	2.87	1.56	1.86	1.76	1.93
AGE_1-10	0.26	0.44	0.22	0.41	0.16	0.36	0.14	0.35	0.53	0.50	0.51	0.50
AGE_10-20	0.66	0.48	0.64	0.48	0.61	0.49	0.59	0.49	0.37	0.48	0.34	0.47
AGE_20-30	0.04	0.21	0.07	0.25	0.23	0.42	0.25	0.43	0.09	0.28	0.12	0.33
BEDROOM	3.04	0.74	3.01	0.79	3.12	1.03	3.02	1.19	3.19	0.76	3.30	0.91
BATH	2.04	0.78	2.09	0.87	2.38	1.12	2.14	1.04	2.14	0.94	2.18	1.00
GARAGE	0.96	0.63	0.87	0.65	0.92	0.72	0.83	0.71	1.04	0.69	0.93	0.73
AREA	95.38	68.19	92.15	67.42	141.51	93.61	122.11	84.60	115.27	76.89	115.94	84.55
SES	3.37	0.91	3.41	0.81	3.57	0.73	3.54	0.73	3.09	0.60	3.02	0.50
POP_DENS	540.37	226.56	427.09	206.67	506.27	256.11	446.35	228.13	434.62	184.49	436.64	176.38
PCNT_INDU	22.76	28.63	16.39	22.28	0.48	2.91	0.87	3.85	13.71	25.52	13.91	26.55
PCNT_COMM	0.00	0.03	0.09	0.49	2.46	5.83	2.26	5.12	0.00	0.00	0.00	0.00
PCNT_INSTIT	1.47	1.96	1.71	2.23	5.86	8.51	8.24	10.17	4.49	8.64	4.57	10.40
PCNT_VACANT	14.08	13.02	14.12	11.28	0.82	3.30	1.63	5.11	7.04	8.93	7.19	9.80
PCNT_GREEN	3.96	8.22	8.78	15.88	2.02	2.41	1.97	2.37	1.87	2.37	1.84	2.47
HOMICIDES	155.89	85.14	116.00	79.33	72.81	37.93	77.71	38.82	198.45	54.41	196.22	56.78
PROX_150M	0.00	0.00	0.00	0.00	0.18	0.38	0.12	0.32	0.25	0.43	0.23	0.42
CLL13	9.95	1.61	10.19	1.37	8.38	3.41	8.56	3.67	8.14	1.78	8.15	1.82
CRA7	0.00	0.00	0.00	0.00	0.34	0.47	0.43	0.50	0.00	0.00	0.00	0.00
CLLE72	0.00	0.00	0.00	0.00	0.36	0.48	0.28	0.45	0.00	0.00	0.00	0.00
CCALI	0.12	0.33	0.23	0.42	0.07	0.25	0.06	0.25	0.01	0.10	0.01	0.11
AVBOYACA	0.42	0.49	0.16	0.37	0.08	0.27	0.08	0.28	0.35	0.48	0.31	0.46

AV68	0.01	0.12	0.02	0.13	0.06	0.24	0.04	0.19	0.13	0.33	0.12	0.32
CRA50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.23	0.05	0.22
AVLONG	0.15	0.36	0.31	0.46	0.10	0.30	0.11	0.32	0.00	0.00	0.00	0.00

Table 4 Pooled hedonic model of network effects of BRT system extensions (hypothesis 1), N = 3976

