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BANGKOK'S URBAN RAIL SYSTEM: AN IMPACT EVALUATION

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Abstract

Urban rail transit remains a topic less explored in a developing country case. This research aims to examine the impact of recent urban rail transit developments on land values in the case of Bangkok, Thailand. A 17-year panel of 24 districts in the Bangkok Metropolitan Region (BMR) is adopted with regression analysis. Insights from the research show that the event of station openings and operations is significant and can generate a premium of 10.2% to land values on average. However, the effects station announcement and construction shows none or relatively little significance in the models.

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1. Introduction

Urban rail transit has long been part of the development of cities around the world. It is part of the answer the global challenges cities face, from sustainable growth of urban areas in terms of emissions (Derrible and Kennedy, 2009) to system-wide congestion issues (Malaitham, 2013). In certain parts of Europe and the United States, the first urban rail transit systems dates from as early as 1863, from the London Underground or the New York City Subway in 1904 (Jackson, 1984).

In contrary, many countries in the developing world are still relatively new to the urban rail transit arena. In Asia, with Japan as an exception, one of the first underground metro systems only first opened in the 1970s (Barter, 2000). Even Singapore's mass transit system only started its operations in 1987 (Barter, 2000). Cities like Bangkok, Thailand, have only had its first "Sky train" system only in 1999. Undoubtedly, Bangkok is among those cities still relatively inexperienced to urban rail transit development. Rail transit development has brought about many noticeable changes to Bangkok. Especially in areas around transit stations, land prices have certainly surged, real estate developments boomed, retailers and offices have relocated. Therefore, impact evaluation of such projects is an interesting area for research.

The purpose of this study is to investigate the economic impact of urban rail transit investments. But since the term economic impact is wide, it will be narrowed down in terms of land/property values. To definition of land/property used in this study is based on Brigham's (1965) findings – a 'property' represents an estate which ranges from being a vacant piece of land to an area employed by various types of buildings; residential, commercial, industrial, etc. Therefore, the terms 'land' and 'property' will be used interchangeably in this research.

The main research question of this study is:

“What is the impact of urban rail transit investments on land/property values in Bangkok?”

The amount of research in this field for developing countries remain relatively scarce compared to those of developed nations. The body of literatures from the case of Bangkok have recently increased in the past decade but still relatively low. Thus, this study should add some insights to the topic. Moreover, none of the Bangkok case studies have looked into the specific effects of announcement, construction, and opening of the stations. In many cases like in Hong Kong, the land-value impacts of urban rail transit already started to capitalize even before the lines are completed (Bae et al., 2003). This is also an interesting area to research. Therefore, the study also aims to answer the following sub-question:

“What is the effect of announcement, construction and operation/opening of urban rail transit stations on land/property values in Bangkok?”

To answer these questions, the study employs time series analysis over a 19-year time frame in the scope of the Bangkok Metropolitan Region (BMR). OLS regression is applied to the panel. More details about the approach is presented in the Methodology section.

The organization of this paper is first built on theory and observations from a comprehensive literature review. Insights from the literature review are used to select variables for the quantitative models later used. Then, the methodology section explains the method, the scope of study, how the focus and control areas are selected, the data, the variable specification, and finally defends the model specifications employed. Next, the results and discussion from the econometric models are presented in the forthcoming section. Lastly, the paper discusses its limitations and concludes its findings by referring back to the research questions.

2. Background and Research focus

Before elaborating the research focus, a brief background of the Bangkok Metropolitan Region (BMR), the context under study and its recent experiences with mass rapid transit developments shall be presented.

2.1 The BMR and its urban rail transit experience: A brief background

The Bangkok Metropolitan Region (BMR) is the urban agglomeration of Bangkok city, Thailand, an area that includes the metropolis itself and its five vicinity provinces namely Nonthaburi, Nakhon Pathom, Pathum Thani, Samut Prakan, and Samut Sakhon; total area of 7.762 km^2 (International Urban Development Association and Nantasenamat, 2012). Bangkok, similar to many other high-density East Asian cities, is characterized by mixed land uses where residential and non-residential aspects can be found throughout the city. Toppled with rapid motorization and growth in vehicle ownership since the 1970s, the high-density city has become extremely traffic saturated resulting in low accessibility levels – the factors of which observed in conjunction is described by Barter (2000) as the 'Bangkok Syndrome'.

Policy focus to alleviate congestion has been primarily on road expansion rather than investing on traffic-segregated public transport such as rail (Barter, 2000). According to Barter (2000), almost all large Asian cities had in place tram systems, but was abolished in most of those cities to make room for road-based transport. This includes the almost one-century-old Bangkok city tram. It was not only until the 1990s where attention to urban rail transit has seriously re-emerged. Amidst a dead-end in system-wide congestion issues, the government eagerly pushed through plans to construct a full-fledged urban rail transit network, the Mass Rapid Transit Master Plan. The project includes construction of 12 rail lines serving the Greater Bangkok area and its vicinities, with elevated and underground routes (Office of Transport Policy and Planning, n.d.).

As of 2014, approximately 30% of planned developments are completed with 4 lines in operation, leaving another 35% under construction, and the remainder in which construction have not yet commenced. Table 1 shows the basic details of the lines currently in operation. The first three lines are run by private operators whereas the Airport Rail Link is under the control of the State Railway of Thailand, a state-owned enterprise.

Table 1 The BMR urban rail transit systems under operation (as of 2014)

Line	**Type of System**	**Operation commenced**		**Daily ridership**	**Operators**
		Initial	Latest extension		
BTS Sukhumvit Line	Elevated rapid transit (Sky train)	1999	2011	combined 650,000	BTSC/KT
BTS Silom Line		1999	2013		
MRT Blue Line	Underground heavy rail (Metro)	2004	-	240,000	BMCL
Airport Rail Link	Elevated Express rail	2010	-	49,000	SRT

Source: http://en.wikipedia.org/wiki/Mass_Rapid_Transit_Master_Plan_in_Bangkok_Metropolitan_Region

2.2 Research focus

This paper focuses only on the lines currently operating and those that pass through the inner-city area of Bangkok. Thus, the analysis includes the first three urban rail transit lines from Table 1 – the BTS Sukhumvit and Silom lines and the MRT Blue Line. The Airport Rail Link will be excluded because the line serves the outer skirts of the BMR. Most studies relating to this subject are focused mainly on short-term before-and-after effects. This research hopes to extend the analysis to examine long-term capitalization of impacts by applying panel data analysis over a 19-year period. It is assumed that capitalization for such projects is not one-time especially in the case of developing countries where new urban rail transit projects continuously emerge through the years. The effects of station announcements, construction, and, opening are also explored.

3. Literature Review

Before proposing the quantitative model, a qualitative review existing literatures related to the subject is presented. Effort is put to focus on research from developing countries to suit the context of study, Bangkok, Thailand even though they are relatively scarce compared to those from developed countries. Various specific Bangkok case studies are also examined.

The section commences by examining basic concepts of accessibility in the context of transport policy. Then, the effect of urban rail transit in general is discussed, followed by a detailed examination on the impact on land values in particular. Case studies from developed and developing countries are presented and compared. The following section then describes how urban rail transit impacts are measured and what model is commonly used. Henceforth, the control factors that needs to be taken into account is explained. Lastly, the section concludes by introducing the cost-benefit aspect when urban rail transit impacts are evaluated.

3.1 The concept of accessibility in transport policy

Various studies have saw proven benefits from improved accessibility delivered by transport infrastructure where effects have been capitalized into property prices (McMillen and McDonald, 2004; Chalermpong, 2007; Malaitham, 2013). This is based on the premise that transport infrastructure provide the ease of reaching opportunities or activities; be it residences, employment centres, public goods and services, or points of production and distribution. Therefore, before one could analyse potential impacts of any particular transport investment, one must examine the direct benefits from such policy implementation – the concept of accessibility.

The notion of accessibility is a common academic literature. Its practicality has been wide-spread in various scientific fields; from transport planning to geography. In transport planning, accessibility serves well as an evaluation criterion to assess for transport services quality since, according to Black and Conroy (1977), it is determined by both land-use patterns and transport system performance.

The definition of accessibility

The broader definition of accessibility is associated with the number opportunities available (Morris et al., 1979). Specifically in the transportation context, accessibility is defined as ‘the ease with which any land-use activity can be reached from a location using a particular transport system’ (Dalvi and Martin, 1976) or extensively as ‘the extent to which land-use and transport systems enable (groups of) individuals to reach activities or destinations by means of (combination of) transport mode(s)’ (Geurs and van Wee, 2004). The latter corresponds to the concept of ‘integral accessibility’ proposed by Ingram (1971) which involves the degree of connection between a given point and all others within a spatial set of points, representing total travel opportunities.

The components of accessibility

Geurs and van Wee (2004) proposed a framework which provided insights regarding the components of accessibility and the relationship between them based on a review of past studies. The four components include the land-use, transportation, temporal, and individual component together is used to assess measures of accessibility. The land-use component involves the distribution of activities. It accounts for both the supply and demand sides for activities located at each destination. For example, the number of jobs or department stores in an area is limited. The demand for these opportunities depends on where the inhabitants live. In the end, competition for jobs or visits to department stores (i.e. number of opportunities) occurs due to capacity constraints. The transportation component represents the transport system. It is the disutility of an individual to travel from one point to another using a specific transport mode. This includes the amount of time, costs, and effort involved. Again, supply and demand aspects are also taken into account – the location and characteristics of a particular mode such as number of lanes or travel speed could represent the supply of transport infrastructure. The third component mentioned in Geurs and van Wee (2004) is the temporal component. It covers time constraints an individual faces which includes the number of activities available at a particular time during the day, the time available for participation, be it for work or recreation. Last, the individual component. this entails an individual's needs, abilities, opportunities, and travel budget which is subject to all personal characteristics from age, to educational level – all of which could influence a person's access to transport modes.

