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The Impact of Bus Rapid Transit on Land Development: A Case Study of Beijing, China

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***Abstract*—**Bus Rapid Transit (BRT) has emerged as a cost-effective transport system for urban mobility. However its ability to stimulate land development remains largely unexplored. The study makes use of qualitative (interview method) and quantitative analysis (questionnaire survey and longitudinal analysis of property data) to investigate land development impact resulting from BRT in Beijing, China. The empirical analysis suggests that BRT has a positive impact on the residential and commercial property attractiveness along the busway corridor. The statistical analysis suggests that accessibility advantage conferred by BRT is capitalized into higher property price. The average price of apartments adjacent to a BRT station has gained a relatively faster increase than those not served by the BRT system. The capitalization effect mostly occurs after the full operation of BRT, and is more evident over time and particularly observed in areas which previously lack alternative mobility opportunity.

***Keywords*—**accessibility, Bus Rapid Transit (BRT), Beijing, property value uplift

I. INTRODUCTION

BUS rapid Transit (BRT) is an emerging form of Mass Transit, which combines the speed and reliability of a rail service with the operating flexibility and lower cost of a conventional bus service. Characterized by modern vehicles, dedicated busway and applications of Intelligent Transportation Systems (ITS) technologies, BRT is increasingly considered as a cost-effective alternative for urban mobility. Reference [1] argued that BRT on exclusive right-of-way achieved comparable performance to rail rapid transit in terms of passenger flow control and off-vehicle fare collection, but with a lower cost of distributing passengers to their ultimate destinations. Reference [2] argued that BRT was an increasingly preferred system to grow public transport patronage and deliver value for money, and recommended all governments to seriously evaluate the appeal of BRT. In order to improve sustainable mobility with less expenditure, many cities across the world have launched ambitious programmes of BRT system implementation with varying success. Inspired by some successful BRT systems, such as in Curitiba (Brazil) and Bogotá (Colombia), Chinese decision makers have adopted BRT schemes as a promising strategy for relieving traffic problems, at a relatively low cost and within a fast implementation time. The first BRT system in China, Beijing BRT line 1 has proved to be a more affordable way than Metro and LRT to provide a high quality transport service. This demonstration project has shown the impressive performance of rubber-tyred rapid transit technology which is being increasingly implemented across the world.

Despite the benefits and cost-effective advantages of a BRT system, BRT is not yet well understood by decision-makers. The attraction of BRT to policy-makers is that it could be a cost-effective approach to moving a large number of people. However, a well developed transport system, such as Metro and LRT, not only accommodates the movement of people, but may also contribute to economic development in a region. It is increasingly accepted that in common with other forms of Mass Transit systems, a full-featured BRT system (one that includes dedicated travel lanes for vehicles, improved stations, vehicles, frequent service, rapid boarding, ITS application and off-board fare collection) has the potential to offer economic effects on land development. A growing body of evidence suggests BRT systems have a positive impact on land development, such as BRT systems in Curitiba, Ottawa, and Brisbane [3-5]. Despite that many BRT systems are successfully in operation across the world (including a number recently introduced in Asia), there remains a lack of empirical evidence about the impact of BRT on land development. Bus services are perceived as slow, polluting, and unreliable by the public, which in turn causes stakeholders to hesitate to consider investing in BRT. Stakeholders, and perhaps more importantly, developers question whether being located near the BRT yields net benefit. Since many cities continue to consider launching a BRT line or expanding a BRT network, understanding the full impacts of BRT is becoming increasingly important, especially as anticipated property value uplift conferred by BRT could be a part of a strategy contributing to BRT project development funds.

The research presented in this paper seeks to examine whether benefits from BRT, specifically travel time saving, has influenced land development around BRT stations. This paper is structured as follows. The next section presents a review of international literature, discussing the current debates relating to the land development impact resulting from BRT. Section 3 discusses the methodology used in this study to investigate the land development impact resulting from BRT investment. Section 4 describes the implementation of the Beijing Southern Axis BRT Line 1. Section 5 presents results from a survey of BRT passengers and interviews with key stakeholder groups. Section 6 describes the longitudinal analysis, analyzing average change in asking price for previously owned apartments in both catchment and control areas in 2003 (before the opening of BRT), 2004 (construction phase) and 2009 (4 years after the

full operation of BRT). Finally, section 7 draws the conclusion and provides recommendations.

II. Literature Review: the impact of BRT on land development

It is well understood that transport improvement can have a positive effect on the timing or probability of land developments. A high quality public transport system can greatly improve the accessibility of its catchment area by shortening travel time. Thus, locations near transport stations which generally have a high level of accessibility to a rapid transit system tend to be desirable for new development or redevelopment. Since households and firms are likely to bid more for proximity to station areas in a competitive property market after weighing the benefits and risks of appreciation, it could be expected that property values increase with proximity to a station. That is to say the economic impact resulting from transport improvement on land development is capitalized into higher land value, reflected by property value uplift. Therefore, the impacts of transport improvement on land development are likely to have at least two types: property value uplift and accelerated development of land use.

There is considerable interest in measuring and exploiting property value uplift conferred by transport investment. It is argued that this issue is of crucial importance largely because property value uplift effect associated with transport infrastructure development could be used as an investment mechanism to finance public transport project [6, 7]. In common with other forms of Mass Transit systems, such as Metro and LRT, BRT systems tend to influence land development. A growing body of evidence suggests that BRT systems have a positive impact on property value uplift. Reference [8] examined the asking price for multi-family residential properties in a 1.5-km area around two TransMilenio corridors in Bogotá, Colombia, and found that rental prices of properties increased between 6.8% and 9.3% for every 5 minutes walking time closer to BRT stations, while controlling for property attributes and proximity related externalities. Although the study was conducted only two years after completion of the BRT system, it showed obvious positive impact of BRT on property value uplift. One explanation was that local residents really appreciate the improvement of accessibility near BRT stations. In a recent working paper, reference [9] analyzed the impact of Seoul`s dedicated median-lane BRT on land-use changes and property value uplift. It was found that the enhanced accessibility was capitalized into the land market and land use along the BRT corridors was intensified. It was further argued that the quality of transport service, specifically the travel time savings, influenced land development and BRT-induced land appreciation could help the BRT investment.

