WCTR 2013 RIO

SELECTED PROCEEDINGS

CAPITALIZATION EFFECTS OF RAIL TRANSIT AND BRT ON RESIDENTIAL PROPERTY VALUES IN A BOOMING ECONOMY: EVIDENCE FROM BEIJING

LIANG MA, PORTLAND STATE UNIVERSITY, E-MAIL: LIANGM@PDX.EDU
RUNING YE, UNIVERSITY COLLEGE LONDON, E-MAIL: R.YE.11@UCL.AC.UK
HELENA TITHERIDGE, UNIVERSITY COLLEGE LONDON, E-MAIL: H.TITHERIDGE@UCL.AC.UK

This is an abridged version of the paper presented at the conference. The full version is being submitted elsewhere. Details on the full paper can be obtained from the author.

ISBN: 978-85-285-0232-9

13th World Conference on Transport Research

www.wctr2013rio.com

15-18 JULY 2013
Rio de Janeiro, Brazil

CAPITALIZATION EFFECTS OF RAIL TRANSIT AND BRT ON RESIDENTIAL PROPERTY VALUES IN A BOOMING ECONOMY: EVIDENCE FROM BEIJING

Liang Ma, *Portland State University, E-mail: liangm@pdx.edu*
Runing YE, *University College London, E-mail: r.ye.11@ucl.ac.uk*
Helena Titheridge, *University College London, E-mail: h.titheridge@ucl.ac.uk*

ABSTRACT

This research investigates the capitalization effects of proximity to rail transit and BRT in fast-growing Beijing. Few related studies have been conducted for Chinese cities because the real estate market was not established until recently. Data were collected on apartment homes sold in the Beijing metropolitan area during 2011, and hedonic price modeling was employed to gauge the price premiums or discounts associated with proximity to transit stations. Overall, we identified an average price premium of around 5% for properties near rail transit stations, but no statistically significant effects are detected at BRT station areas. Moreover, we found that station-proximity effects increase both in magnitude and spatial extent at stations further away from the city center and at stations surrounded by low- and middle-income neighborhoods; for example, the price premium is as high as 10% in some suburban and low-income station areas. We concluded that rail-transit investment is an effective strategy for Beijing to reshape its urban spatial structure, and local governments in China may consider Rail + Property Development model as a future financing solution for rail-transit investment. This study contributes to the evidence of capitalization effects of public transit from a booming and transitional economy.

INTRODUCTION

Few studies have investigated the capitalization effects of transit investment on land and property values in Chinese cities. One reason for this is the social transformation during the past 30 years that has occurred moving China from a socialist planning to a market-oriented system. Factor markets such as the housing and land market were not developed until recently before the 1980s. Housing was a part of the social welfare system that was provided by the government in China. During the 1980s, a series of political and economic reform programs initiated by central government, result in the housing system being privatized and commercialized. In 1998, the public housing provision system was officially ended by central government, and from this point forward, individuals could only obtain homes by purchasing from the real estate market except a few working for government and state-owned corporations. During the past 10 years, housing market has boomed in most of metropolitan cities of China, this is partly due to the rapid urbanization process, and partly because of the enthusiasm of the local governments in land development. The maturity of the real estate market in recent years enabled us to explore the quantitative relationship between public-transport investment and property development within China, and China's growing and transitional economy provides a unique context for comparing and contrasting western countries and further investigating this relationship.

In contrast with most North American cities featuring stable urban patterns and a small percentage of public transit users, Chinese cities are developing differently. Fast urbanization and dramatic transformation are characteristics of Chinese cities today. For example in Beijing, the population has doubled from 9 million in 1980 to 19.6 million in 2010, and the built-up urban area has increased six-fold, from 184 square kilometers in 1980 to 1,209 square kilometers in 2007 (Beijing Statistical Yearbook, 2011). In Beijing, the quantity of newly completed residential construction reached 28.4 million square meters in year 2005, accounting for 13.1% of existing housing market stock (Zheng and Kahn, 2008).

Dramatic expansion of urban space has changed individual travel behavior significantly (FIGURE 1). The traditional modes of transportation, cycling and walking, are gradually becoming impossible due to longer distances between work and home, while private cars are still not affordable for most of the residents. Public transit, therefore, plays an ever more important role for people's daily activities, and has become one of the predominant modes of transport in many big cities of China. For example, the public transit mode share in Beijing was around 40% in 2010, a 10% increase from the transit mode share of 2005, and this share is expected to go up to 50% by 2020 due to substantial investment in the rapid transit system. Similarly, many other cities in China, like Guangzhou, Chongqing, Xi-an, Chengdu, etc., are proposing new rail transit or bus rapid transit (BRT) lines. This study aims to provide practical policy implications for future transit investments in China by investigating the relationship between public-transit investments and property development in Beijing.

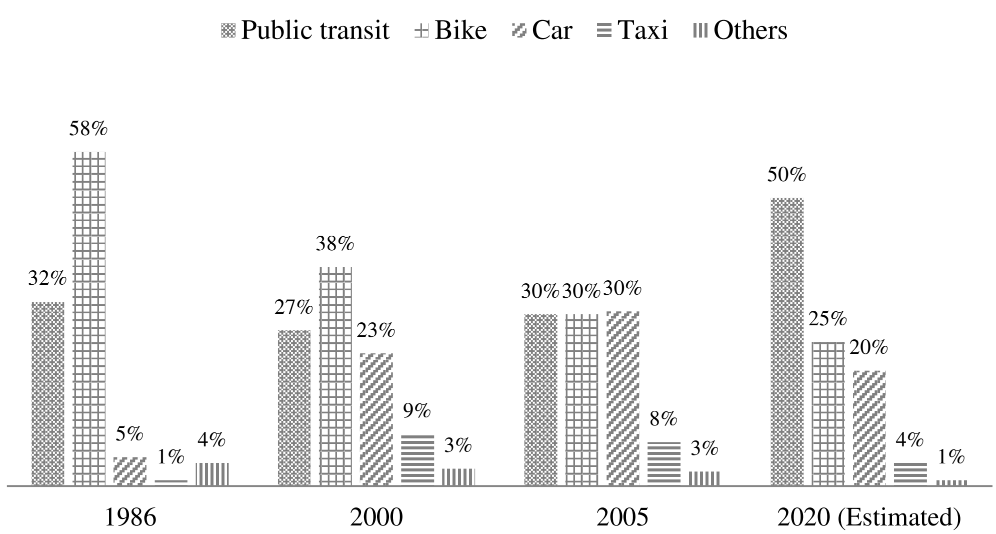

FIGURE 1 Changes of Travel Mode Choice from 1986-2020 of Beijing.