Figure 1 The relationship between components of accessibility

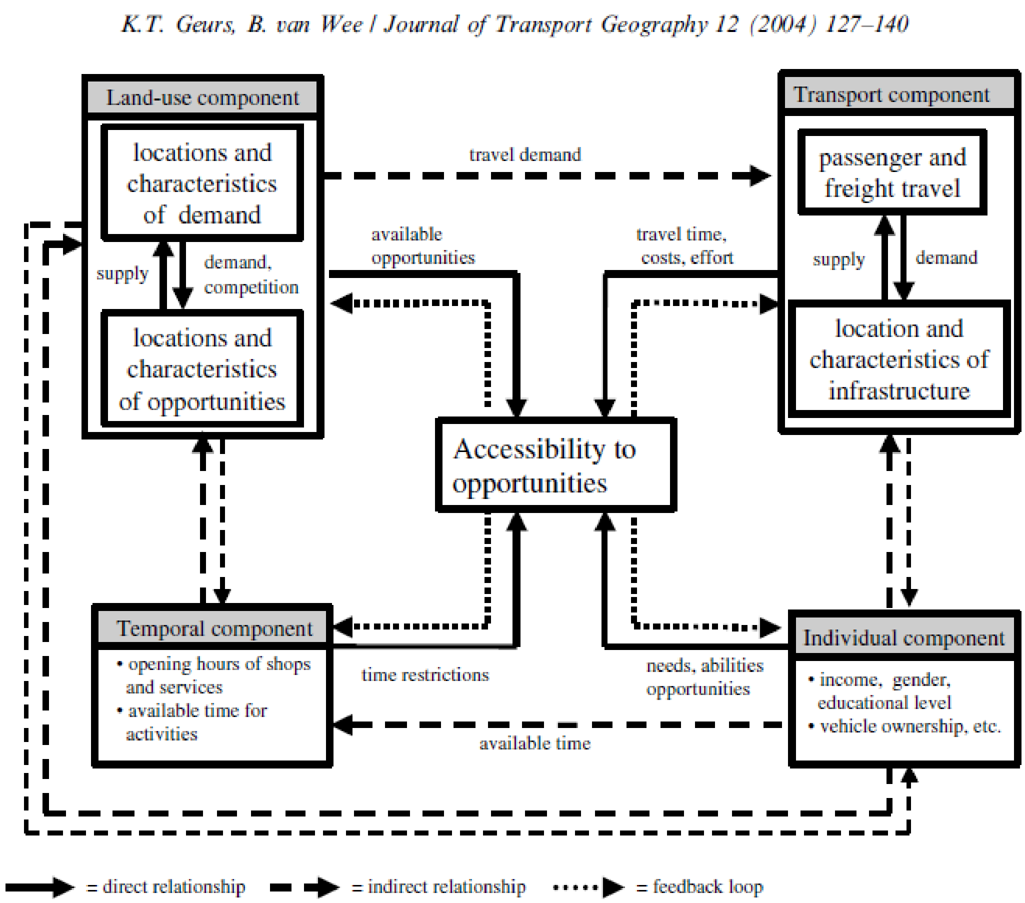


Figure 1, from Geurs and van Wee (2004), shows the relationships between the four mentioned components of accessibility. They could be direct, indirect, or a reversed feedback. To illustrate, the land-use component could influence the transport component through the distribution of activities which in turn affects travel demand. If a department store would be located in an area in the vicinity of a neighbourhood, travel demand may rise. Moreover, it may also influence the temporal component and the individual component. If the distribution of activities, say hospitals and department stores, are closely located in an area, less time is required to reach both places (temporal component) and the opportunities of inhabitants (individual component) will increase. In turn, accessibility itself affects all four components via a feedback loop. The location decision of firms and households (land-use component), travel demand (transport component), the time needed to travel (temporal component), and the social and economic opportunities of inhabitants (individual component) are affected. In general, Geurs and van Wee's (2004) provide a firm framework for the factors affecting accessibility and vice-versa. Their framework can easily be applied to the system-wide transport context. It makes clear the influential role accessibility has as a concept in transport policy.

3.2 Effects of urban rail transit: A general overview

This section provides an overview urban rail transit impacts in existing literature. Governments nowadays seek to justify urban rail transit investments not only by measuring ridership, but also by evaluating the wider impacts for the economy and society. An example could be its impact on employment and urban growth. From existing literatures, the impact of urban rail transit can be divided into four main categories - land-use, urban form, residential location decision, and land/property value impacts. The first two categories are closely linked.

Land-use impacts

Land-use impacts seem to be most evident and extensively explored in literature, although not as much as land value impacts. Chatman et al. (2012) claims that the New Jersey River Line, the city's recent light rail transit altered the economic make-up of the region. He mentions that the number of condominium units and multi-family housing surged in areas close to stations. The impacts are in-line with the increase in building permits since the line's opening. In San Diego, more commercial activities emerge, from shopping centres, offices, to housing developments, along the urban rail transit corridors (Crampton, 2003). Malaitham (2013) examined the impact of Bangkok's recent urban rail transit systems on land-use change in areas within 5 kilometres from transit stations. The study finds land conversion to non-residential (offices, stores) and residential (especially high-rise estates) uses evident.

Altering urban form

The impact of urban rail transit extends onwards from altering land-use patterns to influencing urban form. This corresponds to the proposition of Rodrigue et al. (2013) that transportation planning decisions have direct effects on land-use patterns by influencing the amount of land used for transport facilities, and indirectly by influencing urban form. When development clusters around stations or transit corridors, the concentration of development for a particular area increases. Handy (2005) argues that urban rail transit could potentially be used to counter urban sprawl. This corresponds to the findings of Malaitham (2013) where land developments emerge around station areas/corridors with higher agglomeration of households and population. Although in theory, the extent to which the notion could be successful would depend on whether such policies would alter transportation cost or relative accessibility (Handy, 2005). In terms of transportation cost, if travel time is reduced, then this may actually encourage sprawl rather than countering it, since people will be able to live further and travel into the city within a shorter amount of time (Handy, 2005). Israel and Cohen-Blankshtain (2010) echoes this by showing how rail transit actually influenced the choice of households to relocate to the outer-skirts of Tel Aviv, a major city in Israel. In terms of relative accessibility, if transit enables a particular area to become more accessible over others, developments may flow to that area. Therefore, urban rail transit could induce a redistribution of benefits from one area to another and could control over where developments will occur (Handy, 2005).

Residential location decision

The third category of urban rail transit impact is its effects on residential location decision. Malaitham (2013) finds that proximity to the BTS stations has a significant effect on the Bangkokians' residential location decisions, amid socio-demographic factors such as car ownership as an additional contributing factor. Israel and Cohen-Blankshtain (2010) finds that the rail system of Tel Aviv is one of the determinant factors of the location choice of households. The study concludes households decide to relocate to the urban fringe because the transit system allowed them to maintain strong commuting connections to employment centres.

Land values

Lastly, there is the impact of urban rail transit investments on land or property values. The foundation to this impact has its grounds in the 'Urban rent theory' developed by many authors including Alonso (1960). The theory suggests land values result from a trade-off between transport costs and accessibility. Individuals, households, and firms bid on the price of land by balancing the costs of commuting and its distance from the centre. It suggests that property values should be highest in the city centre and gets cheaper farther away from the centre. These theories have laid fundamental knowledge on the subject but its applicability is still far from realistic. This is because the theory is based on the traditional model of mono-centric cities, where all economic opportunities are centralized in the inner core. Therefore, its applicability is questioned by many as the new era of urban sprawl and decentralized employment sub-centres facing modern cities is emerges (Cooke, 1990; McMillen, 2006).

The most common technique to capture land value impacts is the hedonic pricing model. Hedonic price functions, first developed by Rosen (1974) have laid grounds for further theories and models on urban land rents. The theory assumes that in a heterogeneous market, every good has its set of attributes. One can determine the implicit prices for these attributes by observing the individual willingness to pay for a unique bundle of attributes. This technique allows observation for the values of goods that are not explicitly exchanged in market transactions. The particular good observed in this case is land or properties; the price of land depends on their implicit attributes. This could be neighbourhood characteristics such as crime rates or the quality of public services in an area. Accessibility itself is one of the implicit attributes. The focus of this research is thus the access to an urban rail transit station. Most studies which applies hedonic analysis to land or property values, including Rodriguez and Targa (2004), rely on the assumption that 'access' to transit stations is a scarce good. And thus its benefit to particular land parcels is finite. This means that in a competitive market, households and firms are willing to bid more for properties or land with better accessibility – an indication of how the relationship between transport accessibility and land values should be hypothesized. The hedonic models gave rise to the term 'accessibility premiums' used to measure the impact of urban rail transit on land values (Chalermpong, 2007; Chatman et al., 2012; Malaitham, 2013).To sum up, transport infrastructure is expected to improve accessibility of economic actors to employment and amenities, and thus should lead to a positive effect on land or property values, given all else constant.

Land value impacts are the focus of this research. Therefore, a separate section (Section 3.3) is dedicated to present findings from studies in this aspect.

3.3 Urban rail transit impacts on land and/or property values

The amount of existing literature on this topic is substantial and is explored through different methodological techniques and contexts around the world. It is impossible to explore them all thoroughly. In this section, literatures are selected in attempt to balance insights from both developing and developed countries. Extra focus is also put on studies conducted in the context of Bangkok. Evidence to property value impacts in existing literature lacks consensus. In general, studies in the developing economy context seem to claim positive impacts, whereas neutral and occasionally negative impacts are more common in studies of developed nations.

Bangkok case studies

Research on Bangkok's urban rail transit is increasing in number since 2005, although still relatively small compared to that of developed nations such as the United States or North America. There are several common aspects found in Bangkok case studies of this subject. Firstly, urban rail transit premiums are generally positive. Secondly, hedonic models are widely used in the analyses. Lastly, models often account for spatial variation.

Chalermpong (2007) provides one of the first findings of the effects of the BTS sky train on multifamily residential property values. The effect from the MRT is excluded since during the time the study was conducted, the MRT line has only been under operation for only a year. The results are based on asking price data for multifamily housing collected from real estate magazines. The premium is $10 for every metre closer to a BTS station. This is relatively high when compared to other Bangkok studies. However, arterial road accessibility is still superior to the effects of the rail transit with a premium of $17 per metre closer to the infrastructure (Chalermpong, 2007). Malaitham (2013) examines both residential and non-residential properties along Bangkok's rail transit corridor. The premium is $0.5 per square metre and $2.5 per square metre for every metre closer to a rail transit station for each type of property respectively. The results for these two studies are not directly comparable since the time period under study are different; Malaitham (2013) with the 2008-2011 period and Chalermpong (2007) during 2004-2005. Vichiensan et al. (2011) conducts a case study of the BTS Sukhumvit line on condominium prices. He reports a premium of THB25 for every metre closer to a station. While a substantial amount of Bangkok case literatures have been focused on residential properties, Chalermpong and Wattana (2009) studies office rent capitalization. Contrastingly, the premium is considerably low at only THB0.019 per square metre for every metre closer to a transit station (Chalermpong and Wattana, 2009). Their spatial lag model specification shows that office rents in the sample are extremely inelastic to distance at -0.06 suggesting minimal sensitivity of urban rail transit access to the value for office buildings. However, conclusions from this study must be drawn with precaution since the sample size used is rather small (85 observations).