Network effects from an enhanced BRT network are also found within a city. Reference [10] investigated the property values uplift caused by BRT extension in the area already served by Bogotá`s BRT system, using a before and after hedonic model. The price changes between 2001 and 2006 of residential properties (single-family and units in multi-family apartments), which were located within 1 km of the BRT system, were examined after the TransMilenio system was expanded. The asking price of properties in the BRT catchment area was found between 13% and 14% higher than that in the control area. These findings suggest that BRT network investments can increase property values in an area already served by BRT and improve the attractiveness of land parcels for dense development.

Many public transport planners believe that fixed guideway systems have a positive impact on land development [11, 12]. Reference [12] believed that a BRT system (including busways and enhanced bus stations) could be regarded as being as significant as other fixed guideway facilities. In a report on the land-value impact of Los Angeles Metro Rapid BRT (a BRT-lite system that employs certain components of BRT), reference [11] found that residential properties in the proximity of BRT were generally sold for less, whereas commercial properties generally sold for more. The study concluded that the absence of dedicated right-of-way and the newness of the service (only one year) and the location of route (in an area of socio-economic deprivation) accounted for lower property value. Furthermore, the Metro Rapid BRT system does not have fixed guideways. It runs in mixed traffic using conventional buses and thus residents doubt BRT routes will be modified in future years. More recently, a full-featured BRT, Orange Line BRT was launched in Los Angeles. It was found that the promising performance of the Orange Line BRT could provide joint development projects at Orange Line stations [13].

Despite some successful BRT systems in operation, empirical studies on land development impact resulting from BRT are still limited. Some well established BRT systems in Latin America, North America and Australia indicate that a full-featured BRT system has a positive impact on land development. Like other forms of Mass Transit, BRT could provide accessibility advantages to communities along its corridor. These benefits could be more easily observed in the congested and land-constrained city, where public transport has played a major role in determining accessibility change.

III. Research Methodology

3.1 Research process flowchart

A robust methodology combining quantitative and qualitative techniques is developed in this study, shown on Fig. 1.

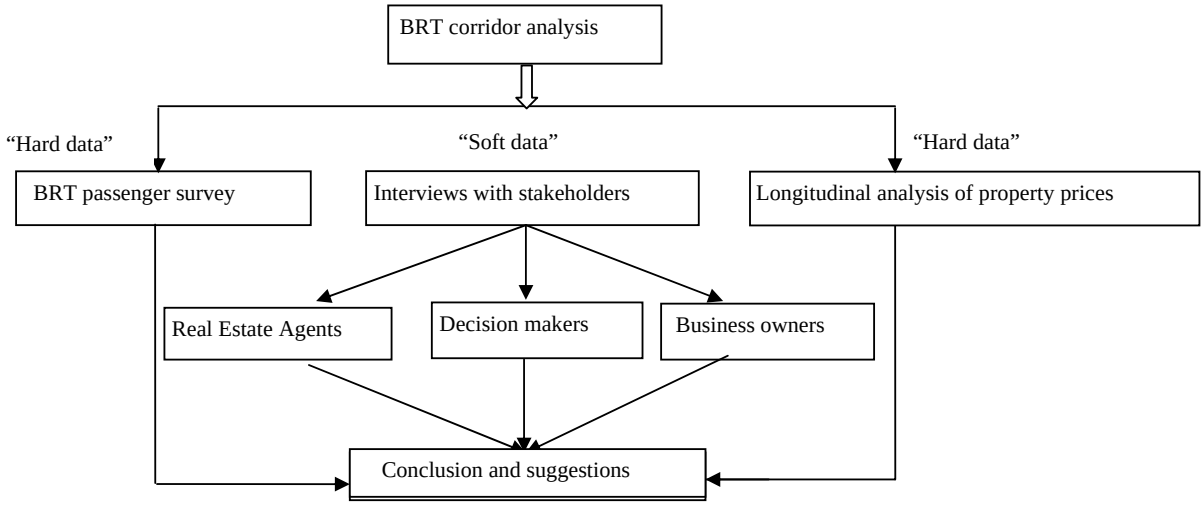

Fig. 1: Research process flowchart

3.2 Development of Passenger Survey

The quality of the public transport service offered is a critical factor contributing to land development. Only a high quality transport system is likely to attract new trips, improve business opportunities and stimulate property development. To gain insight into the public attitude to the BRT services and to explore their perception of living near BRT stations, a questionnaire was designed. Since passengers` travelling behaviour varies between weekdays and weekend, the data collection was conducted on two weekdays (August 12 and 13, 2009) and one weekend day (August 15, 2009) to minimize bias caused by sampling time. The survey was conducted during morning rush, mid-day, afternoon rush and evening. There were no major events, such as a National Congress or international sports festival, or car accidents during the survey, which could have substantial impact on the validity. There were three people in the survey distribution team, including the author and two trained interviewers who were recruited from a local university. A total of 600 questionnaires were distributed on vehicle and at BRT station areas with frequent passenger loading and unloading. The surveyors randomly stopped and asked passengers to fill out the questionnaire. After explaining the purpose of the survey, the respondents were left alone to complete the questionnaire. The surveyors remained in the vicinity making sure that respondents could get a prompt explanation if required.

3.3 Development of interviews with key stakeholder groups

The purpose of interviews is to gain deep insight into land development impacts resulting from BRT investment from the perspectives of stakeholders. The interviewees can be divided into three groups. The first group consists of decision makers, including government officials from the transport planning agency and land management agency, real estate developers, BRT operators and planning consultants who are familiar with the Mass Transit system and land development in Beijing. The second group includes real estate agents who are active within the BRT corridor area. The third group consists of businessmen who are running businesses at BRT station areas.

1) Semi-structured interviews with decision makers

These interviews were conducted according to pre-arranged schedule of meetings with decision makers. These selected individuals were contacted by phone to set up an appointment, mostly in late July, 2009. Each interviewee was sent an interview outline by email in advance so that they could have sufficient time to prepare for the answers and relevant data that can be made available. The interview location was chosen by the participant to ensure the interview was conducted in a comfortable place for the participant. The interviews lasted from 45 minutes to 1 hour, and around 11 questions were asked. All interviewees were provided with written guarantees of confidentiality in the meeting. Some interviews were recorded after getting the permission from the interviewees.

2) Questionnaire for the Real Estate Agents

Real estate agents were chosen from consultancy companies, which have a good reputation in the market. Compared to setting up the interview with government officials and developers, it is much easier to access real estate agents. Those real estate agents were approached by making direct contact in their workplace around BRT stations. After they showed interest they were asked to fill out the questionnaire.