Sources: Beijing travel survey (2007) and Beijing City Planning (2004-2020)

In particular, this study aims to test the following three hypotheses:

1. Rapid transit investment in Beijing confers benefits to residents lived close to transit stations, and the benefits of good accessibility get capitalized into the market value of properties.
2. Effect of proximity to rapid transit varies across station locations. In particular, the effects are lower at stations near the city center and greater at stations further away. Transit users lived in suburbs have longer commuting times, and therefore save greater travel time from rapid transit system than those lived close to the city center. Moreover, availability of other traffic modes, such as regular bus and taxi, is very limited in suburbs. Therefore, suburban residents are probably willing to pay more for being close to a rapid transit station.
3. Effect of proximity to rapid transit also depends on the socio-demographics of neighborhoods around stations. In particular, the effects are lower at high-income stations and greater at low-income stations. Low-income residents are more reliant on public transit for their daily trips than high-income residents as most low-income residence cannot afford a private car and most of them live in a suburb.

The built-up area within the sixth Ring road of Beijing is the focus of the study as most residents who work in downtown commute within this area. Therefore this area can be designated a complete land market. Within the study area, there were eleven rail transit lines, and one BRT line[1] operating in 2011. The location of these rail transit and BRT stations are shown in FIGURE 2.

[1] There were two other bus lines also called BRT lines, however, they did not have dedicated right of way for the whole routes. The user benefits of these two lines were very limited, and therefore they were not included in this study.

In the next section we review the literature on the effect of public transit on land values or rents in urban area. In section three we describe research methodology and data sources. Following that, we present our model results, along with some insights and discussion from our results, and we conclude in section five.

FIGURE 2 Location of rail and BRT stations in Beijing as of 2011.

STUDIES OF TRANSIT AND PROPERTY VALUES

The monocentric city model pioneered by Alonso (1964), Muth (1969), and Mills (1972) provides a theoretical framework for analyzing the interactions between transit investment and land use. The model suggests that urban activities are arranged according to the transportation cost: the closer to the city center, the lower the transportation cost. Firms and households make trade-offs between access to the city center (market) and property price. The choice of location for households and firms is determined by their willingness to pay for different sites in the city. If a place could offer better accessibility to the city center, consumers would be willing to pay a higher price to be located at that place. Therefore, it is hypothesized that if rapid transit brings time saving for travelers, there would be a price premium for living in proximity to a transit station. During the last several decades, abundant research has tested this hypothesis based on evidence worldwide.

Impacts of Rail Transit on Property Values

Empirical studies on the relationship between the rail transit and property values can be traced at least to the 1970s. A recent statistics of Duncan (2011) finds there are at least 50 studies on this topic.

The majorities of these studies collect cross-sectional data and employ hedonic price modeling to extract the sole effect of rail transit on property values. Conclusions of these studies are highly mixed, though majority found a price increase for residential properties near rail transit. Firstly, the magnitude of premiums varies significantly between studies due to different methodology and research context. Thus it is difficult to make a generalization, but a great deal of literature implies that, based on the evidence of North America, the range of price premiums for single family properties should be between 0%-10% (Landis et al., 1995; Debrezion et al., 2007; Hess and Almeida, 2007; Duncan, 2011), and price premiums for multi-family properties are probably much larger, which can be two or three times higher than that for single-family housing (Cervero and Duncan, 2002a, 2002b; Duncan, 2008). Though the mixed results are attributed to the varied methodology, geography, and socio-economic context of research area, another important reason is the failure of these studies to control for factors such as local real estate market conditions, possible negative disamenities (e.g., crime and noise), and design features around station area, which may confound the relationship between accessibility of transit and property values (Bartholomew and Ewing, 2011).

In recent years, several studies with new data have supplemented the previous studies by identifying the factors intervening in the relationship between the rail transit proximity and property values. Bowes and Ihlanfeldt (2001) quantitatively explored the positive effects (e.g., attracting retail activities) and negative effects (e.g., more crime near a station) of being close to rail stations, and concluded that both effects influenced the relationship between property values and rail station accessibility. They also found that larger proximity effects were associated with high-income neighborhoods and locations further from the Central Business District (CBD) center. Their finding of a large premium at stations further away from the CBD is expected because there is more time savings from rapid transit for longer commuters. Their finding on greater premiums at high-income neighborhoods, however, is contrary with expectation. Generally, low-income residents are more reliant on public transit for daily travel and thus they may be more inclined to pay more for living near transit stations. They explained this contrary result was related to the higher opportunity cost of commuting time for high-income residents. Similar with findings of Bowes and Ihlanfeldt (2001), Hess and Almeida (2007) also found that rail transit proximity effects were positive within high-income station areas but negative in low-income station areas, and they contended the reason for the counterintuitive result was because of the counter-traditional city pattern of Buffalo, New York, where old and low quality housing is located in the CBD and housing prices increase over distance to the CBD. An early study from Nelson (1992), however, found a positive effect of proximity to rail transit stations on properties within low-income neighborhoods and a negative effect on properties within high-income neighborhoods. He argued that accessibility benefits are larger than any nuisances from stations for low-income neighborhoods, while nuisances more than offset the benefits for high-income neighborhoods. For the connection between design feature and proximity effects, Duncan (2011) investigated the association between housing price premium and Transit-Oriented Development (TOD) design, and found that TOD design at stations' surrounding areas significantly enhanced the effects of rail transit on property values.

Impacts of BRT on Property Values

Compared with rail transit studies, studies linking BRT with land use are relatively new, but over the past 10 years, literature related to land use with BRT investment has increased. It is traditionally thought that bus transit services have little effect on urban form and land-use patterns due to the lower levels of services compared with rail transit and, thus, no bus proximity premiums are capitalized into the land values nearby (Cervero and Kang, 2009). Knight and Trygg (1977) examined HOV-bus lanes in Washington, DC, California, Seattle in Washington state, and Florida, they concluded that exclusive bus lanes incorporated into highways appeared to have no impact on either residential or commercial development. More recently, Cervero and Duncan (2002c) used hedonic price modeling to estimate the premium of access to BRT in Los

Angeles County. They found that there was no premium accrued to nearby multi-family parcels, rather negative impacts were detected.