Developing-country context

Celik and Yankaya (2006) provides perspective from a developing country. The study focuses on the Izmir subway system influences on residential property values. The time frame under study is from December 2003 to March 2004, already about three years after the opening (Celik and Yankaya, 2006). On average, the accessibility premium for the commuter rail line is $4.76 for every metre approaching the subway station, although it could be as high as $18.70 in some sub-districts in the studied area. Celik and Yankaya (2006) also laid grounds to cost-benefit analyses for future rail investments in Turkey by deriving the value of travel time using a valuation capitalization technique based on walking distance. The cost-benefit aspect of urban rail transit studies is discussed further in upcoming sections.

Developed-country context

The impacts from developed countries are also fairly mixed. Some highlights strong positive premiums (McMillen and McDonald, 2004), others with less profound results (Baum-Snow and Kahn, 2000; Hess and Almeida, 2007) or almost insignificant (Gatzlaff and Smith, 1993; Baum-Snow and Kahn, 2000; Chatman et al., 2012). A study by McMillen and McDonald (2004) of a rail line connecting downtown Chicago with Midway airport uses a comprehensive data set of 17,034 single-family residential transaction prices over a 17-year period in 1983-1999. The line opened in 1993, and thus the data set allowed the authors to extensively examine effects of announcement and opening, and how benefits from the investment is capitalized into property values in a longer time frame than all the other studies reviewed. Housing values increased by 4.2%, 7.4%, and 19.4% with respect to the nearest transit station during the periods up to 1987, 1987-1990, and 1991-1996, respectively. Although in 1997-1999, the authors report that the appreciation rates slowed down to 9.8%, four years after the opening of the line. During the time, areas farther away from the catchment area experienced faster property value appreciation rates. The authors suspect that parking offered at stations may have facilitated farther travels from the outer skirts to transit stations. On average, single-family homes in the sample gained $6000 in value as compared to properties with similar characteristics outside the catchment area; 1.5 miles or farther from the station (McMillen and McDonald, 2004). Contrastingly, a panel study of five representative US cities (Boston, Atlanta, Chicago, Portland, Washington D.C.) in 1980 and 1990 by Baum-Snow and Kahn (2000) reports only minimal impacts. The increase is only $0.0095 per metre away from stations for property rents, and $2.486 for houses. In Buffalo, New York, impacts are not much higher than in Baum-Snow and Kahn (2000) – $3.24 property premium for every metre farther from a transit station, based on network distances (Hess and Almeida, 2007). Straight-line distance proxies, however, resulted in a $7.57 premium (Hess and Almeida, 2007).

Another study of 1,860 single-family homes in Boston, Massachusetts during 1992-1993 finds that values of properties located within half a mile from a commuter rail transit station are 10.1% higher than those outside the catchment area (Armstrong and Rodriguez, 2006). Moreover, the authors claim for every additional driving minute from the station, Boston property values fall by 1.6%, given all else equal (Armstrong and Rodriguez, 2006). Chatman et al. (2012), a recent study of New Jersey's light rail system, finds slightly negative or at best neutral effects on housing values. Arguments to the limited impacts suggested by some authors are the impact of public support, negative media coverage and also nuisance effects (Chatman et al., 2012) – these issues will also be discussed in following sections. Du and Mulley (2007) focuses in the residential sector of homes in Sunderland, UK. Results based on ANOVA analysis shows that other factors like regional economic environment and the quality of dwellings are more influential. In San Diego, effects are positive but also distinctive between condominium units and single-family homes – appreciation rates for the latter property type is much smaller at 6% as compared to 17% to that of condominium units (Duncan, 2008).

The review of studies from varying contexts confirms the lack of consensus regarding the effects of urban rail transit on property or land values. However, positive capitalization of such projects seems more evident in developing country contexts (refer to Table 2). Contrasting urban structure and underdeveloped public transit services as mentioned in Barter (2000) between cities of the developed and developing world may be one of the reasons for the dissimilarity of results. The cities of South-East Asia are characterized by dense urban form with lack of public transport choice (Barter, 2000) where urban rail transit projects only received attention in the last two decades. Consequently, rail transit investments are more likely to benefit densely located neighbourhoods serving a higher ratio of the population. Moreover, studies of rail transit lines in Asia are more likely to be of brand new line openings into areas not previously served by alternative forms of transport. The BTS is one example from Bangkok. On the other hand, many studies in developed nations talk about line extensions or the line may serve an area where pre-existing alternative modes already exist (Baum-Snow and Kahn, 2000; Du and Mulley, 2007).

Table 2 A summary of reviewed literature for Section 3.3

	Authors (publication year)	Context under study	Property (number observations)	Measurement of urban rail transit accessibility	Capitalization of urban rail transit effects
Developed countries	So et al. (1997)	Hong Kong	Middle-income housing (1234)	Walking times	Neutral to positive
	Baum-Snow and Kahn (2000)	Boston, Atlanta, Chicago, Portland, Washington D.C., USA	Residential housing (3369-3546)	Straight-line distances	Neutral to positive
	McMillen and McDonald (2004)	Chicago, USA	Single-family residential (17034)	Distances *Note: Type of distance (e.g. straight-line, network, etc.) was not specified*	Positive
	Armstrong and Rodriguez (2006)	Boston, USA	Single-family residential (1860)	Driving times	Neutral to positive
	Du and Mulley (2007)	Sunderland, UK	Residential (N/A)	N/A *Note: ANOVA method was used*	Neutral to positive
	Hess and Almeida (2007)	Buffalo, USA	Assessed residential property values	Straight-line and network distances	Positive
	Chatman et al. (2012)	New Jersey, USA	Residential (31470)	Network distances	Negative to neutral
Developing countries	Celik and Yankaya (2006)	Izmir, Turkey	Multifamily residential (360)	Walking distances	Positive
	Chalermpong (2007)	Bangkok, Thailand	Multifamily residential (226)	Network distances	Positive
	Chalermpong and Wattana (2009)	Bangkok, Thailand	Offices (80)	Straight-line and network distances	Neutral to positive
	Vichiensan and Miyamoto (2010)	Bangkok, Thailand	Townhouses (447)	Travel times	Positive
	Vichiensan et al. (2011)	Bangkok, Thailand	Condominiums (415)	Walking distances	Neutral to positive
	Malaitham (2013)	Bangkok, Thailand	Assessed land values	Straight-line distances	Positive

3.4 Measurements of accessibility in the urban rail transit context

After discussing the impacts, this section presents the form in which the accessibility premiums are measured.

Distances

Distance is one of the most common measurements for transit accessibility. It represents the time cost of using transit (Baum-Snow and Kahn, 2000). The types of distance used in literatures also vary. Euclidean or straight-line distances is one that is most simple and widely adopted (Bae et al., 2003; Hess and Almeida, 2007; Chalermpong and Wattana, 2009; Malaitham, 2013). It is the shortest distance from a particular point to the nearest transit station which can be measured by a using a ruler or a straight line. To counter the shortcomings of straight-line distances being unrealistic, several other studies apply 'network distances' (Chalermpong, 2007; Chalermpong and Wattana, 2009; Vichiensan et al., 2011; Chatman et al., 2012; Hess and Almeida, 2007). This is the distance measured along the road network and could potentially proxy for actual pedestrian routes (walking distances) to the closest transit station. Hess and Almeida (2007) test for both Euclidean and network distances and in the latter model, effects are much smaller than that of the straight-line model.

Travel times

Travel times are used as proxies of transit accessibility. Rodriguez and Targa (2004) use walking times in their study of the effects of urban transit in Bogota, Columbia. Moreover, in a study of Hong Kong's rapid transit line, walking times to the nearest rail transit station is used as a measure for accessibility (So et al., 1997). McMillen and McDonald (2004), on the other hand substitutes walking distance by including the dummy variable of whether or not the location of the property is one block away from the transit line. Armstrong and Rodriguez (2006) evaluate commuter rail transit accessibility in Boston using driving time in minutes to stations.

Number of transit stations

There have also been studies where 'regional accessibility' has been assessed. In Chalermpong's (2007) context, this constitutes the number of urban rail transit stations which would take passengers to the central station where the central business district is. This also provides indication of how effective the transit development has contributed to access to regional centres of economic activities.

3.5 Moderating factors

This section presents the aspects to control for in hedonic regressions. Ultimately these factors and aspects improve the validity of the estimates.

The spatial dimension

The spatial variation is accounted for in many recent studies (Chalermpong, 2007; Chalermpong and Wattana, 2009; Vichiensan and Miyamoto, 2010; Vichiensan et al, 2011; Chatman et al., 2012; Malaitham, 2013). It is evident in many studies that the impact of urban rail transit, whether positive or negative; differs between particular areas within cities. Hess and Almeida (2007), for example, prove that effects are positive in the high-income areas of Buffalo, New York, and negative in low-income areas. Theoretically, the traditional monocentric model is challenged because modern cities seem to undergo urban sprawl driven by automobile technology (Nechyba and Walsh, 2004). Thus, traditional urban land rent theory based on monocentric models (Alonso, 1964; Muth, 1969) may no longer be valid. The relationship between transportation accessibility and values are now clustered in space rather than randomly distributed. We see that properties closer to the CBD are not always the most expensive, but clusters of higher (or lower) land prices may occur in other areas. Moreover, the spatial dimension commonly adopted in most Bangkok urban rail transit studies. Thus, the aspect is worth examining.

Vichiensan et al. (2011) addresses the impacts of Bangkok's urban rail access on condominium prices in light of spatial regression models. The geographically weighted regression (GWR) is applied. The model extends traditional regression analysis and accounts for spatial non-stationarity, where coefficients are estimated for each data point available in a study area or location. The results show that accessibility premiums vary substantially within the catchment areas (Vichiensan et al., 2011). Another study by Vichiensan and Miyamoto (2010) examines the same effect on residential townhouses in Bangkok and reached the same conclusion. Malaitham (2013) applies distance thresholds in spatial regressions with residential properties. The results show that for both the BTS and MRT, accessibility premiums diminish with distance from stations. For example, at the 0-0.5 km band, the capitalization rate is 12%, 9% at 0.5-1.0 km away from stations, and finally 6% at the 1.0-1.5 km distance threshold category (Malaitham, 2013). Chatman et al. (2012) also used distance thresholds variables to account for nuisance effects of the line from noise, benefits from walking proximity and short driving distances from stations. He suspects that impacts of rail transit stations may be negative if a property is located too close to the line due to noise, and that residents may value short driving distance even though being located slightly farther away from stations (Chatman et al., 2012).