3) Semi-structured interviews with business owners

The business owners, who are running business around BRT stations, have deep experience of the impact of BRT operation on their business. This survey explores the positive or negative impacts of the operation of BRT on the on adjacent business. In BRT station areas, there are many retailers serving the local communities as well as customers changing buses. They were approached by making direct contact in their workplace.

3.4 The treatment of time and space

Since private investment can happen in any phase of the transport investment life cycle: planning and evaluation phase, design phase, construction phase, and operation phase [14], an evaluation period considering pre and post opening is appropriate to understand the overall impact of the investment. This provides a deep insight into the role that transit investment has played in stimulating economic development. In a summary of previous studies about land value and public transport, reference [15] indicated that the change of property values might be observed before the completion of the transport infrastructure, after the opening of the transport system, and in the future years when the full benefits were perceived by stakeholders. Thus, the evaluation of BRT Line 1 was divided into three phases: planning and design phase, construction phase and operation phase.

Catchment areas are small areas around stations that are expected to experience the most significant impacts of the transport system. Although the impact could occur beyond the boundary of catchment area, generally, those areas are expected to attract more development interests than similar areas further from stations. The size of the catchments is mainly based on the pedestrian access distance, i.e. how far passengers are willing to walk to a station from home or destination. In previous studies, some researchers found that 500 metres radius around stations were most likely to be affected [16]. According to the BRT passenger survey in this research in 2009 [17], most residents lived within 500 metres radius around BRT stations. Supplemented by discussion with local real estate agents, the catchment area is defined as a 500 metre radius around BRT stations in this study.

3.5 The Measurement method of property value uplift

Measuring property value capture stimulated by transport investment has become one of the commonly used approaches to gauging the economic benefits of transport improvement. The longitudinal analysis method, comparing the study area with a similar area that does not have the new transport facility is widely found in previous studies [18-25]. This method is frequently used to identify the direct effect of a transport improvement project by using a control area and a catchment area to provide statistical evidence. The study area and control area are both analyzed by a longitudinal comparison, using the data 'before' and 'after' the opening of transport system. As the property value changes incrementally, this is a good way to model data via a time series. More recently, in the BRT evaluation guidelines recommended by Federal Transit Administration, it is suggested that the appropriately designed technique before/after and test/control approach could guarantee with greatest confidence any observed improvement due to the BRT implementation [12].

3.6 Selection of catchment and control areas

The following procedure was adapted:

1) Selection of catchment areas. This took account of significant clusters of housing or commercial service; the nature of the property sub-market along the BRT corridor; and the need to avoid the restricted land use type, such as institutional land.

2) Selection of control areas

Ideally, the control area should be as much like the catchment area as possible and exhibit the following characteristics:

- The control area should have the same sub-market classes (residential, office, retail or industrial property) to its paired catchment area
- The control area properties should have similar location and structure attributes (type of units, age, quality et al) to its paired catchment area properties
- The control area properties should not benefit from BRT implementation (at least 1 km away from a station)
- The control area properties should not benefit from other significant external effects, such as Metro and highway implementation.

Thus, the geographic location, type of units and building age are used as the chief control variables. Local real estate agents also assisted in making judgement in the field.

Three catchments areas: Dahongmen Xili, Heyinanzhan, Liuyingmen and three control areas: Guangcailu, Jiugongzhenxi, Jiugonglu were selected for the comparison study, as indicated in Fig. 2 below.

Fig. 2 Locations of catchment areas and control areas,
Source: based on the map from http://map.sogou.com/

These station areas have significant clusters of housing and are expected to have more pressure in terms of land development and redevelopment. All the residential projects in catchment areas are located within the 500-metre radius, and a number are immediately adjacent to a station. The control area properties are located at least 1.2 km from the BRT corridor.

3.7 Data collection and analysis method

Transaction price data are normally seen as an effective way of reflecting property value. However, it proved difficult to get these transaction data as those data are normally not open to

public. Thus, the property data used in this study combines asking prices from professional reports provided by local real estate agents and data from real estate websites. The real estate websites display the latest information on the properties, including current asking price, historical house prices (time-series), information on structure features, such as floor space, housing type, size, age, number of bedrooms, and location amenity, such as recreational facilities, open space, and shopping facilities.

The asking prices, as a reflection of transaction prices, are used in many past studies [8, 10, 20, 25], due to the high correlation between asking data and transaction data. In this study, the data on commercial property values are extremely limited. Beijing Southern areas are far less developed than the Northern part, where most employment lies. In this case, data on commercial property values cover either a short time period or a small geographic data. Therefore, no detailed study on the impact of BRT on commercial property price change has been completed. This study investigates the residential property price change at three time points, 2003 (before the opening of BRT), 2004 (construction phase) and 2009 (4 years after the full operation of BRT). The asking prices of previously owned apartments (RMB/m^2) in catchment area (N=252 in 2003; N=265 in 2004; N=525 in 2009) and control area (N=304 in 2003; 325 in 2004; N=487 in 2009) were chosen as a measure of residential property value change. The high-density, low or middle income apartments, with mostly two-bedroom or three-bedroom units, dominate residential neighbourhoods along the BRT corridor, as shown in Fig. 3.

Fig. 3 High-density apartments

IV. Overview of Beijing Southern Axis BRT Line 1

The Southern Axis BRT line 1 (Fig. 4) started commercial operations in December 2004. The pilot line was only 5.5km in length in the first stage. In December 2005, BRT Line 1 began full operations and it was extended to 16.5 km. The route starts at Qianmen (the city centre) and ends at Demaozhuang (a southern resident area), running through 17 stations. It has adopted many LRT features, a dedicated busway, modern vehicles, enhanced stations, off-board fare collections and various ITS tools. The specific goals of this BRT system are to satisfy the increasing travel demand and provide a service that offers a faster, more reliable option for passengers travelling from the city centre to the Southern area. This rubber-tyred transit system, has achieved almost 40% travel time reduction and high ridership (120,000 average daily passengers in a single corridor[1]), with only 1/15 capital cost of a Metro line.

1 Advanced vehicle
2 Enhanced station
3 Off-board fare collection
4 Screen door system
5 Exclusive busway
6 Barrier
7 Overpass

Fig. 4 Beijing Southern Axis BRT line 1

The BRT line 1 is an integrated technology package, combining six main elements whose characteristics are summarized below.