On the contrary, more and more research finds significantly positive impacts of BRT on the values of the residential properties surrounding its stations. For example, Mullins et al. (1990) found that the BRT route in Ottawa, Canada had an effect on the development of land surrounding the stations to a certain extent. Levinson et al. (2002) contended that BRT in Ottawa, Pittsburgh, Brisbane, and Curitiba could have land-use benefits similar to those produced by rapid rail as long as the BRT and land-use planning for station areas could be integrated as early as possible. They stipulated that realizing the benefits of a BRT system required close coordination of land-use and transport planning from the beginning. In addition, Levinson et al. (2003) studied the BRT southeast line in Brisbane, Australia, and they found that the value of properties near the busway were 20% higher than those farther away and property values within 6 miles of stations grew 2 to 3 times faster than those at a greater distance.

Furthermore, Bogota's BRT system is frequently cited as a case study. Rodriguez and Targa (2004) employed a hedonic price model to analyze the feasibility of BRT in Bogota and found out that for every 5 minutes of additional walking time to a BRT station, the rental price decreased by between 6.8% and 9.3%. Rodriguez and Mojica (2009) compared the asking prices of residential properties belonging to an BRT "intervention area" and a "control area" in Bogota and found 13%-14% higher prices in the BRT "intervention area" than in the "control area" after adjusting for structural, neighborhood, and regional accessibility characteristics of each property.

In the meantime, some scholars believe that the ability of BRT to impact land use depends on other non-accessibility factors. Polzin and Baltes (2002) argued that the extent to which BRT was able to create land-use impacts would significantly depend on the actions of professional planners, funding agencies, and decision makers toward leveraging the investment in BRT. If the decision makers or professional planners delivered good information of locating close to BRT to developers, development would happen near the BRT station. Estupinan and Rodriguez (2008) found that the built environment attributes, like crosswalks and sidewalks, were important in explaining boarding rates for Bogota's BRT stations.

Literature Gaps

In summary, it has been well established in developed countries that rail transit investment promotes property development, however, the evidence from developing countries is very limited. The policy implications derived from previous studies based on western countries may not be applicable in developing countries due to different political and economic structure, different zoning system, and different socio-demographics of transit users. In addition, few previous studies have examined the how the station-proximity effects are influenced by other confounding factors, such as station location, socio-demographical characteristics of transit users, and urban design around station area. Answering this question will help to make more effective policies tailored to specific urban districts and groups of transit users. This study aims to partially fill in these gaps in the literature by investigating the case of Beijing.

Moreover, empirical studies on BRT are rather limited and results from current studies are highly mixed. Mixed results are associated with different BRT facilities and services, places, and characteristics of cities, such as the urban density, urban economic level, urban spatial structure, or the locations of the BRT line in the city, or people's travel culture in different places. This study aims to provide another unique context to examine the hypothesis linking BRT and land development.

METHODOLOGY AND DATA

Model Specification

To explore the effects of proximity to stations on property values, a standard hedonic price model was used. As semi-log is a common form of such a model, we specified the dependent variable as the natural log of sale price per square meter. It should be noted that the interpretation of estimated coefficient should be the approximate percentage change of sale price associated with one unit change of independent variable.

$$LnP = c + \sum a_3\boldsymbol{X}_s + \sum a_2\boldsymbol{X}_n + \sum a_1\boldsymbol{X}_l + \sum a_0\boldsymbol{X}_p + \varepsilon \quad \text{(Model 1)}$$

In the equation, P is the sale price per square meter of the residential property; X_s indicates structural characteristics of the property, such as size and design of the property, X_n indicates neighborhood conditions for the property, such as services and amenities of the neighborhood, X_l indicates regional location of the property, and $X_p$indicates proximity to transit stations. a_3 a_2,a_1 and a_0 are coefficients to be estimated; c is the model constant, and ε is the residual error. This is the basic model employed to estimate the effect of proximity to a station on property values.

In order to test Hypothesis 2 and 3, two additional models are built by creating interactive terms based on the basic model. Model 2 aims to test whether the distance between station and the city center influence the proximity effects. Model 3 aims to test whether the proximity effects vary among neighborhoods with different income levels.

$$LnP = c + \sum a_3X_s + \sum a_2X_n + \sum a_1X_l + \sum a_0X_p + \sum b(X_p * Z_d) + \varepsilon \text{ (Model 2)}$$

$$LnP = c + \sum a_3X_s + \sum a_2X_n + \sum a_1X_l + \sum a_0X_p + \sum b(X_p * Z_a) + \varepsilon \text{ (Model 3)}$$

In the above two equations, X_p indicates the proximity to stations; Z_d indicates the property's distance to the city center; Z_a indicates the property's administration fee, which is used to represent the income level of the neighborhood; $X_p * Z_d$ is the interactive term between proximity to stations and property's distance to city center; and $X_p * Z_a$ is the interactive term between proximity to stations and property's administration fee. The administration fee of a neighborhood in China is a comprehensive index to reflect the whole quality of a neighborhood; a higher administration fees means higher levels of services and better amenities in the neighborhood. People with different income level are sensitive to this fee. Neighborhood services are unique for residents, and only high-income people are willing to pay higher administration fees to enjoy extra services and amenities. Therefore, it is reasonable to use administration fee to represent the income level of residents in each neighborhood.

Data Sources

The attributes and transaction data of each residential property are available from a primary housing transaction website (www.soufun.com), which is based in China. The site provided information on tremendous property transactions covering whole Beijing in 2011, and we only selected second-hand properties and those located within study area. This includes data on property prices per square meter, structural and locational information of property, and information on neighborhood amenities. Different from first-hand property transactions, which are mainly distributed in suburbs, second-hand transactions cover far more heterogeneous properties and a broader area from the inner city to the outskirts of the city. After deleting the missing data, 1,695 sampling properties are geocoded in GIS and selected for the final model estimation.

Variable Specification

The natural logarithm of sale prices per square meter serves as the dependent variable in the model. Independent variables accounting for property characteristics can be divided into four kinds: structural variables, neighborhood variables, locational variables and proximity variables.