Spatial regressions complement the traditional OLS estimations in many ways. Firstly, the model seem to statistically fit real estate values better (Chalermpong and Wattana, 2004; Armstrong and Rodriguez, 2006; Chalermpong, 2007; Chatman et al., 2012). Consequently, premiums are often more accurate and not overestimated as OLS estimates tend to be more biased. Moreover, the significance of variables often is affected by this transformation and can thus influence conclusions.

The focus on different market subsets

Some studies also focus on different types of property markets. There is evidence that the implications to different types of property markets or types of land vary. The main categories are residential properties and non-residential properties.

Most studies reviewed here are focused on residential markets (So et al., 1997; Baum-Snow and Kahn, 2000; McMillen, 2004; Armstrong, 2006; Celik and Yankaya, 2006; Chalermpong, 2007; Du and Mulley, 2007; Hess and Almeida, 2007; Vichiensan and

Miyamoto, 2010; Vichiensan et al., 2011; Chatman et al., 2012). However, there are also different types of residences which means that it is possible to remain extremely focused on particular market subsets. The Bangkok case studies illustrates a variety of focus, from multifamily homes Chalermpong (2007), townhouses (Vichiensan and Miyamoto, 2004) and condominiums (Vichiensan et al., 2011). The impacts vary significantly. The multifamily housing market in Bangkok seems to benefit most from urban transit accessibility (Chalermpong, 2007). This corresponds to the case of Izmir where premiums are in the $4.76-$18.70 range (Celik and Yankaya, 2006). In the US, impacts for residential properties are relatively less profound (Baum-Snow and Kahn 2000; Armstrong and Rodriguez, 2006; Chatman et al., 2012). In addition, residences are also categorized by demographic subsets, namely income groups. An early study by So et al. (1997) focuses on Hong Kong's middle-income neighbourhood, Quarry Bay. The study reveals that middle income households barely value bus accessibility but much more of urban rail accessibility (So et al., 1997). The authors expects this result since the working class (middle to low income people) value faster travel times given their lower wage rates relative to the high-income citizens. Hong Kong's urban rail system complements these necessities with high service frequency (So et al., 1997). Chatman et al. (2012) finds that in New Jersey, the impact is much more profound for lower-income. Appreciation rates were at 35% for low-income housing but neutral for high-income housing. The author infers a value transfer effect from these results. This indicates also that lower income households are more likely to use public transit than to drive. In conclusion, it seems that the value-added for poorer neighbourhoods is much higher (Chatman et al., 2012).

Other studies explore the non-residential dimension. Damm et al. (1980) finds that the impact of the Washington Metro differs between retail property and residential property. The price elasticity of retail is up to ten times more elastic than that of residential properties. The results of a Bangkok study align with that of Damm et al. (1980). The recent study finds that the accessibility premium for commercial and industrial properties in Bangkok is five times higher than that of residential properties (Malaitham, 2013). On the other hand, Chalermpong and Wattana (2004) find that the capitalization of Bangkok's office rents is relatively low to negligible. These results echo those from Ryan (2005), a 1986-1995 panel study of the San Diego metropolitan area, where access to light rail systems is insignificant to office and industrial property values.

Another study shows that urban rail has a positive influence on commercial property values in the Midtown area of Atlanta (Nelson, 1999). The author also finds that commercial property price also depends on support policies which encourage intensive development around station areas. In Atlanta's case, lowering parking and floor area restrictions in Special Public Interest Districts (SPIDs) plays a role. Another study also in the case of Atlanta during the period 1978-1989 concludes similarly (Cervero, 1994). In conjunction with real estate development policies, the rail accessibility impact receives an added value of $3 per gross square foot. This reflects the fact that these policies magnify existing positive impacts from rail transit investments (Cervero, 1994).

Lastly, Debrezion et al. (2007) finds that capitalization impacts vary per type of urban rail system. Commuter rail stations are more influential on property values than light and heavy rail (Debrezion et al., 2007).

In all, the reviewed studies show that accounting for different market subsets is significant. For all dimensions, results still lack consensus. A special case lie for commercial properties because the importance of real-estate policies seem to also play a role. Certainly, these are points for further research.

Accessibility

Accessibility from other transport modes other than urban rail also should be controlled for. Examples are access to the expressways (Chalermpong, 2007; Malaitham, 2013) and bus stops (Chatman et al., 2012). In Bangkok, Chalermpong (2007) finds that access to arterial roads is $8 more valuable than access to a BTS station. Malaitham (2013) finds that residential properties in Bangkok tend to be priced 5000 to 30,000 Thai baht per square metre more for every kilometre closer to the main road. The study also highlights that such premiums are especially high in the urban fringes (the vicinities of

Bangkok) where road transport is the only dominant mode for commuters (Malaitham, 2013). In Hong Kong, access to public transport, specifically to the minibuses is the most influential factor of residential property values in the middle-income census tract (So et al., 1997).

Accessibility can also be expressed in terms of ease of reaching employment opportunities. Many studies account for this by including the distance to the CBD. In Bangkok, the Siam Square area is used as a proxy for some studies because it is one of the centres of economic activity; it proves to be significant (Vichiensan et al., 2011; Malaitham, 2013). These results correspond to that of Chalermpong (2007) – the spatial lag and spatial error model indicates a premium of $3050 (THB116,000) and $4210 (THB160,000), respectively for every station closer to BTS Siam station. The number of BTS stations to Siam station is used to represent the ease to reach centres of economic activities. This is because during the time of study, it is the only station which is an interchange between two BTS lines that gives direct access to the city's two main employment centres, the Silom and Sukhumvit areas (Chalermpong, 2007). Chalermpong and Wattana (2009) report that the impact of an office being located in the CBD area of Bangkok (using the Silom area as proxy) is far more substantial than the impact of rail transit accessibility. This evidence proves the agglomeration benefits for offices being located close to other businesses. The point is proved also in Santa Clara County, California by Cervero and Duncan (2002). The results show that capitalization is 120% for a commercial-retail or office property located in the CBD within a quarter-mile vicinity of commuter rail station, whereas effects were only a 23% rate for a typical land parcel in the vicinity of a light rail transit stop (Cervero and Duncan, 2002). In Boston, Massachusetts, auto commuting time to downtown is negatively related in property prices which also suggest the positive influence of CBD accessibility on property values (Armstrong and Rodriguez, 2006).

Physical property characteristics

The influence of specific physical property characteristics attached to buildings or land parcels must not be ignored in hedonic analysis. Malaitham (2013) interestingly account for land attribute variables into her Bangkok study. The percentage of side-walk areas positively influences land values in areas like Asoke, where non-motorized modes dominate and vice-versa in areas where motorized modes are more popular (Malaitham, 2013). Specific physical building characteristics are examined in various other studies (So et al., 1997; Bae et al., 2003; McMillen and McDonald, 2004; Chalermpong, 2007; Vichiensan et al., 2011; Chatman et al., 2012). Both studies by So et al. (1997) and Vichiensan et al. (2011) report that ages of properties tend to lower their prices and that units located in higher floor levels tend to be more expensive. Sizes of homes also do matter. According to McMillen and McDonald (2004), small homes tend to come with an appreciation rate of 42% higher than comparable properties although effects are not statistically significant. The study also included comprehensively the effects of the age of properties, number of bedrooms, whether a house has a basement, a garage, an attic, or central air conditioning (McMillen and McDonald, 2004).

Neighbourhood characteristics

Another control attribute that became increasingly common in literatures is the neighbourhood characteristics. Certain neighbourhood characteristics are expected to damper the impacts of urban rail transit on property values. Crime is one of the examples. When a transit line unexpectedly connects distressed neighbourhoods, it may attract criminals to another area (Bowes and Ihlandfeldt, 2001; Hess and Almeida, 2007; Chatman et al., 2012). Chatman et al. (2012) use this as a potential explanation for the neutral impacts of New Jersey's River Line. Bowes and Ihlandfeldt (2001) examine the role of crime on single-family housing values in Atlanta using the variable crime density. The study indicate that the variable itself also has negative direct effect on housing values but also an indirect effect through its interaction with urban rail transit accessibility. A more recent study in Buffalo, New York found that a 1% increase in violent crime rate leads to a $292 decrease in the value of a property (Hess and Almeida, 2007).

Neighbourhood composition and racial diversity are also considered in some research studies. For example, the share of the African American population or Hispanics (Cervero and Duncan, 2004; McMillen and McDonald, 2004; Chatman et al., 2012). In Santa Clara County, California, higher racial diversity lowers residential property values (Cervero and Duncan, 2004). Malaitham (2013), on the other hand uses the variable median income to distinguish the type of neighbourhood present in the Bangkok Metropolitan Region.

Economic conditions

Another factor to consider is the economic outlook of an area. In Santa Clara County, California, the substantial premium found from urban rail transit accessibility was attributed to the strong economic conditions and the scarcity of housing of the county itself (Cervero and Duncan, 2002). Hess and Almeida (2007) prove that the depressed areas facing economics decline in Buffalo, New York experience lower premiums from improved rail transit access. However, Chatman et al. (2012) prove the opposite. The authors claim that the effect may be an indication of value transfer from rich to poor neighbourhoods. In Miami, an early study by Gatzlaff and Smith (1993) found that property value increases were more evident in neighbourhoods characterized by strong economic growth. Economic conditions of an area are controlled for by including fixed county or community area dummies, as in McMillen and McDonald (2004) and Chatman et al. (2012). From reviewing past studies, it seems that property appreciation and decline can also be influenced by how well a region is progressing economically.