V. Analysis of Beijing Southern Axis BRT Corridor

In common with other forms of Mass Transit systems (Metro and LRT), a full-featured BRT has the potential to influence both travel behaviour and land development. The following sub-sections presents results from the BRT passenger survey and interviews with key stakeholders, as well as statistical analysis of change in the asking price of apartments.

Table I Main elements of the Southern Axis BRT line 1

Running way	- A16.5-km median busway - Two lanes in each direction
Vehicles	- 18m single-articulated bus with Metro-like characteristics - Full low-floor buses - Three doors level boarding
Enhanced Stations	- 17 upgraded bus stations located in the median of the road - Level boarding and alighting.
Frequent Service	- Typical headway: 1.5 min (two vehicles) on peak 2-3 min off peak - BRT timetable: departure station: 05:00-22:30 terminal station: 05:30-23:00
Pre-board Fare Collection	- Smart card application - Tickets can also be purchased from sales clerks - Fare structure: 1 Yuan by cash or 0.4 Yuan by smart card
ITS technologies	- Transit Signal Priority - Ticketing System - Monitoring systems - Real-time Passenger Information

5.1 Analysis of results from passenger survey

A total of 600 questionnaires were distributed and 525 questionnaires were valid for further analysis. The following issues were explored in the questionnaire. Further details may be found in Deng and Nelson (2010).

1) Evaluation of the BRT service

Seven attributes: speed, reliability, safety, convenience, frequency, comfort & cleanliness and overall service quality were measured for evaluation of the BRT service. In total, 85.5% of passengers rated overall satisfaction of BRT service as “very satisfied” or “satisfied”. In particular, respondents thought BRT was fast and convenient. Totally, 88.4% and

[1] Data from www.chinabrt.org

85.5% of respondents rated “Speed” and “Convenience” as “very satisfied” and “satisfied” respectively. Negative comments primarily relate to the coverage of service and interior of vehicle. An independent-samples t-test was conducted to examine whether the perception of the BRT service from car users is significantly different from non-car users. Three factors, reliability, comfort & cleanliness, and overall satisfaction, are found to be significantly different between car users and non-car users within a 95% confidence interval. These results suggest that car users have a higher expectation on reliability, comfort & cleanliness, and overall satisfaction of BRT service than non-car users.

2) Respondents` perception of living near BRT stations
Respondents were asked to indicate whether they lived within reasonable walking distance of BRT stations. 43.4% of passengers (N=228) were local residents who lived near a BRT station.
- a) Date when residents moved to be near the BRT corridor

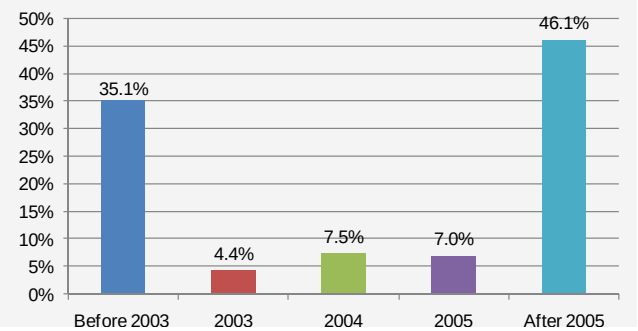

Fig. 5: Relocation time of respondents (N=228)

The data show that a large majority of respondents (46.1%) moved to a place near BRT stations after the full operation of BRT line 1 commenced in December 2005. Although residential location choices are affected by complex factors, it may be inferred that proximity to the BRT corridor can reduce the time and money cost of commuting, and this has significantly improved the residential property attractiveness near BRT.

-b) Distance from respondents` residence to their nearest station

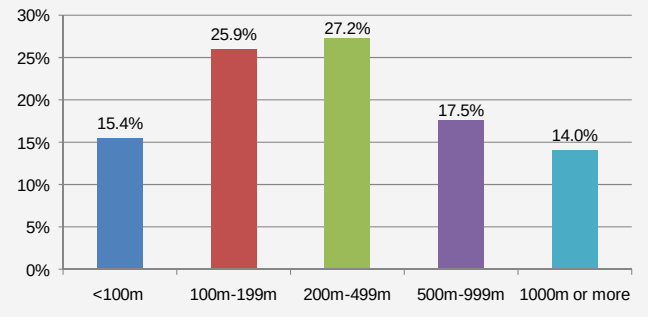

Fig. 6: Distance from respondents` residence to the nearest BRT station (N=228)

the nearest BRT station, indicating the attractiveness distance of BRT in the southern suburban area. Most respondents (68.5%) lived within a 500 metres radius around BRT stations.

It is worth noting that 14.0% of respondents travelled over 1000m to take the BRT service, among whom 68.8% used BRT at least 1 time/day, 50% took bus and 31.2% walked to a BRT station. It may be concluded that as a major transport improvement project in the Beijing southern area which connects with the Metro network, the BRT line 1 has greatly improved accessibility for communities and produced a large attractiveness distance.

-c) The importance of BRT to the relocation choice
(For respondents who moved near a BRT station after the full operation of the BRT system in December 2005)

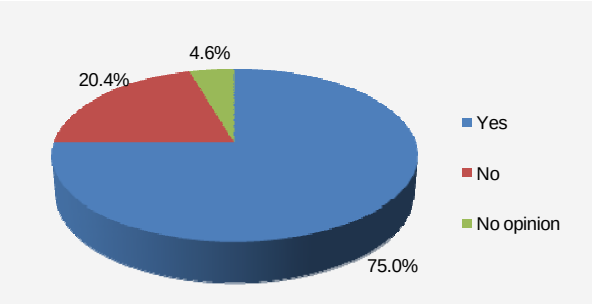

Fig. 7: The importance of BRT to the relocation choice (N=108)

As can be seen from Fig. 7, a large majority of respondents (75.0%) stated that BRT was an important factor in their choice when choosing to live near the BRT corridor. One possible reason is that BRT is a convenient rapid transit for local residents to travel to the downtown. Living near the BRT corridor can reduce the time and money cost of commuting. Although residential relocation choices are affected by many factors, transport is a very important factor to many residents` relocation choice. This may indicate that the implementation of BRT has made the residential property in the Beijing southern area become more desirable. 20.4% of passengers didn`t deem BRT an important reason to live near BRT corridor. Most explanations are related to career change.