Ten variables are created to explain the structural characteristics of property, including number of bedrooms (*Bedroom*), living rooms (*Living room*), bathrooms (*Bathroom*), and kitchens (*Kitchen*), orientation of apartment (*Head*), whether it is a business apartment (*Business*), ventilation condition (*Ventilation*), low-rise (*FL6*) or high-rise building (*FL18+*), and age of the apartment (*Age*). Bedroom, living room, bathroom, kitchen, and age are the most commonly used variables in hedonic price model (Hess and Almeida, 2007; Duncan, 2011), while others are closely associated with the culture of China. Orientation of apartment (*Head*), in particular whether the home faces South, is a concern for Chinese in choosing their homes. South-faced houses have several advantages over houses faced to other directions, for example south-faced houses can block most of the sunlight in summer while allowing more sunlight shed into the room in winter. South-faced properties are therefore preferred by most home buyers in China. Business apartments, which are originally designed for the business persons for temporary living, have a higher standard of neighborhood services than common apartments, and most business apartments are already furnished (e.g., painted walls and flooring) by developers. People buying a business apartment prefer its high quality of services and convenience to move in. Ventilation condition, is defined as, whether or not the houses has windows on both north and south walls, and if so, it means good ventilation because the predominant wind direction of Beijing is north and south and thus houses structured with north and south windows can drive air flow within rooms. Moreover, we assumed that residents of Beijing are not willing to choose the low-rise apartment building (6 stories or fewer), most of which were built before the 1980s and located in old neighborhoods, nor the super high-rise buildings (more than 18 stories), which means super high population density within neighborhoods.

Eight variables are selected to represent neighborhood characteristics. As mentioned above, administration fee (*Admin_Fee*) represents the levels of service in the neighborhood, including security, sanitation, maintenance, and other management services. The ratio of green space (*GreenR*) in a neighborhood also represents quality of natural environment and density of the neighborhood, and a higher ratio of green space means a better neighborhood environment. Floor area ratio (*FAR*) reflects the building density of the neighborhood, and a lower FAR is associated with better amenities and a higher price. Similar to school enrollment systems in the U.S., schools in Beijing are also run by school districts. Even though most residential neighborhoods have schools and kindergarten nearby in Beijing, schools and kindergartens of high quality and good reputation are rare resources. Most parents with children treat school district as their top priority in choosing their new homes, and thus good school districts should create a significant premium in housing price. We identified the top 50 kindergartens (*Kindergarten*), elementary (*Elementary*) and middle schools (*Middle*) based on their enrollment rate and reputation as the standard to designate the good school districts in Beijing, and property attributes data include school district information that enable us to identify whether the property belongs to one of the good school districts. Moreover, proximity to an open space can have significant effects on a home's sale price (Bolitzer and Netusil, 2000). In order to measure the effect of parks on housing price, the properties located within a walkable distance (1/4 mile) of major parks (*Parks*) in Beijing were identified. Finally, the percentage of commercial and entertainment land use (*Com*) around the property also can influence the property value (Song and Knaap, 2004).

Three variables measuring regional location of property are created. Distance to city center reflects (*Dis_Center*) the regional location of properties in the city, and higher proximity to the city center means lower transportation costs. Tiananmen Square is the traditional center of Beijing, and people very care about their home's distance to this center even though its cultural meaning as a center is more than its significance as an actual employment center. Moreover, Beijing is gradually transforming from a typical mono-centric to a poly-centric urban pattern (Feng et al., 2009), and there are several sub-centers that have emerged, such as Zhong Guancun, CBD, Jin Rongjie, Yizhuang, Shangdi, etc., therefore we also calculated property's distance to these sub-centers (*Dis_Emp*). Also, distance to the nearest arterial road (*Dis_Road*) reflects the level of accessibility of residents.

For station proximity variables, we first created variables using different buffer widths (say, 0.25, 0.5, 1, 1.25, 1.5, 2 mile[2]) and added all into the model, but we found that proximity distance over 1 mile was hardly significant in the model, and therefore we only kept the following four variables in the final models: apartments located within ½ mile of rail stations (*Rail_Hlf*); apartments located between one-half and one mile of rail stations (*Rail_Hlf_One*); apartments located within one-quarter mile of BRT stations (*BRT_Qtr*); and apartments located between one-quarter and one-half mile of rail stations (*BRT_Qtr_Hlf*).

The variable names and corresponding summary statistics are provided in TABLE 1.

[2] Distance bands were calculated based on Euclidian distance rather than network distance due to the lack of data for detailed street network.

TABLE 1 Variable Summary Statistics (N=1695)

Variables	Description (Unit of Measure)	Mean	Std. Dev.
Dependent Variables			
Price	The sale price per sq. meter of floor area of the sold housing units (RMB/Sq. meter)	28,696	13,804
LnPrice	Natural log-transformation of the sale price	10.19	.39
Structural Variables			
Bedroom	# Bedrooms in the apt (#)	2.20	.87
Living room	# Living rooms in the apt (#)	1.32	.52
Bathroom	# bathrooms in the apt (#)	1.25	.53
Kitchen	# kitchens in the apt (#)	1.01	.16
Head	Direction of home entrance faces (Binary: 1=south)	.69	.46
Business	Business apartment: aim for business persons (Binary: 1=yes)	.03	.17
Ventilation	Both North and South walls have windows (Binary: 1=yes)	.68	.47
FL6	Building 6 or less stories high (Binary: 1=yes)	.43	.50
FL18+	Building 18 or more stories high (Binary: 1=yes)	.22	.41
Age	Age of the building (#)	11.78	6.72
Neighborhood Variables			
Admin_Fee	Fees for neighborhood admin and services (RMB/Sq. meter/month)	1.98	1.93
GreenR	Ratio of open space within neighborhood (percentage)	26.80	13.89
FAR	Floor area ratio	2.67	1.58
Middle	Have top-ranked middle school (Binary: 1=yes)	.34	.47
Elementary	Have top-ranked elementary school (Binary: 1=yes)	.28	.45
Kindergarten	Have top-ranked kindergarten (Binary: 1=yes)	.29	.45
Parks	Have parks within quarter mile of property (Binary: 1=yes)	.08	.27
COM	Ratio of commercial and entertainment land use within quarter mile of property (percentage)	13.77	12.24
Locational Variables			
Dis_Center	Property distance to the city center (mile)	5.77	3.47
Dis_Emp	Property distance to the nearest sub-centers (mile)	3.42	2.30
Dis_Road	Property distance to the nearest arterial road (feet)	426.5	328.1
Proximity Variables			
Rail_Hlf	Property located within in a half-mile of rail station (Binary: 1=yes)	.34	.48
Rail_Hlf_One	Property located between a half and one mile of rail station (Binary: 1=yes)	.32	.47
BRT_Qtr	Property located within a quarter-mile of BRT station (Binary: 1=yes)	.03	.17
BRT_Qtr_Hlf	Property located between a quarter and a half mile of BRT station (Binary: 1=yes)	.08	.27

Note: 1RMB= 0.156 US Dollar (based on average exchange rate of 2011).