Amenities

An interesting factor to take into account is the amenities provided for in an area. In Bangkok, Malaitham (2013) regresses the distance of specific land parcels to shopping centres but found counter-intuitive results. The coefficient was negative instead of positive. So et al. (1997) did the same but found that proximity to shopping centres contribute positively to residential property values. The study finds that the presence of a park in an area is also an important factor to determine house prices (So et al., 1997). Chatman et al. (2012) include the locational attribute; distance to New Jersey's

Delaware River to account for demand for waterfront property. However, the authors did not find such strong impacts to housing values. In Hong Kong, however, home buyers strongly value sea views (So et al., 1997). A study of the Bangkok condominium prices also conclude that units situated in higher levels (with better view of the city) are more expensive (Vichiensan et al., 2011). Other effects such as the share of schools in an area (Malaitham, 2013), airport proximity (McMillen and McDonald, 2004) and parking (Bowes and Ihlandfeldt, 2001; McMillen and McDonald, 2004) are also considered in other various other studies.

Market anticipation of urban rail transit projects

Ex-ante market anticipation to new transit line openings are expected to be influential on property value capitalization. Economic theory postulates that given rational expectations, individuals anticipate future events based on all information available (Muth, 1961). Applying this to the real estate market, individuals will take all information under consideration which includes also expectations about future transport investments and improved accessibility. Those with higher expectations would be willing to pay more than those with lower expectations, driving property prices upwards, given all else equal. And since most transport infrastructure projects involve advanced announcements of its happenings, it should be plausible to assume that the effects of such investments on property values should occur before project completion. There are efforts in trying to incorporate the effect of these expectations in hedonic models.

The announcement effect of rail transit facilities is common in literature. An early study of the Washington Metro proves the impact substantial (Damm et al., 1980). Knaap et al. (2001) present the case study of Washington County, Oregon where the announcement of the city's light rail construction plans influence station-area land values positively. Land parcels within half a mile from station locations rose by 36% in value after the announcement. The study, however, only considered effects of construction announcements and did not further explore the impact of line openings. Bae et al. (2003), on the other hand, did so extensively in a study of Seoul's Line 5 subway station. The period of analysis covers a stretched timeline from announcement of construction, line opening, and a few years after operation. The authors found that anticipatory effects on Seoul's property values exist significantly through the years of announcement and opening. But the impacts seem to dampen three years after the line's opening (Bae et al., 2003). The authors explain that the impact of the opening could have been limited since Seoul's public transit system is already well-established with enough modal of choice.

McDonald and Osuji (1995) observe Chicago's Midway Line on residential land values, focusing on the year 1990, three years before the line's opening. The results prove the market's anticipation of the transit line with residential values within half a mile from stations being 17% higher as a result of the line's construction. The realized premium is calculated using a before-and-after-method of the years 1980 and 1990 and resulted in a 1.9% increase in property values (McDonald and Osuji, 1995). However, the model suffers from its fairly low significance of only 91% and a small sample size of 79 observations. Contrastingly, another study under the same context employs a comprehensive data set of 17,034 observations based on single-family residential transaction prices (McMillen and McDonald, 2004). The study extends the analysis of anticipated gains from project announcement, commencement, and ground-breaking based on a 17-year panel (McMillen and McDonald, 2004). The announcement commenced in 1979, whereas property value capitalization became evident up to 1987, already six years prior to the line's opening at 4.2%, and continue to increase in magnitude to 7.4% during 1987-1990 (McMillen and McDonald, 2004). The Midway Line opened in 1993 and capitalization effects during 1991-1996 was 19.4%, effects then, slowed down to 9.8% in 1997-1999 as home values raised more rapid in location farther from transit stations (McMillen and McDonald, 2004).

The role of media and public support

The role of media is mentioned in only a few of the urban rail transit studies reviewed. Chatman et al. (2012) comment that the neutral effects found in their study of New Jersey's River Line on residential property values could partly be due to continuous negative press. The authors claim that the project suffered from negative media which created an image of uncertainty to the public. The degree of uncertainty was high up until the day of ground-breaking (Chatman et al., 2012). Moreover, the line also suffered on rumours that it would bring more criminality by attracting unwanted people from economically distressed areas (Chatman et al., 2012). This corresponds to the framework developed by Mackett and Babalik Sutcliffe (2003). The study claims that transport investments which suffer from perceptions related to criminality are usually bound to be stifled from success. In Sheffield, the United Kingdom, the announcement of the construction of the city's Supertram in 1988 led to a decline in housing values. The author mentions that the negative impact was due to anticipated nuisance caused by construction (Hennebury, 1998). The case of the Delhi metro in India highlights the importance of authorities to gather public support through publicizing and to invest in creating a positive image to enhance the success of such systems (Siemiatycki, 2006). Even though public transport projects have been in the realms of political conflict throughout the history of the country, with dedicated, coordinated efforts of several parties involved to construct a strong branded image of this metro system, the project was able to proceed through to success (Siemiatycki, 2006).

Table 3 A summary of Section 3.5

Moderating factor	Example
Spatial dimension	Distance threshold variables e.g. A dummy of whether a land parcel is 0-0.5 km from a station
Specific market subsets	Separate effects from residential and non-residential properties Focus on low-income housing
Accessibility (non-rail-transit)	Distance to bus stops Distance to arterial roads
Physical characteristics	Age of dwelling Parking Number of bedrooms
Neighbourhood characteristics	Crime rates Ratio of racial diversity Share of Hispanic or Black people
Economic conditions	Fixed county Year dummies
Amenities	Share of schools Parks River-side parcel
Market anticipation	Effects of announcement Effects of ground-breaking Effects of opening
Role of media	Not explicitly found in literature

3.6 The cost-benefit discussion

After reviewing the impact of urban rail transit on land values and all the control factors, this section describes how some studies come to weigh out the benefits and costs of urban rail transit projects. As discussed in the previous section, the influence of urban rail transit infrastructure on land values has an obvious spatial dimension which complicates traditional urban land rent theory. The relationship is not simply randomly distributed, nor does it changes with respect to distance from the city's inner core, but is clustered over space. As a result, certain aspects of literature have been focused on factors which have rooted this land/property value differential. This includes the discussion of why certain areas have been experiencing unexpected negative impacts from urban rail transit investment. Plus, the scope of discussion goes on as to whether such investments have been successful from a cost-benefit perspective. Theoretically, urban rail transit access has two opposing effects on land values – either positive or negative. Researchers suspect that the existence of these opposing factors may have led to ambiguous results. Chen et al. (1998) claim that positive impacts exist in the form of improved accessibility, and that negative impacts come as nuisance effects. In particular, when positive accessibility effects outweigh negative nuisance effects, we get a premium (net effect) in property values being located closer the stations (Chen et al., 1998).

Potential negative impacts

Chatman et al. (2012) suspects the negative influence of noise to homes being located too close to railway tracks. The authors extend their original hedonic model by including the spatial variable, distance to urban rail track as a proxy to effects of operation noise. The study did not find any negative impact related to this variable. Chen et al. (1998) have also introduced the variable 'proximity to railway track' in the study to represent nuisance effects and found the variable significant. Another study exploring the impacts of Eastern Massachusetts' commuter rail line prove that negative externality impacts do exists regarding proximity to the right-of-way (Armstrong and Rodriguez, 2006). The estimates suggests that for every 1000 ft. closer to the urban rail right-of-way, property values fall by $732, all else held equal (Armstrong and Rodriguez, 2006). The authors suggest that nuisance effects from noise of the commuter rail line operation in conjunction with occasional night freight trains operation sharing the same tracks are held accountable for these results (Armstrong and Rodriguez, 2006). This corresponds to findings from McMillen and McDonald (2004) where in Chicago, being located one block away from the transit line negatively influences residential values, in which authors have discussed as being the effect of noise and congestion externalities.

Weighing costs and benefits – net impacts

Once negative impacts from rail transit is acknowledged, there are efforts to incorporate both positive and negative impacts, to reach the 'net impact/benefit' of urban rail transit investment. Chatman et al. (2012) calculate the net effects of New Jersey's River Line by using the sum of distance-to-station coefficients for pre-opening and post-operation. For example, the study's full model results show that before the line's opening, there is a negative effect (positive coefficient) on property values of 0.1% per one-tenth of a mile closer the a station, whereas after the line's opening, there is larger positive impact of 0.2% per one-tenth of a mile distance from a station. Therefore, the net impact (premium) is 0.1%.

Some studies weigh cost and benefits by comparing gains with costs of construction (Gomez-Ibanez, 1996; Baum-Snow and Kahn, 2000). McMillen and McDonald (2004) aggregate the increase in property values from 1986-1999 which resulted from Chicago's Midway Line construction. The total benefit is $215.9 million, almost half of the total construction investment of $410 million. One distinction to the study is that it is conducted in a longer time frame of 17 years. This allow for long-term benefits capitalized in land values to reveal. Moreover, the authors speculate that gains can still also be evaluated in other terms rather than only in the property market aspect. Celik and Yankaya (2006) laid grounds to future cost-benefit analysis studies of public transit projects in Turkey. The authors derive the 'value of travel time' using a value capitalization technique based on walking distance. The value of travel time is $1.45 to $1.83 per hour (Celik and Yankaya, 2006). Baum-Snow and Kahn (2000) monetize urban rail transit benefits not only in terms of monthly rent increases, but also in terms of savings of the portion of the population who benefit most from a city's rail transit network. The results show that rents have not increased as much as savings for the specific group of the citizens who walk to transit stations and utilize them to travel - $19 per month vs. $100 savings per month (Baum-Snow and Kahn, 2000). These results are based on data from five main cities in the US namely Boston, Atlanta, Chicago, Portland, and Washington DC (Baum-Snow and Kahn, 2000).

In general, existing literatures have started to consider both negative and positive impacts of urban rail transit project on land/property values through extensive spatial hedonic models (Chen et al., 1998; Armstrong and Rodriguez, 2006; Chatman et al., 2012) and have put effort into incorporate both opposing factors to reach estimates of 'net impacts' of such investments. Some studies have already been extended towards comparing costs and benefits (Baum-Snow and Kahn, 2000; McMillen and McDonald, 2004; Celik and Yankaya, 2006), for example McMillen and McDonald (2004) providing a benchmark from aggregate benefits as compared to initial investment costs for urban rail transit projects.

4. Methodology

4.1 Method and Scope of study

This study aims to observe the change in land values over-time as a result of urban rail transit investments. To achieve the purpose, a panel data of 104 observations from 24 districts of the Bangkok Metropolitan Region (BMR) are applied under OLS regressions. The econometric techniques applied are conducted through a software named Stata. The time frame observed is spread over a 19-year period and divided into 5 periods as follows: 1996-1999, 2000-2003, 2004-2007, 2008-2011, and 2012-2015. This is because land value data comes from the government's assessed land value accounts which come in 4-year averages corresponding to the mentioned time periods. Therefore, two dimensions exist in this panel data set – the 5 time periods and different districts. As mentioned before, the study focuses on the effect of the 3 operating lines (refer to Table 1 in Section 2.1) – the BTS Sukhumvit Line, the BTS Silom Line, and the MRT Blue Line.