5.2 Interpretation of interviews with stakeholders
1) Decision makers` viewpoint
The survey intended to understand the importance of BRT line 1 in improving the accessibility to the Beijing southern area and its capability to stimulate land development from decision makers` perspectives. A total of 7 in-depth interviews were held with 13 practitioners from 6 organizations involved. The primary findings from discussion with decision makers include:

- It is believed that BRT line 1 has a substantial impact on transit-supportive land development. The travel time savings has made locations near a BRT station more desirable for development. Many residential projects, specifically high-density apartments, were built after the implementation of the BRT system, and this is mainly due to the accessibility enhancement in the southern area.
- Just like other transport facilities, BRT also has negative

effects on nearby properties resulting from noise, pollution, and traffic intrusion. However, the value of accessibility provided by BRT line 1 is significantly stronger than these nuisance effects.

- BRT line 1 has provided some opportunities for joint development, but busway stations are not well integrated into surrounding land development. For BRT projects, promoting land development is currently not within the scope of transport planners. The extent to which BRT is able to stimulate land development is highly dependent on the co-ordination among stakeholders. Thus, it requires government collaboration to facilitate improvement of the integration of BRT and land development.
- The importance of physical infrastructure was emphasized by decision makers.
- The commercial projects were less referred to in the interviews, and it is expected to take a longer time to examine its impact.

2) Opinions from local real estate agents

A questionnaire was administered to 35 real estate agents who specialize in the property market within the BRT corridor area. According to the survey, all of the 17 BRT stations areas are covered by respondents` business. This survey aimed to investigate how real estate agents perceive the property sub-markets to have changed due to the implementation of the BRT line 1. The primary findings from discussion with local real estate agents include:

- The BRT line 1 has a high profile in the property market along with its adjustment and improvement. Properties adjacent to the BRT stations benefit by accessibility enhancement. There was generally a consensus on the prosperous nature of the property market, such as rising property values, rents, and real estate performance, benefiting from the opening of BRT. The overwhelming majority (94.3%) believed that the operation of the BRT Line 1 had caused a noticeable change in property prices in proximity to the BRT corridor.
- The property value uplift conferred by the BRT mostly occurred after its full operation and happened within 500 metres distance from a BRT station.
- BRT was fundamental to many customers` interest in the local area. From the real estate agents` perspective, most customers would like to pay a premium (10% to 25% of rental or capital value) for properties near the BRT corridor.
- 85.7% of respondents believed that BRT has become a driver for property development along its corridor.

3) Main findings from survey with business owners

The interview with business owners near a BRT station intended to gain an understanding of the possible impact of BRT line 1 on adjacent business. The survey was conducted around five BRT stations: Nanyuanlu Guoyuan, Dahongmen Xili, Dahongmen Qiao, Liuyingmen and Demaozhuang. In these areas, there are many retail facilities to serve the local communities as well as customers changing buses. 15 business owners, who operated retail businesses facing the street, participated in this survey. All participants were small business owners, and their business included food, clothes, electronic products, cosmetics, books and periodicals sale. 9 of the 15 participant set up business before the opening of BRT line 1 in 2005, and 6 participants started business after that.

Visits and interviews with some business owners revealed that BRT line 1 may have improved business opportunities for people to work in station areas. After the opening of BRT line 1, more customers travel from downtown to the southern area. The BRT service may attract many new trips to boost the patronage of nearby businesses. The survey was conducted only 4 years after the full operation of BRT line 1. Further investigation on the commercial sector is required after a longer period.

VI. Property Value Capture Analysis

A a quantitative method – longitudinal analysis, is conducted to provide “hard evidence” to complement the findings from the previous qualitative study.

BRT line 1 is located in the Beijing southern area. The 16.5 km busway corridor is located in the middle of a north-south traffic artery. As Beijing continues its rapid expansion, this road becomes one of the important corridors connecting the city centre to the southern area. Prior to the opening of the BRT, conventional buses provided poor public transport service on the southern main road. The BRT now offers a larger capacity and much faster connection for local residents and businesses in the southern area to the downtown. Although the general traffic movement is frequently paralyzed at peak time, BRT Line 1 could operate at up to 22km/h on peak time and 26km/h off peak time. This has reduced a previous one-hour bus journey to 37 minutes [26], equating to a 38.3% reduction in average travel time for passengers.

The land use along the BRT corridor is predominantly residential buildings and contains commercial, institutional, leisure, office, and vacant land. Recently, the Beijing southern area has experienced high-speed urban development. The living quality has been upgraded by the improvement of regional environmental quality and transport condition.

6.1 Overall comparison of properties prices change

Before comparing the catchment and control areas, it is necessary to have a look of property market in Chongwen and Fengtai districts, where the BRT route passes through, and Beijing metropolitan area, from a regional perspective. Fig. 8 shows that there is a significant increase in average apartments asking price for previously owned (i.e. second hand) apartments in Chongwen and Fengtai districts and Beijing metropolitan area, over the period of 2003 to 2009.

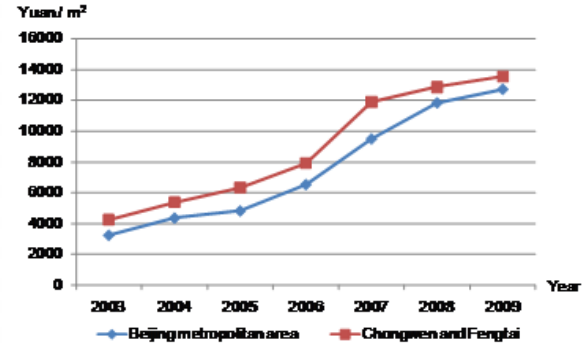

Fig. 8: Previously owned apartments prices change in the Beijing metropolitan area from 2003 to 2009
Source: data based on property prices obtained from local real estate agents and China Real Estate Index System (CREIS)

a

high rate from 2003 to 2006, and increased sharply between 2006 and 2008, with a relatively moderate increase in 2009. The previously owned apartment market in Beijing has boomed recently due to tremendous consumption demand from consumers. The effect of the Olympic Game and the government`s support policy for the property market contribute to the significant increase of property prices from 2006 to 2009. These powerful effects have boosted the booming property market in Beijing, even under the global economic recession in late 2008 and 2009. Chongwen and Fengtai district, where BRT line 1 passes, had an average property price above that of Beijing metropolitan area level.