		OLS robust errors			Weighted Least Squares			ML Spatial Lag			ML Spatial Error		
Variable	VIF	Coef.	Std Err		Coef.	Std Err		Coef.	Std Err		Coef.	Std Err	
YR_2002	11.29	-0.048	0.059		0.034	0.046		-0.071	0.053		-0.081	0.052	
YR_2003	12.02	-0.091	0.060		-0.046	0.044		-0.093	0.050	*	-0.105	0.051	**
YR_2004	13.75	-0.034	0.054		0.011	0.039		-0.033	0.045		-0.040	0.045	
YR_2005	11.94	0.054	0.054		0.088	0.038	**	0.050	0.044		0.042	0.045	
YR_2006	9.31	0.095	0.058		0.122	0.041	***	0.103	0.048	**	0.095	0.048	*
INTXYR_2001	8.53	-0.008	0.052		0.041	0.040		-0.065	0.046		-0.022	0.080	
INTXYR_2002	6.15	0.064	0.040		0.035	0.037		0.031	0.042		0.087	0.078	
INTXYR_2003	6.07	0.207	0.040	***	0.202	0.034	***	0.141	0.039	***	0.208	0.076	**
INTXYR_2004	4.53	0.152	0.028	***	0.172	0.025	***	0.080	0.030	***	0.136	0.071	*
INTXYR_2005	3.49	0.103	0.030	***	0.138	0.025	***	0.044	0.029		0.098	0.071	
INTXYR_2006	3.5	0.155	0.038	***	0.215	0.030	***	0.077	0.036	**	0.128	0.074	*
APT	2.94	0.001	0.023		-0.025	0.017		0.001	0.019		0.002	0.019	
FLOOR	1.88	0.016	0.002	***	0.017	0.002	***	0.015	0.003	***	0.015	0.003	***
AGE_1-10	6.26	-0.101	0.041	***	-0.107	0.030	***	-0.092	0.035	***	-0.084	0.035	**
AGE_10-20	10.49	-0.047	0.042		-0.067	0.030	**	-0.043	0.035		-0.035	0.035	
AGE_20-30	7.56	-0.081	0.044	*	-0.108	0.031	***	-0.081	0.036	**	-0.071	0.036	**
ROOM	2.6	0.078	0.009	***	0.094	0.007	***	0.082	0.008	***	0.081	0.008	***
BATH	1.68	0.092	0.007	***	0.091	0.006	***	0.086	0.007	***	0.084	0.007	***
GARAGE	1.27	0.147	0.010	***	0.155	0.007	***	0.141	0.008	***	0.137	0.008	***
AREA	3.08	0.00326	0.00015	***	0.00309	0.00009	***	0.00325	0.00011	***	0.00326	0.00011	***
SES	1.41	0.198	0.014	***	0.219	0.007	***	0.186	0.008	***	0.193	0.008	***
POP_DENS	1.51	-0.00005	0.00003		-0.00002	0.00002		-0.00011	0.00003	***	-0.00011	0.00003	***
PCNT_INDU	1.96	0.00287	0.00056	***	0.00277	0.00043	***	0.00215	0.00050	***	0.00266	0.00066	***
PCNT_COM	1.21	-0.002	0.001	*	-0.002	0.001	**	-0.007	0.001	***	-0.006	0.002	***
PCNT_INSTIT	1.4	0.00084	0.00085		0.00097	0.00062		0.00214	0.00072	***	0.00370	0.00083	***
PCNT_VACANT	2.26	0.00046	0.00102		0.00025	0.00076		0.00076	0.00087		0.00181	0.00121	
PCNT_GREEN	1.79	0.005	0.001	***	0.006	0.001	***	0.002	0.001	**	0.004	0.002	**
HOMICIDES	3	-0.00016	0.00017		-0.00031	0.00014	**	0.00027	0.00016	*	-0.00021	0.00040	
PROX_150	1.19	-0.025	0.020		-0.016	0.016		-0.036	0.018	**	-0.027	0.018	
CLL_13	2.86	-0.009	0.003	***	-0.008	0.002	***	-0.001	0.003		-0.013	0.008	
IMP_APT	1.52	0.080	0.017	***	0.061	0.013	***	0.072	0.015	***	0.078	0.015	***