In measuring urban rail transit impacts, various methods are adopted in existing research; from the ANOVA method (Du and Mulley, 2007), hedonic regressions (Baum-Snow and Kahn, 2000; McMillen and McDonald, 2004; Celik and Yankaya, 2005; Chatman et al., 2012) to extended spatial regression models (Chalermpong, 2007; Chalermpong and Wattana, 2009; Vichiensan and Miyamoto, 2010; Vichiensan et al, 2011; Chatman et al., 2012; Malaitham, 2013). Out of common ground, most of these studies are cross-sectional and are focused on a before-and-after analysis, observing the changes in property value before and after an event of a new urban rail transit system (Baum-Snow and Kahn, 2000; Chatman et al., 2012). Consequently, these studies, like that of Chatman et al. (2012) assumes a one-time capitalization effect of urban rail transit investment on property values or either opted to measure only its short-run effects. However, land price adjustments often take some time to reach its stabilized long-run equilibrium (Grimes and Atiken, 2010). Moreover, in the case of Bangkok, new urban rail transit projects recently started to commence continuously in the past few years. The limited scope of cross-sectional studies will not represent the situation as precisely. Therefore, to account for network effects the new lines may add to the overall accessibility of the region, this research opts to measure effects in the long-term using time series data. The study also examines specifically the effects of station announcement, construction, and opening throughout the five periods. The method in this research is most comparable to that of McMillen and McDonald (2004) where Chicago's property value capitalization as a result of the Midway Line construction is examined via a 17-year panel.

4.2 Focus and control areas

Assumption 1

> *"The focus districts are selected when there is at least one station from the 3 rail transit lines under study is present."*

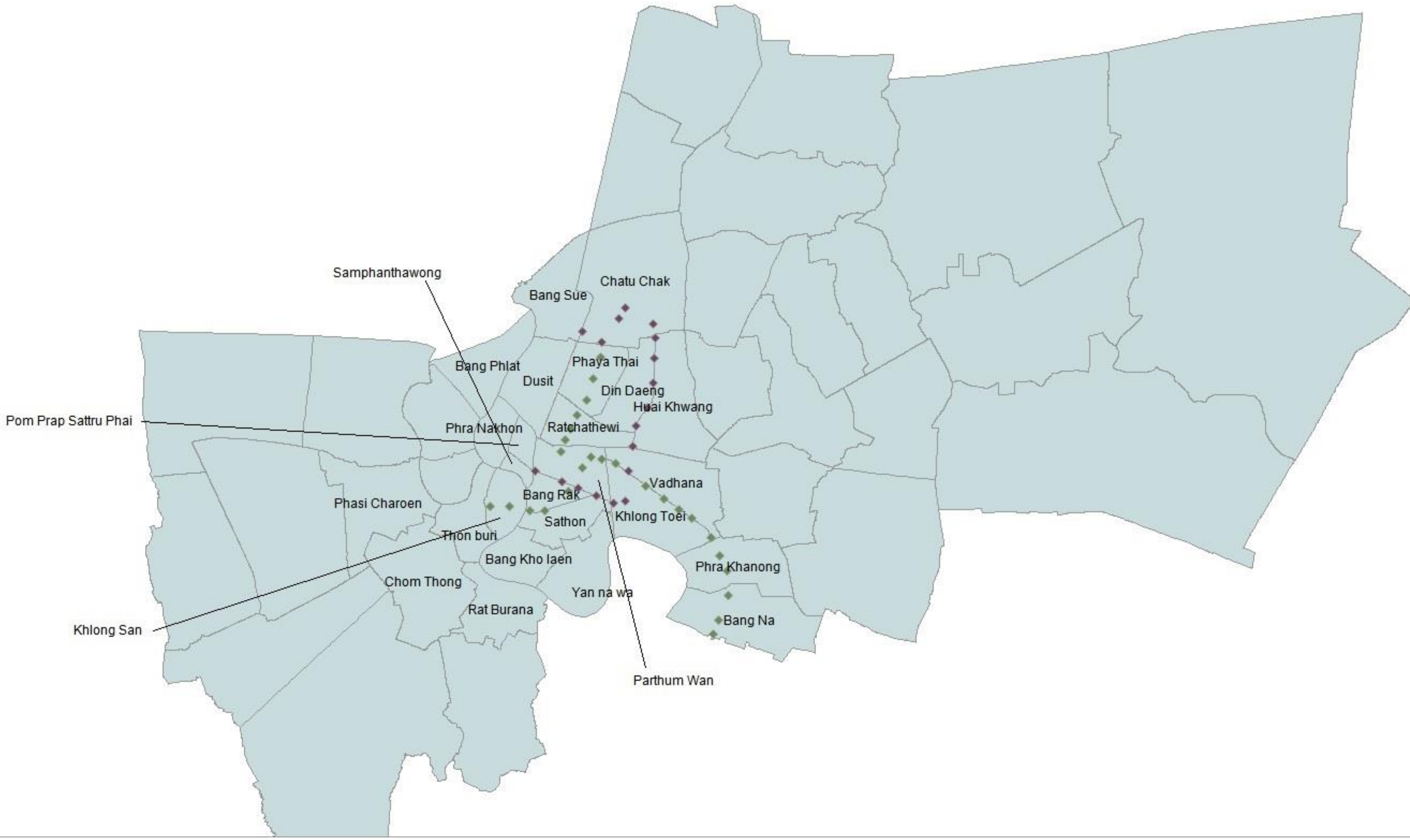
In the sample, 24 districts are included. 16 of the 24 districts is the catchment area and are selected based on the presence of one or more station that belongs to the 3 lines under study. The remaining 8 districts are included as control areas. They are selected to fill in the gaps so that the whole 24 districts represent the inner-city area of the BMR. Table 4 shows the names of districts included in the sample. The control districts are those which stations of the 3 operating lines do not exist but are considered an inner-city district. This is to control for district differences in accessibility caused by having station access. In other studies, distances from stations were used as cut-off points to determine the catchment areas (Du and Mulley, 2007). But since parcel-level data is not available, the presence of at least one rail transit station within a district is used instead.

Apart from the original 3 rail lines under study, the study also accounts for the construction of 4 new lines and/or extensions. – the MRT Blue Line; the north and south extensions, the SRT Red Line, and the MRT Purple Line. This is done by also including the construction and announcement effects of new stations which are located in the 24 districts. The effects of these new lines has been accounted for in the following districts in our sample – BangSue, Pomprap Sattru Phai, Phra Nakorn, Pasi Charoen, Chatuchak. Thus, the effects of announcement and construction can be more fully captured. Image 1 show the focus and control districts. The green dots show the BTS stations and the brown dots show the MRT stations.

Table 4 Names of districts under study

Focus districts (N = 16)	**Bangsue, Chatuchak, Din Daeng, Huai Kwang, Ratchatewi, Wattana, Klongtoei, Pathumwan, Bang Rak, Bang Na, Phra Khanong, Payathai, Sathorn, Klongsarn, Thonburi, Pasi Charoen**
Control districts (N = 8)	Ladprao, Dusit, Rat Burana, Phra Nakhon, Pomprap Sattru Phai, Sampan Thawong, Bang Ko Laem, Yan Nawa

Image 1 A map of the focus and control districts with BTS/MRT station locations



4.3 Data

All data have been collected from local secondary sources. Most of the data obtained are from official government records apart from the year of announcement, construction, and opening where some were obtained from the websites of related parties. Refer to Table 5 to see a break-down of data sources. Throughout the course of conducting this study, several limitations within the data has been a huge barrier to overcome and will be discussed along-side explanations in upcoming sections.

Table 5 Data sources and original format

Data	Source	Format given
Assessed land values in sq. yards)	The Treasury Department (obtained in hard copy)	4-year averages in intervals or absolute numbers per sub-district for the periods: 1996-1999 | 2000-2003 | 2004-2007 2008-2011 | 2012-2015
Year of announcement **Year of construction** **Year of opening**	Official Government reports Bangkok Mass Transit System Pcl. website[1] Bangkok Metro Public Company Pcl. website[2]	N/A
Income per capita	The National Statistical Office (NSO) website[3]	Per district for the years: 2004 | 2006-2010
Number of students	Bangkok Metropolitan Administration (BMA) Data centre website[4]	Per district for the years: 2004-2014
District size (sq.km)	Bangkok Metropolitan Administration (BMA) Data centre website[4]	Per district for the years: 1993-2014
Number of department stores	Bangkok Metropolitan Administration (BMA) Data centre website[4]	Per district for the years: 2004-2013

[1] http://www.bts.co.th
[2] http://www.bangkokmetro.co.th
[3] http://www.nso.go.th
[4] http://www.bangkok.go.th/info

Population density	Official Statistics Registration Systems website[5]	Per district for the years: 1993-2013
Household density	Official Statistics Registration Systems website[5]	Per district for the years: 1993-2013
Type of community	Bangkok Metropolitan Administration (BMA) Data centre website[4]	Per district for the years: 1999-2010

z

4.4 Variable Specification

This section will elaborate on the variables that are included in the empirical model – how the data is transformed and the assumptions taken to accommodate the model. The limitations within the data are discussed briefly. The dependent variable observed for is the change in land values. The independent variables are categorized as transport accessibility, market trends, neighbourhood characteristics, and amenities. The variables are selected based on the theories presented in Section 3.5, refer to Table 3 for the summary of findings from that section.

The dependent variable

Land values (growth)

The only source of far-stretched historical information for (proxies of) Thai land/property values is that of the Treasury Department, under the Ministry of Finance. Hence, the "assessed" land values were obtained from there. These values are assessed by the government assessors at the beginning of each period. For example, in 2012, the assessed averages for the period 2012-2015 are announced. When assessing a parcel value, the assessors take into account the current market value, the location of the parcel, the demand, specific characteristics of the neighbourhood, and certainly access to public transport. Therefore, the assessed values certainly hold elements of the

[5] http://stat.bora.dopa.go.th/stat

market value. However, it is still a prediction/expectation of the future based on current information observed today.

Assumption 2

“Assessed land values bear direct relationship with real market prices.”