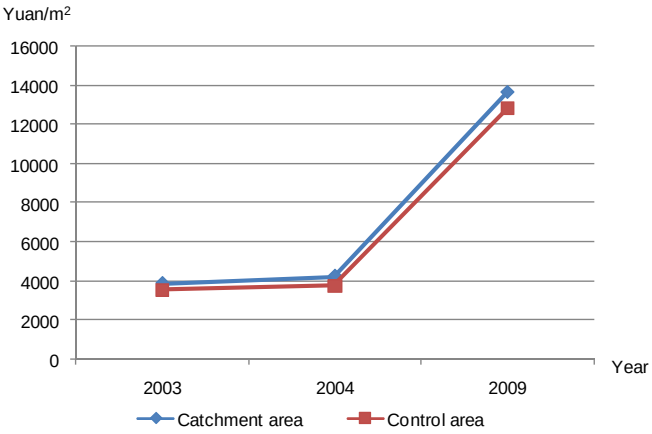

Fig. 9: Previously owned apartments prices comparison between catchment and control areas *Source:* data based on property prices obtained from local real estate agents and real estate websites

years, under a favourable regional economy. Both of the catchment areas and control areas consist of many high-density, middle income residential neighbourhoods, with mostly two-bedroom or three-bedroom units. It is believed that external factors, especially the 2008 Beijing Olympic Game, present economic crisis and government policy of supporting property market, affecting both control and test units similarly. From 2003 to 2004, average values of residential properties increased 6.7% near the BRT stations, compared to 8.3% in the control areas; from 2004 to 2009, average values of residential properties in the catchment areas rose 66.71% annually, compared to an annual increase of 64.41% in the control areas. Both values for catchment and control areas increased dramatically, benefiting from an excellent regional property market. The asking price of apartments in the BRT catchment area (500 meters radius of the BRT system) was 1.08%, 1.12% and 11.04% higher than that in the control area in 2003, 2004 and 2009 respectively. The results suggest that average apartments price adjacent to a BRT station has gained a relatively faster increase (2.3% annually) than those not served by the BRT system, and this trend is more apparent after the operation of BRT in 2005. The finding is in accord with the survey to local real estate agents; most agents (40%) anticipated that most of their customers would like to pay a premium (10% to 25% of capital value) for similar residential properties near the BRT corridor. These results are comparable with the finding by reference [10], examining the property value uplift resulting from Bogotá`s BRT system extension. The asking price of properties (single-family and units in multi-family apartments) in the catchment area was between 13% and 14% higher than that in the control area, using price changes of residential properties between 2001 and 2006.

6.2 Longitudinal analysis

Fig. 8 shows the trend of apartments prices change at three time points, 2003, 2004 and 2009. It indicates that asking price of previously owned apartments near a BRT station have a stronger growth trend than those not served by the BRT. However, a more powerful statistical analysis is necessary to further explore this question: Has the accessibility enhancement conferred by BRT been capitalized into the local property values?

ANOVA (Analysis of Variance) is used to examine the mean price change for residential properties (apartments) in catchment and control areas, over two periods: 2003 (planning phase) to 2004 (construction phase), and 2004 to 2009 (operation phase). At a 5% level of significance, the null hypothesis (H0) is rejected if a *p*-value is less than 0.05.

1) Hypothesis 1:
H_0 : There is no significant difference in property prices for catchment and control area at a time point.
H_1 : There is a significant difference in property prices for catchment and control area at a time point.
Hypothesis 2:
H_0 : There is no significant difference in property prices in an area over a period of time.
H_1 : There is a significant difference in property prices in an area over a period of time.

A one-way ANOVA method with contrast tests was used to for testing hypotheses 1 and 2.

TABLE II RESULTS OF CONTRAST TESTS FOR CATCHMENT AND CONTROL AREAS (1)

Station	Hypothesis 1			Hypothesis 2		
	Contrast	*p*-value	Accept H_0	Contrast	*p*-value	Accept H_0
DahongmenXili	Ca03-Co03	0.106	√	Ca03-Ca04	0.517	√
	Ca04-Co04	0.535	√	Ca04-Ca09	0.000*	**X**
	Ca09-Co09	0.763	√	Co03-Co04	0.126	√
				Co04-Co09	0.000*	**X**
Heyinanzhan	Ca03-Co03	0.118	√	Ca03-Ca04	0.232	√
	Ca04-Co04	0.112	√	Ca04-Ca09	0.000*	**X**
	Ca09-Co09	0.000*	**X**	Co03-Co04	0.295	√
				Co04-Co09	0.000*	**X**
Liuyingmeng	Ca03-Co03	0.741	√	Ca03-Ca04	0.445	√
	Ca04-Co04	0.744	√	Ca04-Ca09	0.000*	**X**
	Ca09-Co09	0.000*	**X**	Co03-Co04	0.810	√
				Co04-Co09	0.000*	**X**

Note: Ca03—Co03 means the contrast for the catchment and control in 2003, and so forth. * Indicates significance level <0.05;

As can be seen from Table 2, the null hypothesis (H0) for hypothesis 1 is accepted in the contrasts for each pair of the catchment area and control areas in 2003 and 2004. This means that there is no significant difference between mean prices of catchment and control areas before the opening of BRT line 1 in 2003 and even during the construction phase of BRT in 2004. Firstly, this finding confirms the suitability of the selection of catchment and control areas, as the mean value of each paired group was not significantly different in the early stage. Secondly, it may suggest that the construction of BRT in 2004 did not notably influence the adjacent residential projects. H0 for hypothesis 1 in the contrast of Dahongmenxili and its paired control group is also accepted in 2009, suggesting that the BRT line 1 might not remarkably effect Dahongmenxili station compared to its paired area after 5 years operating. H0 for hypothesis 1 in the contrast of Heyinanzhan, Liuyingmen and their paired groups were rejected in 2009, implying that BRT has brought about significant impact on Heyinanzhan and Liuyingmen staions. One explanation for the finding is that the capitalization effect resulting from BRT to adjacent properties is mostly observed in the places which previously lack mobility by a Mass Transit system. The region where Dahongmenxili station is located is the relatively developed in southern area and now served by two Metro lines. Although even the closest Metro station is around 2.5 km far from Dahongmenxili station and 1.5 km away from paired control group, people may anticipate the possible extension of Metro line due to favourable economic trend and booming property market. Heyinanzhan and Liuyingmen stations areas were less developed and far from any Metro system, and thus the adjacent properties enjoy a much faster property value uplift than those in the control groups.