		OLS robust errors			Weighted Least Squares			ML Spatial Lag			ML Spatial Error		
Variable	VIF	Coef.	Std Err		Coef.	Std Err		Coef.	Std Err		Coef.	Std Err	
IMP_AGE	1.53	-0.069	0.014	***	-0.071	0.011	***	-0.068	0.013	***	-0.066	0.013	***
CRA7	2	0.088	0.023	***	0.073	0.017	***	0.088	0.020	***	0.046	0.024	*
CLL72	1.14	0.047	0.015	***	0.033	0.012	***	-0.003	0.015		0.014	0.020	
CCALI	1.37	-0.006	0.020		-0.005	0.017		0.003	0.020		0.007	0.029	
AVBOYACA	1.32	0.045	0.021	**	0.065	0.020	***	0.021	0.023		0.000	0.031	
AV68	1.32	0.045	0.030		0.066	0.025	***	-0.026	0.029		-0.133	0.058	**
CONSTANT		9.592	0.096	***	9.452	0.064	***	5.454	0.449	***	9.729	0.120	***
W_LOGPRICE		-	-		-	-		0.372	0.040	***	-	-	
LAMBDA		-	-		-	-		-	-		0.805	0.044	***
R-squared		0.692						0.701			0.703		
Lagrange Multiplier (lag)		159.76											
Lagrange Multiplier (error)		128.55											
Breusch-Pagan test								673.32			681.89		

* , ** and *** denote statistical significance at the 90%, 95% and 99% level of confidence (two-tailed test), respectively.

Coefficients for dummy variables (in bold) are adjusted as suggested by Kennedy (1981).

The spatial weights matrix for the spatial lag and spatial error model is row-standardized and based on observations within a 0.5-km distance band.

Table 5 Pooled hedonic model of local access effects of BRT system extensions (hypothesis 2), N = 2928

		OLS robust errors			Weighted Least Squares			ML Spatial Lag			ML Spatial Error		
	VIF	Coef.	Std Err		Coef.	Std Err		Coef.	Std Err		Coef.	Std Err	
YR_2002	8.95	-0.038	0.060		0.035	0.042		-0.073	0.047		-0.068	0.047	
YR_2003	10.36	-0.067	0.063		-0.020	0.040		-0.085	0.045	*	-0.086	0.045	**
YR_2004	10.17	0.003	0.057		0.051	0.036		-0.012	0.040		-0.012	0.040	
YR_2005	8.38	0.097	0.057	*	0.136	0.036	***	0.082	0.040	**	0.076	0.040	*
YR_2006	6.55	0.118	0.060	*	0.154	0.038	***	0.113	0.043	**	0.109	0.043	**
INTXYR_2001	5.34	-0.011	0.059		0.075	0.036	**	-0.006	0.041		-0.066	0.049	
INTXYR_2002	4.87	0.046	0.039		0.046	0.034		0.081	0.039	**	0.015	0.047	
INTXYR_2003	5.06	0.061	0.040		0.084	0.031	***	0.083	0.035	**	0.027	0.044	
INTXYR_2004	3.53	0.021	0.029		0.053	0.025	**	0.034	0.029		-0.023	0.040	
INTXYR_2005	2.48	0.008	0.031		0.032	0.027		0.017	0.031		-0.041	0.042	
INTXYR_2006	2.56	0.025	0.038		0.077	0.032	**	0.030	0.036		-0.025	0.046	
APT	3.8	-0.131	0.025	***	-0.147	0.020	***	-0.131	0.022	***	-0.141	0.022	***
FLOOR	2.39	0.007	0.004	*	0.010	0.004	**	0.007	0.004	*	0.007	0.004	*
AGE_1-10	7.92	-0.013	0.028		-0.016	0.027		-0.010	0.031		-0.014	0.031	
AGE_10-20	7.63	0.078	0.031	**	0.033	0.029		0.069	0.033	**	0.067	0.033	**
AGE_20-30	4.05	0.096	0.041	**	0.037	0.034		0.084	0.039	**	0.081	0.039	**
ROOM	1.99	0.038	0.011	***	0.039	0.008	***	0.045	0.009	***	0.044	0.009	***
BATH	2.15	0.165	0.009	***	0.157	0.008	***	0.155	0.009	***	0.154	0.009	***
GARAGE	1.39	0.133	0.011	***	0.141	0.008	***	0.127	0.009	***	0.121	0.009	***
AREA	3.37	0.00178	0.00017	***	0.00192	0.00012	***	0.00179	0.00013	***	0.00179	0.00013	***
SES	1.4	0.264	0.012	***	0.255	0.008	***	0.245	0.010	***	0.247	0.010	***
POP_DENS	1.45	0.00009	0.00004	**	0.00013	0.00003	***	0.00006	0.00003	*	0.00013	0.00004	***
PCNT_INDU	1.57	0.00068	0.00029	**	0.00059	0.00024	**	0.00074	0.00027	***	0.00078	0.00038	**
PCNT_COM	1.18	0.010	0.018		0.009	0.021		0.019	0.024		0.002	0.027	
PCNT_INSTIT	1.37	-0.00036	0.00067		0.00017	0.00071		-0.00003	0.00081		-0.00109	0.00112	
PCNT_VACANT	1.43	0.00054	0.00072		0.00036	0.00054		0.00079	0.00060		0.00069	0.00087	
PCNT_GREEN	1.91	0.003	0.001	***	0.004	0.001	***	0.001	0.001	*	0.003	0.001	**
HOMICIDES	2.6	-0.00024	0.00014	*	-0.00041	0.00010	***	0.00024	0.00013	*	0.00005	0.00024	
PROX_150	1.25	-0.028	0.016	*	-0.015	0.015		-0.021	0.017		-0.044	0.017	***
CLL_13	2.64	-0.033	0.006	***	-0.039	0.004	***	-0.008	0.006		-0.051	0.010	***
IMP_APT	1.58	0.066	0.018	***	0.073	0.014	***	0.062	0.016	***	0.066	0.016	***