Several Bangkok studies have also used asking prices collected from real estate magazines although all are limited as cross-sectional studies (Chalermpong, 2007; Vichiensan and Miyamoto, 2010). The main claim for all of these proxies was that they are still more or less correlated with transaction data, respective to their contexts (Du and Mulley, 2007). Similar to this study, several others also used assessed land values including a case study of Buffalo, New York (Hess and Almeida, 2007) and two other Bangkok case studies (Malaitham, 2013; Vichiensan et al., 2011). Specifically in the case of Thailand, it is plausible to assume that assessed land values bears direct relationship with real property values because explicitly the related department states that they have taken the market value, plus expectations about recurrent developments (E.g. Better transport accessibility, market trends, etc.) into account.

These data came in 4-year averages per ‘sub-district’ (E.g. roads, alleys, etc.) and then were categorized and presented per district of the Bangkok Metropolitan Region. Some sub-district averages came in absolute terms and some as intervals. Since all the other control variables are available only at district level, the sub-districts land values were summed up to calculate the ‘district’ average. Sub-district average intervals were transformed into midpoints before included in the district average calculation. An illustration of such case can be seen in Table 6. If we would assume that all sub-districts in Table 6 belong to District X. Then the average land value for District X would be:

$$\left(\frac{43{,}000+51000}{2} + 51{,}000 + \frac{47{,}000+51{,}000}{2}\right) \div 3\ = 49{,}000\ baht/sq.yard$$

Table 6 Example of sub-district assessed land value data, District X

Area	Assessed value 2004-2007 (Baht / sq. yard)
Yen ar-kard alley 2	43,000 – 51,000
Yen ar-kard alley 3	51,000
Palm William Village	47,000 – 51,000

Unfortunately, a weighted-average was not possible to compute since surface area or population data were not available at the specific sub-district levels. For consistency with other control variables (i.e. student per square kilometre, population density, household density, department store coverage), the averages were then transformed to baht per square kilometre units. Then, for ease of analysis and to transform data to normality, the log of the land values is taken and is used in the models.

Transport accessibility – the variable of interest

Number of stations

The number of stations is categorized into three groups as follows:

- Announced – the year a contractor has won the concession from the government; there is then a degree of certainty that the station will be built
- Under construction – the year construction of a station commences
- Operating – the year where the station starts its operations

The number of stations announced, under construction, and operating within a particular district is incorporated to the respective periods under study (1996-1999, 2000-2003, 2004-2007, 2008-2011, 2012-2015). The coding is different for the three station events. The coding is done such that in the end, the operation effect reflects the net (realized) impact of urban rail transit.

Assumption 3

"The effect of announcements lasts for only one period."

The effects of announcements must not be ignored because it is the first assurance that a line will be built. However, the counts for announced stations will last for only one period because it is assumed that the effect of announcement is transformed to the effects of construction once construction actually starts. In Thailand, transport project suffers negative press and media publicity. Even if a concession has passed, there is still risk that the project will not be implemented or will be delayed. The public perceives as a norm, that chances of delay or cancellations exist. In the past, projects were stifled due to vast public objection; corresponding to the literature review stressing how the media plays an essential role to generate public support for such projects (Mackett and Babalik Sutcliffe, 2003; Siemiatycki, 2006). Thus, 'announcements' are an assurance to the public but not a guarantee that an event will happen.

Assumption 4

> *"The effect of construction is transformed into the effects of operation in the period the station starts operating."*

When construction starts, it acts as a second assurance that the line will be there and will generate expectations to the market. Stations under construction will only be counted up until the period where construction ends. This is because the nuisance effects from construction (Hennebury, 1998) will vanish eventually. Moreover, up until the opening date the net impact is assumed as realized by the operation effects.

Assumption 5

> *"The effect of operating stations represents the realized net impact of urban rail transit."*

The operating stations will always be counted continually as long as the station still operates within a specific period. It is assumed that once a station is present it adds on to the accessibility of an area which will remain as long as the station still persists. Plus, it represents the realized net impact of the station. This variable should capture the impacts passed on from announcements and construction.

Table 7 An example of how the number of stations variables are coded: the case of Bangsue district (District 1)

District	Period	# announced stations	# constructed stations	# operating stations
1	1	4	4	1
1	2	0	4	1
1	3	0	0	5
1	4	1	1	5
1	5	0	1	5

The coding of the transport accessibility variables are as seen in Table 7. As shown, in period 1, four stations were announced and constructed and already one station is operating. In period 2, the number of announced stations ceased to zero because it is assumed that announcement effects do not prolong and is transformed into the construction effects. The construction of these four stations then lasted for 2 periods (period 1 and 2). In period 3, these four stations previously under construction opened and thus were added to the number of operating stations from period 3 onwards. As seen, the operation effects are prolonged because it is assumed to represent the net impact and the permanent accessibility it generates to the system.

As a result, three separate variables are constructed for the three events. This element has been scarcely explored in current literatures although is most comparable to that of McMillen and McDonald (2004) where these impacts were explored also over a long time frame. These variables will be the main variables of interest since it should control for the relative station accessibility of a district. Although in other studies, dummy variables were used to represent for example the presence of more than one transit station in an area (Armstrong and Rodriguez, 2006); the actual "number" of stations in a district is adopted in this study. This is to control for the superior access of districts with more than two, three, or four stations in an area which is specific to the case of Bangkok. The Pathumwan district for example, holds access of up to 8 stations after the opening of the MRT subway in addition to the BTS line.

Station concentration

In addition, to fully account for differences in accessibility between different districts, the number of stations per event of announcement, construction and operation is divided by the district size (in sq.km). This is done to control for the coverage of stations in an area. For example, the Pathumwan district is 4 times smaller than the Chatuchak district, but still has 8 stations whereas the other only has 5 operating. This illustrates how smaller districts can be much more accessible with more number of stations per area. The variable constructed is named station concentration.

Market trends

Income per capita (growth)

The income per capita variable is included in the model as a proxy for the economic condition of the region. Supportive literatures have associated property value movements with the state of the economy (Gatzlaff and Smith, 1993; Hess and Almeida, 2007; Chatman et al., 2012).

Income per capita data at district level was available for the years 2004 and 2006-2010. To project the missing years for 2005 and 2010-2014, the GPP (Gross Provincial Product) growth was applied for 2004 and 2010 to the data points of its respective years. Then, to align the scale with the 4-year average of the dependent variable (land values), 4-year averages were taken accordingly to the five time periods. Finally, the exponential log is taken to determine the growth rate of income per capita.

Assumption 6

> *"Land value movement is related to income growth."*

Assumption 7

"District income growth is constant in the years 2003-2005 and 2010-2014 and follows the growth trends of the province based on GPP growth."

As a result from transforming the data it automatically was assumed that the growth prospect of the region, namely the province (Bangkok itself) has a direct influence on the growth of district-level income, likewise district-level economy.

Neighbourhood characteristics

Population and household density

Population and household density variables are included to control for whether the urban land rent theory under the monocentric city (Alonso, 1960) or the modern urban sprawl theory (Brueckner and Fansler, 1983) holds better in the case of Bangkok Metropolitan Region. Several hedonic studies have found population density (Bae et al., 2003) and household density (Malaitham, 2013) significant and so the two variables will be adopted in the model.

Both population and household data were the most complete relative to all the other variables in the panel. Yearly data from 1993 to 2013 was available and therefore no projections were needed. Population and household data were divided by respective district size to calculate for their densities. Then, once again, 4-year averages were calculated according to the five periods. The data was also transformed to exponential log form for ease in analysis.

Low-grade community ratio

A variable to account for different types of communities which compose a district are also included in the model. The data is available yearly from 2004 to 2014. The BMA[6] has categorized six community types as follows: public housing, housing estates, rural, metropolitan, high-rise estates, and slums. Half of the six are considered low-grade communities which separates the middle and higher income people from the working class – those in public housing, rural communities, and slums. The variable is

[6] Bangkok Metropolitan Administration

constructed as a ratio of low-grade communities to the overall number of communities within a district. The 4-year average of the ratios was then computed. A negative influence on land values is expected.

Amenities

Number of students per sq.km

The presence of schools and their qualities has been regarded as a special amenity which adds value to an area (Bae et al., 2003; Malaitham, 2013). The proximity of schools could be a contributing factor to drive up demand for land or properties around a particular neighbourhood. Although, the number of schools itself do not vary much year by year and is not so much representative of quality. The number of students in an area could represent the quality and attractiveness of schools within an area better and hence was adopted instead.

To control for relative district differences, the absolute student numbers is divided by district size. For example, Thonburi district is half the size of Pasi Charoen, but the number of students per square kilometre is much higher, indicating the potential popularity of schools in the area. However, correlation with population and household numbers may also exist. Then, since data is available yearly from 2004 onwards, 4-year averages were calculated accordingly from that year. And lastly, the exponential log transformation was also applied.

Department store coverage

Another amenity variable which reflects very well the Thai life-style is the number of department stores. The past few decades, these shopping centres remain the most influential form of retailing and have diverted structural changes in consumer behaviour (Feeny et al., 1996). The metropolitan life-style seeks for convenience where every demand can be served in one place. A recent study by Malaitham (2013) have accounted for shopping centre accessibility using distances from a particular land parcel. In this study, the variable department store ratio is constructed by dividing the number of department stores in an area with district size to account for the size differential per district. Finally, the 4-year average was computed. To note, the term ‘department store’ and ‘shopping centre’ is assumed to have the same meaning in this research and will be used interchangeably.

4.5 Model Specification

This study employs hedonic regression models with panel data, controlling for accessibility characteristics (transport and network), neighbourhood characteristics, market trends, and amenities. It aims to extend the scope of previous before-and-after impact analysis and disregards the assumption that there is only a one-time capitalization effect as taken by some studies; Chatman et al. (2012). Thus, the models in this research aim to take into account network effects from line extensions and new projects that contribute to the connectivity of regions.

Assumption 8

“Land value capitalization as a result from urban rail transit is not one-time.”

Time series data is scarcely found in urban rail transit impact analyses. Although McMillen and McDonald (2004) have done so, their models only control for physical housing characteristics and a few neighbourhood aspects. Therefore, this research tries to extend the variety of control factors by including market conditions and amenities. Insights from extra control factors which accounts for market conditions and amenities should bring new dimensions to existing research.