The null hypothesis (H0) for hypothesis 2 is accepted in all the contrasts for both catchment and control areas over the period 2003-2004, implying their mean value did not change significantly. During the period 2004-2009, H0 for hypothesis 2 is rejected in all the contrasts for both catchment and control areas, suggesting the mean values of properties in 2009 significantly different from those in 2004. This finding proves the property value uplift does occur to properties adjacent to BRT stations and this effect is much more evident after a relatively short period (5 years) of BRT operation, but the finding is not sufficient to support that BRT is the single factor contributing the property value uplift.

2) Hypothesis 3:

H_0 : There is no significant interaction effect between time and area.

H_1 : There is a significant interaction effect between time and area.

A repeated measures ANOVA method with tests of within-subjects contrasts was used to compare mean value of properties in catchment and control areas over time, indicated in Table 3.

TABLE III RESULTS OF CONTRAST TESTS FOR CATCHMENT AND CONTROL AREAS (2)

Station	Hypothesis 3		
	within-subjects contrasts	*p*-value	Accept H_0
DahongmenXili	the period: 2003-2004	0.704	√
	the period: 2004-2009	0.680	√
Heyinanzhan	the period: 2003-2004	0.046*	X
	the period: 2004-2009	0.021*	X
Liuyingmeng	the period: 2003-2004	0.002*	X
	the period: 2004-2009	0.004*	X

Note: Indicates significance level <0.05;

The null hypothesis (H_0) for hypothesis 3 is accepted in the contrast of Dahongmenxili station and its paired group, and rejected for Heyinanzhan and Liuyingmen stations and their paired groups during two periods. One explanation for the acceptance of H_0 for hypothesis 3 in the contrast of Dahongmenxili station and its control group is that it should be expected to be the same as the acceptance of H_0 for hypothesis 1. The investors in the paired area of Dahongmenxili station may anticipate the possible extension of a Metro line, although the control group is 1.5 km away from the closest Metro terminal. Since there was no significant difference for property prices in Dahongmenxili and its paired group during the period 2004-2009, and Dahongmenxili station is much further than the control area to a Metro terminal (at least 2.5 km away), it is suggested that the BRT line 1 has a positive impact on adjacent properties in Dahongmenxili station. As for the Heyinanzhan and Liuyingmen, which are located away from the extensive Mass Transit network in the downtown, the results clearly suggests that there is a significant difference for the property prices in the catchment and control areas over time.

It is worth noting that using the similar statistical procedure, reference [25] examined the short-term land value impact of the

extension of Tyne and Wear Metro in Sunderland, England, after 1 year opening of that urban rail. There was no significant land value uplift found around the Metro stations. Reference [25] indicated that unfavourable regional economic trends largely accounted for a smaller land-use impact in Sunderland than for other places under favourable economic conditions. It was suggested that a longer evaluation period was needed to examine the effects of improved accessibility.

The result of the ANOVA analysis suggests that the influence of the BRT system on land development is related to time and area. The finding from Beijing BRT line 1 is consistent with the quantitative evidence from studies of BRT systems in Bogotá [8, 27] and Seoul [9]: the increased accessibility was capitalized on the property market, reflected by residential property values gaining premiums with proximity to BRT stations. Although enhanced accessibility is captured to increase property value along the BRT corridor, this study suggests that peripheral areas which previously lack the alternative mobility opportunity by a Mass Transit system have experienced greater change, due to larger marginal increase in urban mobility. In the Bogotá TransMilenio case study, it was suggested that the property value uplift effects resulting from BRT investment might be more notable in the peripheral areas, where there was no other Mass Transit system [27]. The findings from the Beijing case are also consistent with available studies on Metro systems. In a report of assessing the change in land and property values attributable to Jubilee Line Extension (JLE), reference [28] also suggested that areas where JLE made the greatest accessibility enhancement would show a greater change than those which were relatively already well served by other rapid transit.

VII. Conclusion and discussion

For many years rail-based transport systems, such as Metro and LRT, have gained extensive support at both central and local government level. However, the high capital cost and consequently high operating cost have limited their development in many budget-constrained cities. BRT presents a cost-effective and flexible alternative for high-performance transit services, which have increasingly gained interest to policy-makers. An appropriately designed BRT system offers a high-quality transport service, comparable to a rail service, but at a relatively low cost and short implementation time. BRT is cheaper to implement than a rail system, but it still represents a capital-intensive system. Like other forms of Mass Transit, BRT can add capacity to an existing transport corridor which could enhance its accessibility. BRT systems can run at a faster speed than conventional buses which enables users to travel further at a given commute time. Households and businesses generally choose where to locate by weighing costs and benefits of alternative sites. Considering the saving of the cost of transport, residential and commercial properties near transport facilities tend to become more attractive. Many existing studies have suggested that the appreciable accessibility benefits, especially travel time savings, conferred by BRT are already recognized by many decision makers.

In China, BRT schemes are being successfully adopted in many cities as a promising strategy for relieving traffic problems. The Beijing Southern BRT line 1 is a significant transport improvement to the southern area, which has greatly improved accessibility for communities along its route to the city centre. It has gained a high satisfaction over passengers and attracted modal shift from private cars. The BRT line 1 has a large attractiveness distance, which has attracted 14.0% of respondents in this study to travel over 1000m, mainly by bus and walking, to take the service. A large majority of respondents (46.1%) moved to a place near BRT stations after the full operation of BRT line 1 in December 2005, suggesting that proximity to the BRT corridor can reduce the time and money cost of commuting, and this has significantly improved the property attractiveness near BRT.

Interviews with key stakeholder groups, including decision makers, real estate agents, and business owners, together with supporting longitudinal analysis of changes in property prices reveal that BRT line 1 has had positive development effects on adjacent properties, reflected by higher property values and accelerated land development. BRT as an emerging form of transport system is generally appreciated by stakeholders, with particular emphasis on its rapid nature and reliable service. Overall the opening of BRT line 1 has contributed to improving residential and commercial property attractiveness in the southern region and provided some opportunities for transit-oriented development. Locations near a BRT station have become a more desirable place for developing residential projects, specifically high-density apartments. Business opportunity is also improved for people to work in BRT station areas.