	VIF	OLS robust errors			Weighted Least Squares			ML Spatial Lag			ML Spatial Error		
		Coef.	Std Err		Coef.	Std Err		Coef.	Std Err		Coef.	Std Err	
IMP_AGE	1.33	-0.055	0.014	***	-0.063	0.012	***	-0.055	0.013	***	-0.050	0.013	***
AVBOYACA	1.65	0.098	0.016	***	0.121	0.014	***	0.040	0.016	**	0.042	0.021	**
AV68	1.75	0.114	0.026	***	0.106	0.023	***	0.097	0.026	***	0.077	0.036	**
CRA50	1.89	-0.150	0.049	***	-0.203	0.036	***	-0.092	0.041	**	-0.084	0.052	*
AVLONG	1.69	0.054	0.030	*	0.056	0.022	**	0.082	0.025	***	0.138	0.036	***
CCALI	1.38	0.057	0.024	**	0.073	0.021	***	0.071	0.024	***	0.077	0.033	**
CONSTANT		9.715	0.116	***	9.734	0.076	***	6.112	0.417	***	9.930	0.128	***
W_LOGPRICE		-	-		-	-		0.306	0.034	***	-	-	
LAMBDA		-	-		-	-		-	-		0.759	0.056	***
R-squared		0.744						0.752			0.752		
Lagrange Multiplier (lag)		119.23						0.752			0.752		
Lagrange Multiplier (error)		142.93						0.752			0.752		
Breusch-Pagan test								569.11			572.35		

***, ** and * = Coefficient significantly different from zero at the 1, 5 and 10% levels of significance (two-tailed test), respectively.

Coefficients for dummy variables (in bold) are adjusted as suggested by Kennedy (1981).

The spatial weights matrix for the spatial lag and spatial error model is row-standardized and based on observations within a 0.5-km distance band.