RESULTS AND DISCUSSION

TABLE 2 presents the coefficients, standard errors and significance statistics for the three models. The three models all have a good overall fit with an R^2 above 0.6. Most of the controlling variables show statistically significant coefficients with the expected sign. Variance inflation factors (VIF) for all variables are all below 3, indicating that no serious multicollinearity problems exist in the models. We also considered the potential endogeneity problem; however, an advantage of conducting such a study for Beijing is the location of many public goods (e.g., key schools and parks) is exogenous to housing price due to the former planning economy and path dependency (Zheng and Kahn, 2008). Many of the core public goods in Chinese cities were planned and built long ago by central or local governments and seldom change their locations after they are built. The last issue associated with using hedonic price modeling is the potential spatial dependence effect, which is supposed to bias the estimation of OLS. A spatial error model with spatial weighting matrices is often employed to correct this problem. Empirical studies comparing estimates from OLS and spatial error models, however, suggest that there is no significant difference between them (Mueller and Loomis, 2008), and OLS estimates are still unbiased in the presence of spatial error dependence and spatial heteroskedasticity (Anselin, 1988).

Structural Characteristics

Results of Model 1 indicate that, all else being equal, one more living room and bathroom are associated with a 3.7% and 9.8% increase in property price; the south-faced design of houses raises property price by 4.4%; the price of business apartments is approximately 9.0% higher than the average apartment price; good ventilation design adds 5.5% additional value to the house; and low-rise or super high-rise buildings are not welcomed by homebuyers in Beijing.

Neighborhood Characteristics

Moreover, all else being equal, one RMB increase of neighborhood administration fee is associated with a 2.8% increase of property price, indicating home buyers' concern for the quality of neighborhood services; a higher ratio of green space within neighborhood and being close to a park are positively and significantly associated with property price, indicating residents of Beijing pay much attention to the natural environment within and around their neighborhoods; being located within the districts of top middle schools, top elementary schools, and top kindergartens elevates the property price by 2.5%, 5.6%, and 3.0% respectively; and the ratio of commercial and entertainment land use around neighborhood is also significantly related to property price: the higher the ratio, the higher the property price.

Locational Characteristics

One kilometer distance from the city center and sub-centers is associated with a 3.5% and 2.5% decrease of property price. This result reconfirms the argument that Beijing is emerging in a polycentric urban pattern. Distance to the nearest arterial road is not significant, and this is probably due to the counteracting effects of being close to highway: accessibility and disamenities (e.g., noise and gas emissions).

Transit Proximity Effects

For proximity variables, we find interesting results from the three models. Results of Model 1 detect statistically significant price premiums for properties within a half mile of station area; in particular, locating within a half mile of rail transit stations brings a 4.8% increase on property price. The magnitude of this proximity effect in Beijing is at the same level as the effects found in U.S. cities. Beyond the half-mile radius area, however, effects of proximity to rail transit are not statistically significant any more.

Moreover, no statistically significant proximity effects are detected within a quarter mile of BRT stations, even significantly negative effects are found between one-quarter and one-half mile of BRT stations. The negative sign of coefficient may contribute to the factors that are not controlled in the model, but these results at least indicate that capitalization effect of this BRT line upon property value is negligible.

Differences on attributes between BRT and rail transit, such as capacity, guide way, frequency, comfort, punctuality, etc., contribute to the smaller effects of BRT than rail transit. This BRT line has a dedicated right-of-way and the average operating speed can reach 16 miles per hour, which is lower than average speed of rail transit lines in Beijing, 21-31 miles per hour. In addition, though it operates at the same headway (2 minutes) as rail transit lines during the peak time, its daily average ridership (150,000 person times) is less than a quarter of average daily ridership of rail transit lines (750,000-1,000,000 person times).

Another reason for non-significant effects of proximity to BRT stations may contribute to the design features of the station's nearby area. It was very difficult for the residents nearby to access to the BRT stations; BRT riders had to either use a pedestrian bridge or walk through an underground corridor to reach the stations. As Estupinan and Rodriguez (2008) found, the built environment attributes around station, like crosswalks and sidewalks, were important for BRT to have premium effects. Absence of walkable environments in the immediate area of BRT stations, therefore, is probably another factor that limits the effects of this BRT line. In addition, the lack of integration of the BRT station design and zoning around the station area in advance is possibly another important factor contributing to the insignificant effects of this BRT line. Levinson et al. (2002) suggested that early integration of station design and zoning is one of the prerequisites for BRT having similar effects as rail transit on property values.

TABLE 2 Models Results (N=1695; dependent variable: LnPrice)

	Model 1		Model 2		Model 3	
Variables	Coeff.	t-Statistics	Coeff.	t-Statistics	Coeff.	t-Statistics
Structural Variables						
Bedroom	.008	.913	.008	1.000	.007	.808
Living room	.037 **	2.471	.039 **	2.570	.037 **	2.457
Bathroom	.098 ***	6.298	.095 ***	6.145	.094 ***	6.078
Kitchen	.063 *	1.738	.062 *	1.732	.059 *	1.652
Head	.044 ***	3.171	.047 ***	3.338	.042 ***	2.997
Business	.090 ***	2.674	.087 ***	2.603	.082 **	2.476
Ventilation	.055 ***	3.572	.053 ***	3.454	.055 ***	3.597
FL6	-.043 ***	-2.845	-.041 ***	-2.750	-.034 **	-2.299
FL18+	-.054 ***	-3.332	-.058 ***	-3.568	-.054 ***	-3.347
Age	.000	.264	.000	.285	.001	.555
Neighborhood Variables						
Admin_Fee	.028 ***	7.216	.029 ***	7.376	.080 ***	7.706
GreenR	.307 ***	5.524	.302 ***	5.437	.249 ***	4.442
FAR	-.010 ***	-2.601	-.009 **	-2.289	-.008 **	-2.166
Middle	.025 **	1.993	.030 **	2.392	.025 **	1.979
Elementary	.056 ***	4.253	.052 ***	3.998	.062 ***	4.704
Kindergarten	.030 **	2.305	.029 **	2.275	.025 **	1.990
Parks	.042 **	2.004	.044 **	2.118	.035 *	1.683
COM	.224 ***	4.139	.224 ***	4.106	.232 ***	4.300
Locational Variables						
Dis_Center	-.035 ***	-26.597	-.043 ***	-20.177	-.035 ***	-25.920
Dis_Emp	-.025 ***	-14.067	-.026 ***	-14.665	-.025 ***	-14.107
Dis_Road	-.022	-.372	-.002	-.026	-.008	-.134
Proximity Variables						
Rail_Hlf	.048 ***	3.036	-.062 *	-1.855	.156 ***	6.180
Rail_Hlf_One	.012	.802	-.132 ***	-4.026	.090 ***	3.447
BRT_Qtr	-.048	-1.153	-.296 ***	-3.177	.082	1.175
BRT_Qtr_Hlf	-.062 **	-2.307	-.079	-1.464	-.097 **	-2.042
Interactions						
Rail_Hlf *Dis_Center			.009 ***	3.251		
Rail_Hlf_One *Dis_Center			.013 ***	4.846		
BRT_Qtr *Dis_Center			.027 ***	2.689		
BRT_Qtr_Hlf *Dis_Center			.002	.263		
Rail_Hlf *Admin_Fee					-.059 ***	-5.500
Rail_Hlf_One *Admin_Fee					-.047 ***	-3.856
BRT_Qtr *Admin_Fee					-.100 **	-2.048
BRT_Qtr_Hlf *Admin_Fee					.023	.860
	R^2= 0.633		R^2= 0.638		R^2= 0.640	