Rapid growth of the previously owned apartment market in Beijing marked the years 2003 to 2009. Nonetheless, the proximity to a BRT station appears to have had an additional positive impact on prices of residential properties. The statistical analysis suggests improved accessibility conferred by BRT is capitalized into higher real-estate prices. The capitalization effect mostly occurs after the full operation of BRT, and is more evident over time and particularly observed in locations which lack mobility opportunity by a Mass Transit system. The results also imply that the positive impact of BRT on property value uplift is more evident over time. From 2004 to 2009, the average values of residential properties near a BRT station increased faster (annually 2.3% higher) than those not served by the BRT. These findings support the argument that accessibility enhancement, rather than the type of transit system, is a far more important reason to influence land development.

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REFERENCES

[1] Jarzab, J T, Lightbody, J. and Maeda, E. (2002) Characteristics of Bus Rapid Transit Projects: An Overview, *Journal of Public Transportation*, 5 (2), pp. 31-46.
[2] Hensher, D. A., Sustainable public transport systems: Moving towards a value for money and network-based approach and away from blind commitment, *Transport Policy*, 2007, 14, pp 98–102.
[3] Levinson, H., Zimmerman, S., Clinger, J., Rutherford, S., Smith, R. L., Cracknell, J. and Soberman, R., 2003a. TCRP Report 90: Bus Rapid Transit, Vol. 1, Case Studies in Bus Rapid Transit, Transportation Research Board of the National Academies, Washington, DC.
[4] Levinson, H., Zimmerman, S., Clinger, J., Gast, J., Rutherford, S. and Bruhn, E., 2003b. TCRP Report 90: Bus Rapid Transit, Vol. 2, Implementation Guidelines, Transportation Research Board of the National Academies, Washington, DC.
[5] Wright, L.and Hook, W. (2007) *Bus Rapid Transit Planning Guide*, Institute for Transportation & Development Policy, New York, USA.
[6] Enoch, M., Ison, S. and Ptter, S. (2004) Recapturing value from property owners and developers to finance public transport a review of possible mechanisms, Paper presented at the European Transport Conference 2004, October, Strasbourg.
[7] Banister, D. (2005) Property values and public transport investment, Paper presented at the European Transport Conference 2005, October, Strasbourg.
[8] Rodi´guez, D. A. and Targa, F. (2004) Value of accessibility to Bogotá's Bus Rapid Transit system, *Transport Reviews*, 24 (5), 587–610.
[9] Cervero, R. and Kang, C. D. (2009) Bus Rapid Transit Impacts on Land Uses and Land Values in Seoul, South Korea, Working Paper UCB-ITS-VWP-2009-4, University of California at Berkeley.
[10] Rodríguez, D. A. and Mojica, C. H. (2009) Capitalization of BRT network expansions effects into prices of non-expansion areas, *Transportation Research Part A*, 43, 560-571.
[11] Cervero, R. and Duncan, M. (2002) Land Value Impacts of Rail Transit Services in Los Angeles County, Report prepared for the National Association of Realtors and the Urban Land Institute.
[12] Federal Transit Administration (FTA) (2002) Evaluation Guidelines for Bus Rapid Transit Demonstration Projects.
[13] Callaghan, L. and Vincent, W. (2007) Preliminary evaluation of Metro Orange Line bus rapid transit project, *Transportation Research Record*, 2034, pp.37-44.
[14] Sammer, G., Roman, K. and Oliver, R. (2003) Final Report: TRANSECON: Urban Transport and local Socio-Economic development: Deliverable 7, GMA1-2000-27049
[15] Royal Institution of Chartered Surveyors (RICS) (2002) Land Value and Public Transport : Stage 1 – Summary of findings, Royal Institution of Chartered Surveyor and Office of the Deputy Prime Minister.
[16] Al-Mosaind, M.A., Kenneth J. Dueker, and James G. Strathman. (1993) Light-Rail Transit Stations and Property Values: A Hedonic Price Approach, *Transportation Research Record*, 1400, pp. 90-94.
[17] Deng, T. T. and Nelson, J. D. (2010) The perception of Bus Rapid Transit: A passenger survey from Beijing Southern Axis Line 1, Paper presented at the 42nd Annual Conference of the Universities' Transport Studies Group, Plymouth, January. Paper Session 2A-2, CD ROM.
[18] Cervero, R. and Landis, J. (1993) "Assessing the Impacts of Urban Rail Transit on Local Real Estate Markets Using Quasi-Experimental Comparisons," Transportation Research 27A, 1:13-22.
[19] Bernick, M., Cervero, R. and Mentotti, V. (1994) Comparison of Rents at Transit-Based Housing Projects in Northern California, Working paper 624, University of California at Berkeley.
[20] Dueker, K. J. and Bianco, M. J. (1999) Light Rail Transit Impacts in Portland: The First Ten Years. Presented at Transportation Research Board, 78th Annual Meeting.
[21] Chesterton (2002) Second Property Market Activity (Final Report), Prepared for the Jubilee Line Extension Impact Study Unit, University of Westminster, London, http://www.wmin.ac.uk/transport/jle/wp (Accessed October 2009)
[22] Weinstein, B. L. and Clower, T. L. (2002) An assessment of the DART light rail transit on taxable property valuations and transit-oriented development, Center for Economic Development and Research, University of North Texas, Denton.
[23] Lane, R., Powell, T., Eyers, T., Paris, J., Lucas, K. and Jones, P. (2004) Final Report: Jubilee Line Extension (JLE) Summary Report, Prepared by Transport Studies Group, University of Westminster, For Transport for London and the Department for Transport, http://www.wmin.ac.uk/transport/jle/wp, Accessed March 2009.
[24] Gibbons, S. and Machin, S.J. (2005) Valuing rail access using transport innovations. Journal of Urban Economics, 57 (1). pp. 148-169.
[25] Du, H. B. and Mulley, C. (2007) The short-term land value impacts of urban rail transit: Quantitative evidence from Sunderland, UK. Land-use Policy, (24): 223–233.
[26] Darido, G. (2006) Bus Rapid Transit Developments in China: Perspectives from Research, Meetings, and Site Visits in April 2006, Federal Transit Administration, U.S. Department of Transportation, Washington.
[27] Munoz-Raskin, R. (2010) Walking accessibility to bus rapid transit: Does it affect property values? The case of Bogota´, Colombia, *Transport Policy*, 17,pp. 72–84.
[28] Jones Lang Lasalle (2004) Land & Property Value Study: Assessing the Change in Land & Property Values Attributable to the Jubilee Line Extension, Pilot Study: Southwark & Canary Wharf, Transport for London http://home.wmin.ac.uk/transport/ Accessed in April, 2010.

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