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

Relationship between Proximity Effects and Distance to City Center

The results of Model 2 show the interactions between station proximity and the property's distance to the city center are positive and statistically significant for three of the four interaction terms, indicating that premiums of access to transit stations increase as distance from the city center increases. In other words, the further a station is from the city center, the larger the effect of the proximity to the station. This result is expected because more commuting time can be saved from rapid transit for residents living further away from downtown, and aligns well with the findings from Bowes and Ihlanfeldt (2001).

Moreover, we calculate the marginal coefficient for station proximity as moderated by distance to the city center. Only the results of rail transit are shown in FIGURE 3, because the marginal effect of BRT is not significant at any distance. The equations developed by Aiken and West (1991) are used for calculating the marginal coefficient and corresponding standard error. The calculated marginal coefficient and corresponding 95% confidence intervals are then plotted in FIGURE 3, where the solid line indicates the marginal coefficient, and the dashed lines indicate the 95% confidence interval for the coefficient. If the 95% confidence interval crosses zero, then the *P* value must be greater than 0.05. Conversely, if the 95% confidence interval does not cross zero, then the *P* value must be less than 0.05.

FIGURE 3 shows the size and 95% confidence interval of the marginal coefficient for *rail_hlf* and *rail-hlf-one* as moderated by *dis_center*. It clearly illustrates that proximity effect goes up as distance to the city center increases. For half-mile proximity area (*rail_hlf*), only the stations more than 6.2 miles (10 kilometers) away from the city center confer statistically significant effects on apartment price, and for half- to one- mile proximity area (*rail_hlf_one*), statistically significant price premiums are only detected at stations more than 8.1 miles (13 kilometers) from the city center. We should note that coefficient for *rail_hlf_one* was not significant in Model 1 but become significant at suburban stations, and this indicates that the spatial extent of the proximity effect also increases at stations farther from the city center. Moreover, stations located at approximately 12.42 miles (20 kilometers) away from the city center can contribute as high as 12% premiums on property price.

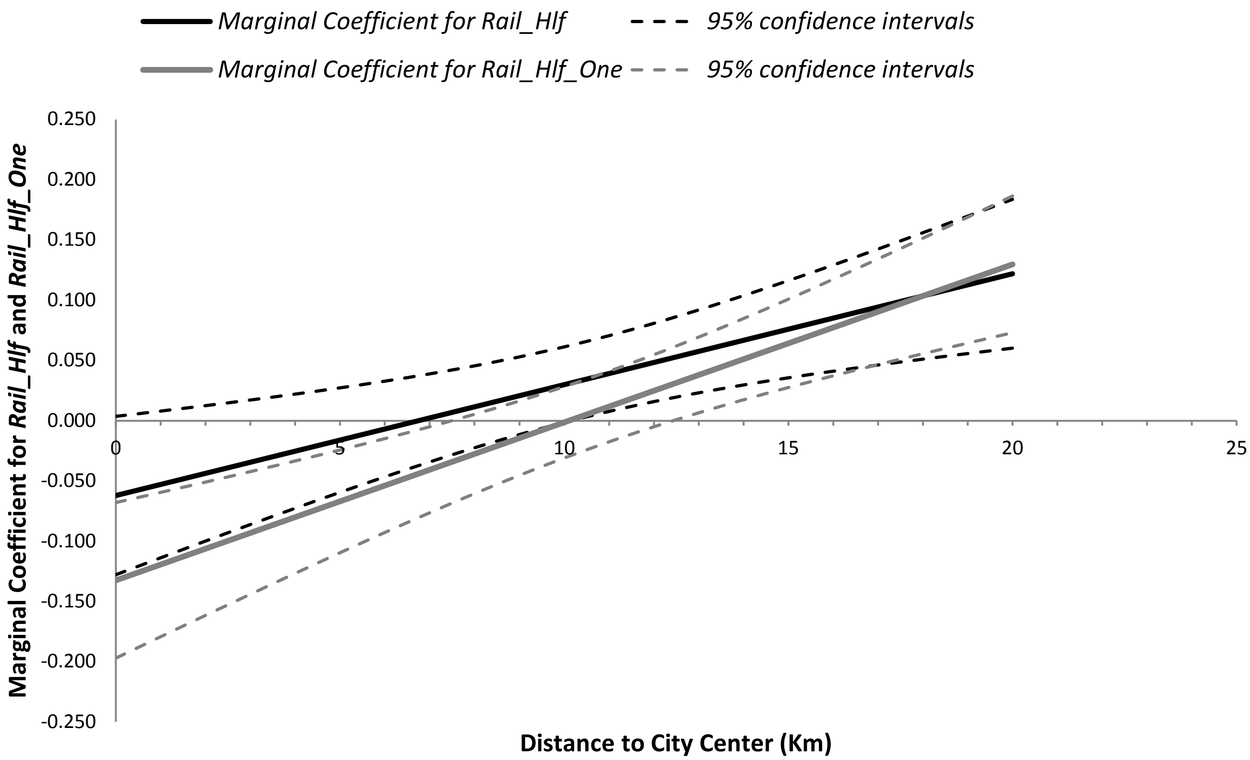

FIGURE 3 Marginal coefficient for *Rail_hlf* and *Rail_hlf_one* as conditioned by distance to city center.

Relationship between Proximity Effects and Income Level of Residents

The results of Model 3 show the interactions between station proximity and administration fee of neighborhood are negative and statistically significant for three of the four interaction terms, indicating that homeowners in high-end neighborhoods are reluctant to pay for being close to a transit station. In other words, the effects of station proximity are greater in stations surrounded by low- and medium- income neighborhoods. This result is consistent with the findings from Nelson (1992), but contrary to Bowes and Ihlanfeldt (2001) and Hess and Almeida (2007). Marginal coefficient for station proximity as moderated by administration fee was also calculated for both rail transit and BRT, but still the marginal effect of BRT was not significant at any level of administration fee. We therefore only reported the results of rail transit.

FIGURE 4 shows the size and 95% confidence interval of the marginal coefficient for *rail_hlf and rail_hlf_one* as moderated by *Admin_Fee*. FIGURE 4 clearly illustrates that proximity effect goes down as administration fee increases. For the half-mile proximity area (*rail_hlf*), significant price premiums are only detected for neighborhoods with an administration fee of less than 2 RMB, which generally applies to most low- to medium- income neighborhoods in Beijing. Statistically significant price discounts, however, are found at stations in neighborhoods with an administration fee of higher than 3.5 RMB, which generally applies to the high-income neighborhoods in Beijing. Similarly, for the half- to one- mile proximity area (*rail_half_one*), significant price premiums are found for neighborhoods with an administration fee of less than 1.5 RMB, with significant price discounts for neighborhoods with an administration fee of more than 3.0 RMB.

These results suggests that, in Beijing, low- and medium- income residents are more dependent on public transit because they cannot afford a car, and the benefits of access transit stations more than offset any nuisances generated by stations for low- and medium- income neighborhoods, while nuisances more than offset the benefits for high-income neighborhoods.

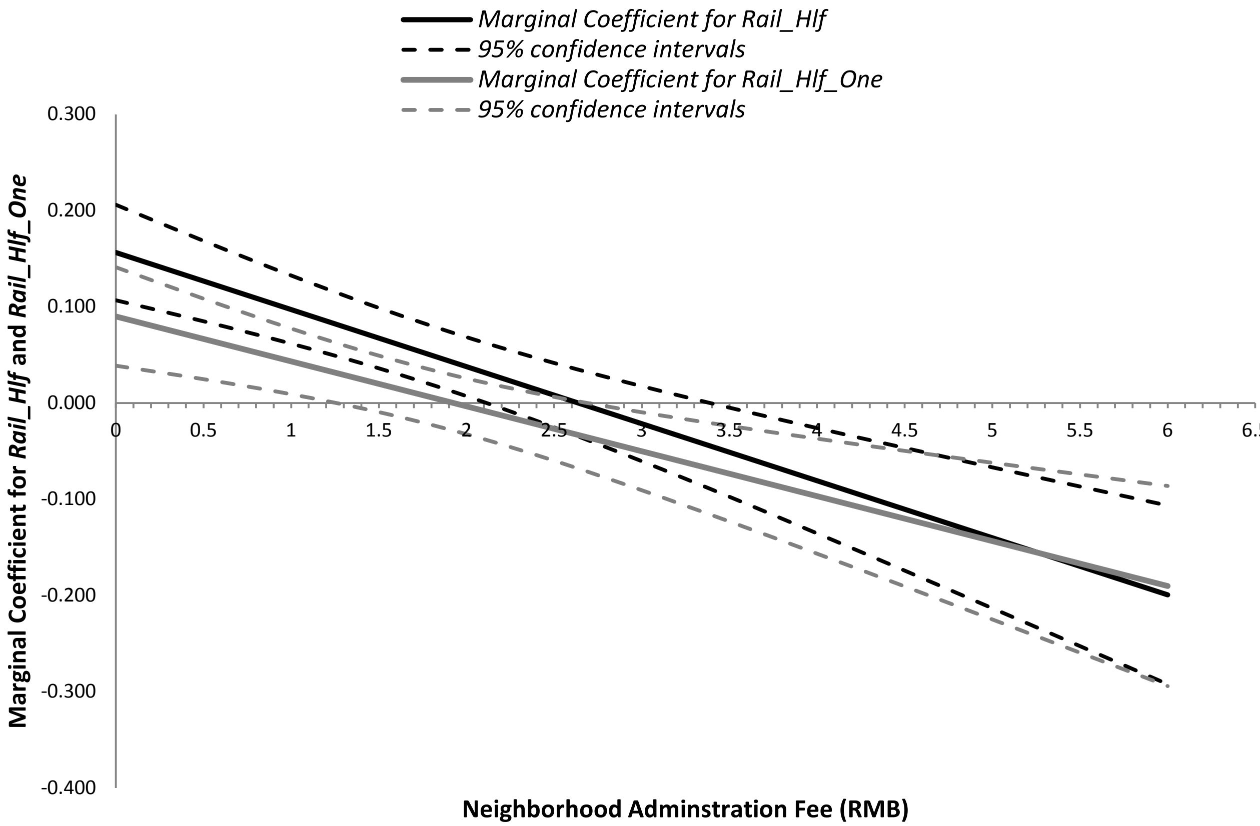

FIGURE 4 Marginal coefficient for *Rail_Hlf* and *Rail_Hlf_One* as conditioned by administration fee.

CONCLUSION AND POLICY IMPLICATIONS

Overall, with the evidence from Beijing, we can draw the conclusion that there are statistically significant price premiums for accessing rail transit stations, but no statistically significant effects for being close to BRT stations. Results from models with interaction terms further point out that station proximity effects can be greater both in size and spatial extent at locations further from the city center and in low-income neighborhoods.

Rapid transit development is an important strategy for Beijing to reshape its urban spatial structure and change people's travel behavior. This study shows that rail transit attracts property development and encourages high-density development nearby station areas. Therefore urban planners or policy makers in Beijing may use rail-transit investment as an effective tool to guide development of urban spatial patterns and to promote urban regeneration in some old and poor districts. On the other hand, urban planners in Beijing may increase the allowed development density nearby station areas by zoning to enable the land-development impact of rail transit to happen, especially to the station proximity areas in the suburbs. Significant capitalization effect of rail transit implies the possibility of other creative financing strategies, such as "Rail + Property Development" (R+P) model (Cervero and Murakami, 2008), which has been successfully operated in Hong Kong for many years. Under the R+P model, Hong Kong is one of the few places in the world where public transit makes a profit. Facing the tremendous debt in rail investments, local governments in China may consider the R+P model as a future financing solution.

This study also indicates that the priority to locate rail-transit stations should be in the low- and medium- income neighborhoods, whose residents are more dependent on public transit for daily travel activities, and in the meantime, planners should take actions to mitigate the negative externalities emitted by the stations, especially the negative effects for the high-income neighborhoods.

For BRT, this study indicates that BRT does not confer statistically significant effects on residential land development even though it brings accessibility benefits to nearby residents. Improvement on the level of service and planning interventions that integrate station design and residential land development in advance may strengthen the effects of future BRT investments on land development.

Finally, it requires mention that cross-sectional nature of this study limits its causal inference, and a before-after study design can make more rigorous evaluation of the effect of transit investment on land development.

ACKNOWLEDGEMENTS

Funding for collecting the data used in this research partially came from the Lincoln Institute of Land Policy.

REFERENCE

Aiken, L. S. and S. G. West (1991). Multiple regression : testing and interpreting interactions. Newbury Park, Calif. [u.a.], Sage Publ.

Alonso, W. (1964). Location and land use; toward a general theory of land rent. Cambridge, Harvard University Press.

Anselin, L. (1988). Spatial econometrics : methods and models. Dordrecht; Boston, Kluwer Academic Publishers.

Bartholomew, K. and R. Ewing (2011). "Hedonic Price Effects of Pedestrian- and Transit-Oriented Development." Journal of Planning Literature **26**(1): 18-34.

Bolitzer, B. and N. R. Netusil (2000). "The impact of open spaces on property values in Portland, Oregon." Journal of Environmental Management **59**(3): 185-193.

Bowes, D. R. and K. R. Ihlanfeldt (2001). "Identifying the Impacts of Rail Transit Stations on Residential Property Values." Journal of Urban Economics **50**(1): 1-25.

Cervero, R. and M. Duncan (2002a). "Land Value Impact of Rail Transit Services in San Diego County." Report prepared for National Association of Realtors Urban Land Institute, Washington, D.C.

Cervero, R. and M. Duncan (2002b). "Land Value Impacts of Rail Transit Services in Los Angeles County." Report prepared for National Association of Realtors Urban Land Institute, Washington, D.C.

Cervero, R. and M. Duncan (2002c). "Land Value Impacts of Rail Transit Services in Los Angeles County." Report prepared for National Association of Realtors Urban Land Institute.

Cervero, R. and C. D. Kang (2009). "Bus Rapid Transit Impacts on Land Uses and Land Values in Seoul, Korea." UC Berkeley Center for Future Urban Transport: A Volvo Center of Excellence, Institute of Transportation Studies, UC Berkeley.

Cervero, R. and J. Murakami (2008). Rail + Property Development: Amodel of sustainable transit finance and urbanism, UC Berkeley Center for Future Urban Transport.

Debrezion, G., E. Pels, et al. (2007). "The Impact of Railway Stations on Residential and Commercial Property Value: A Meta-analysis." The Journal of Real Estate Finance and Economics **35**(2): 161-180.

Duncan, M. (2008). "Comparing rail transit capitalization benefits for single-family and condominium units in San Diego, California." Transportation research record.(2067).

Duncan, M. (2011). "The Impact of Transit-oriented Development on Housing Prices in San Diego, CA." Urban Studies **48**(1): 101-127.

Estupinan, N. and D. A. Rodriguez (2008). "The relationship between urban form and station boardings for Bogotá's BRT." Transportation Research Part A: Policy & Practice **42**: 296-306.

Feng, J., Y. Zhou, et al. (2009). "The spatial restructuring of population in metropolitan Beijing: Toward polycentricity in the post-reform era." Urban Geogr. Urban Geography **30**(7): 779-802.

Hess, D. B. and T. M. Almeida (2007). "Impact of Proximity to Light Rail Rapid Transit on Station-area Property Values in Buffalo, New York." Urban Studies **44**(5-6): 1041-1068.

Knight, R. L. and L. L. Trygg (1977). "Evidence of land use impacts of rapid transit systems." Transportation **6**(3): 231-247.

Landis, J., R. Cervero, et al. (1995). Rail transit investments, real estate values, and land use change : a comparative analysis of five California rail transit systems. Berkeley, Calif. (316 Wurster Hall, Berkeley 94720), University of California at Berkeley, Institute of Urban and Regional Studies.

Levinson, H. S., S. Zimmerman, et al. (2002). "Bus Rapid Transit: An Overview." Journal of Public Transportation **5**(2): 1-30.

Levinson, H. S., S. Zimmerman, et al. (2003). "Bus rapid transit." TCRP Report 90, Transportation Research Board.

Mills, E. S. (1972). Studies in the structure of the urban economy. Baltimore, Published for Resources for the Future by Johns Hopkins Press.

Mueller, J. M. and J. B. Loomis (2008). "Spatial dependence in hedonic property models: Do different corrections for spatial dependence result in economically significant differences in estimated implicit prices?" J. Agric. Resour. Econ. Journal of Agricultural and Resource Economics **33**(2): 212-231.

Mullins, J. A., E. J. Washington, et al. (1990). "Land use impacts of the Houston transitway system." Transportation Research Board(1237): 29-38.

Muth, R. F. (1969). Cities and housing; the spatial pattern of urban residential land use. Chicago, University of Chicago Press.

Nelson, A. C. (1992). "Effects of elevated heavy-rail transit stations on house prices with respect to neighborhood income." Transportation research record.(1359).

Polzin, S. E. and M. R. Baltes (2002). "Bus Rapid Transit: A Viable Alternative?" Journal of Public Transportation **5**: 47-69.

Rodriguez, D. A. and C. H. Mojica (2009). "Capitalization of BRT network expansions effects into prices of non-expansion areas." Transportation Research Part A: Policy & Practice **43**: 560-571.

Rodriguez, D. A. and F. Targa (2004). "Value of accessibility to Bogota's bus rapid transit system." Transport Reviews: A Transnational Transdisciplinary Journal **24**(5): 587-610.

Song, Y. and G.-J. Knaap (2004). "Measuring the effects of mixed land uses on housing values." Regional science and urban economics. **34**(6): 663.

Zheng, S. Q. and M. E. Kahn (2008). "Land and residential property markets in a booming economy: New evidence from Beijing." J. Urban Econ. Journal of Urban Economics **63**(2): 743-757.