Models

Model 1: Number of stations

$$\ln(\text{landvalue})_{ij} = \beta_0 + \beta_1 \textbf{announce}_{ij} + \beta_2 \textbf{construct}_{ij} + \beta_3 \textbf{operate}_{ij} + \beta_4 \ln(\text{income}) + \beta_5 \ln(\text{pop\_dens})_{ij} + \beta_6 \ln(\text{house\_dens})_{ij} + \beta_7 \text{community}_{ij} + \beta_8 \ln(\text{student\_dens})_{ij} + \beta_9 \text{depstore}_{ij} + \varepsilon$$

Model 1 accounts for the number of stations in light of announcement, construction, and operation all at current time periods. This model reflects how the market price should be reflected.

Model 2: Time-lagged number of stations

$$\ln(landvalue)_{ij}$$

$$= \beta_0 + \beta_1 \mathbf{announce\_1_{ij}} + \beta_2 \mathbf{construct\_1_{ij}} + \beta_3 \mathbf{operate\_1_{ij}}$$

$$+ \beta_4 \ln(income) + \beta_5 \ln(pop\_dens)_{ij} + \beta_6 \ln(house\_dens)_{ij}$$

$$+ \beta_7\, community_{ij} + \beta_8 \ln(student\_dens)_{ij} + \beta_9\, depstore_{ij} + \varepsilon$$

Model 3: Station concentration

$$= \beta_0 + \beta_1 \mathbf{c\_announce}_{ij} + \beta_2 \mathbf{c\_construct} + \beta_3 \mathbf{c\_operate_{ij}} + \beta_4 \ln(income)$$

$$+ \beta_5 \ln(pop\_dens)_{ij} + \beta_6 \ln(house\_dens)_{ij} + \beta_7\, community_{ij}$$

$$+ \beta_8 \ln(student\_dens)_{ij} + \beta_9\, depstore_{ij} + \varepsilon$$

Model 3 replaces the station counts with station concentration variables. For supportive arguments, refer to Section 4 (Pg. 40).

Model 4: Time-lagged station concentration

$$\ln(landvalue)_{ij}$$

$$= \beta_0 + \beta_1 \mathbf{c\_announce\_1}_{ij} + \beta_2 \mathbf{c\_construct\_1}_{ij} + \beta_3 \mathbf{c\_operate\_1}_{ij}$$

$$+ \beta_4 \ln(income) + \beta_5 \ln(pop\_dens)_{ij} + \beta_6 \ln(house\_dens)_{ij}$$

$$+ \beta_7\, community_{ij} + \beta_8 \ln(student\_dens)_{ij} + \beta_9\, depstore_{ij} + \varepsilon$$

To note, the time-lagged models were added due to the nature of the data. Since assessed land value is published before the actual period starts, it is a projection by assessors based on market trends and their knowledge of the market rather than real market value – this model reflects better the nature of the data used. For example, in 2012, a 4-year assessment of land values in 2012-2015 is published and henceforth. Therefore, Models 1, and 3 are run in the current time dimension and Models 2 and 4 in the lagged time dimension. This translates as the station accessibility variables of the previous period determine the assessed land values of the current period. Intuitively, an assessor would take previous information of developments (i.e. construction of a new transit line) into account when assessing land values for the current and forthcoming years.

Goodness-of-fit

Model 1 is used to test for the goodness-of-fit. The Breusch-Pagan LM test for random effects was applied. The null hypothesis that variances across entities are zero (i.e. no panel effect) was rejected at 5% significance (p-value = 0.0001). The test suggests that a Random effects regression is more efficient than a simple OLS regression. The test results can be found under Appendix.

The Hausman test results show that the difference in coefficients between the Fixed and Random Effects model is not systematic, and thus the Random Effects model is more efficient. This shows that the there is enough variation within the data throughout the years and that the different aspects of the panel (district) is well controlled for. The results to be presented in subsequent sections will therefore be based on the Random Effects Model. The Stata outputs can be found in the Appendix.

To control for the heteroskedasticity of the residuals, the log transformations are made to the land values, income per capita, population density, household density, and the number of students per square kilometre. Unfortunately the Breusch-Pagann test for heteroskedasticity cannot be applied with a Random effects model data.

The residuals have also been tested for normality using the Kernel Density estimate, the Q-plot, and the P-plot. The outputs can be found under the Appendix. Even though the indicators show that the residuals is slightly skewed, it should not affect our estimates. This is because the normality assumption is only required for hypothesis testing but is not required in order to obtain unbiased estimates for regression coefficients.

5. Results and Discussion

Before the analysis of results is presented, it should be emphasized that after accounting for all the variables in the model, only 69 observations remain in the models. Moreover, all the results reported in this section are based on the Random Effects model. The regression outputs from Stata for all models can be found under the Appendix.

5.1 Interpretation of models

The interpretation of the models is separated into sections. The first section compares Models 1 and 2, where the number of stations variables and their lagged forms are the main variables of interest. The second section then compares Model 3 and 4, where the station concentration variables and their lagged forms are the focus. The results are analysed and interpreted to compare whether they align with expectations and theory.

Number of stations: lagged and non-lagged model

Table 8 shows the estimated coefficients and p-values for Models 1 and 2. The control variables department store per square kilometre and household density are significant in both models. The models suggest that household density affects the average land values positively. This result is intuitive because the increase in the household density, *ln(household_dens)*, suggests the popularity of the area for living, and thus drives up land values. Model 1 and 2 suggests that within a 4-year period, if household density increases by 1%, average land values increases by 1.31% and 1.28%, respectively, all else held equal. The results are significant at the 5% and 1% level for Models 1 and 2, respectively.

The interpretation for the department store coverage (deptstore) is as follows. Within a 4-year period, when the coverage of department store increases from 0% to 10% (per square kilometre) in a district, average land values increases by 4.3% and 3.1%, for Models 1 and 2, respectively. The coefficients are significant at the 5% and 10% levels in Models 1 and 2, respectively. These results contradict to that of Malaitham (2013), also a case study of Bangkok, where the closer a property is located to a shopping centre, its value decreases. However, in this model, the coverage at a district level is measured whereas in Malaitham (2013), the variable is coded as the distance to shopping centres from a specific land parcel.

Table 8 Estimated coefficients and p-values for Models 1-2 (number of stations)

	Number of stations		
	Models / Variable	**Model 1**	**Model 2 (Lagged)**
Transport accessibility	**nr_announce**	0.0572178 (0.182)	
	nr_announce_1		-0.0489854 (0.354)
	nr_construct	-0.0392387 (0.394)	
	nr_construct_1		-0.0351683 (0.518)
	nr_operate	0.0597265 (0.223)	
	nr_operate_1		0.102313 (0.031)
Market trends	**ln(income)**	-0.2849557 (0.462)	-0.0873695 (0.810)
Neighbourhood characteristics	**ln(pop_dens)**	-0.5629641 (0.126)	-0.4546525 (0.172)
	ln(house_dens)	1.307967 (0.004)	1.272498 (0.001)
	community	-0.4926848 (0.107)	-0.4576623 (0.110)
Amenities	**ln(student_dens)**	0.0425438 (0.651)	0.0549059 (0.518)
	deptstore	0.4398855 (0.024)	0.3231448 (0.081)

The variables of interest are the absolute number of stations announced, under construction and operating. Comparing the two models in general, the significance of these variables has not changed much apart from the operation effects. In this case, the operation effects became significant at the 5% level once transformed into the lagged form. The nature of the data supports this because assessed land values are announced at the beginning of the period. The information about the operation would occur ***in the current period*** but the assessor would include this in the assessment for ***the upcoming period***.

In Model 2, the lagged operation variable (nr_operate_1) suggests that if ***in the current 4-year period***, an extra station opens in a district, in the next 4-year period, the assessor expects average land values to increase by 10.2%, all else held equal. The effect is significant at the 5% level. However, Model 1 suggests that if ***in the current period***, an extra station opens in a district, then in that same period; average land values would only rise by 5.9%. This could be an indication that the assessors have overestimated the effect of a station's opening/operation whereas in reality, the market's reaction may be not as strong. Although the interpretation for Model 1 should be treated with precaution since the operation effects in that model is not significant.

Interestingly, the announcement effects show different signs – positive in Model 1 (nr_announce) and negative in Model 2 (nr_announce_1). However, the effect is not significant in both models. The difference in signs could be interpreted as follows. The assessor may have perceived that the announcement of stations will lower average land values. Or somehow the land parcels in a certain district would become less attractive. These results could be partly explained by the fact that the public acknowledges very well the uncertainty of such projects in Thailand. There have always been doubts that delays will happen and construction will be prolonged (Smith, 2014). This would mean that nuisance from construction; noise and congestion may prolong and no guarantee is made of when the station will be completed. The assessor opts to think that the station will not be completed in the near future. However, the market may perceive the announcements positively as an assurance that the stations will be there eventually, and so market values adjust upwards. This could be the case why Model 1 saw a positive coefficient for announcement effects. It reflects how the expectations of assessors and the market's reaction could misalign. Nonetheless, positive announcement effects correspond to that of McMillen and McDonald (2004) although in their model, the number of stations is not taken into account, and the variable used there is simply a year dummy for the period where there is an announcement of a transit line. The announcement effects are not significant therefore results must be dealt with precaution.

The coefficient for construction effects in Model 1 (nr_construct) is larger (in absolute terms) than Model 2 (nr_construct_1). However, both coefficients are not significant. In this case, the assessor may underestimate the nuisance from congestion and noise. On the other hand, the market ***in the current period*** may receive solid news of delay and so the negative effect is slightly larger. The interpretations must be dealt with precaution since the variables are not significant at any level.

The case for negative announcement and construction effects is valid since it is true that the recent lines that are taken into account in the model were actually delayed in terms of construction. This is the case for the SRT Dark Red Line which is also included in the model. The lines were announced already in 2010-2011 but there were a considerable degree of uncertainty of when the construction would actually start. These events are partially reflected by evidence from the following source:

"Implementing the M-MAP has always been plagued by delays either at the approval, contracting or construction phase. Two new lines (MRT Purple Line and SRT Dark Red Line) and two extensions (MRT Blue Line and BTS Bearing to Samut Prakan extension) are currently under construction. These were all approved in 2010-11 but have been subject to delays both before they were approved and after construction began.

Other lines were originally planned to be completed by 2008 or 2009, but their construction has not started. Four new lines or extensions (BTS Mor Chit to Khu Khot extension, the ARL extension, and MRT Pink and Orange lines) were planned to be tendered by 2013 during the term of the previous government. However, these were all delayed for policy reasons, and thereafter due to the seven-month political struggle during which parliament was dissolved and elections in February were annulled."

(Bangkok Post, 2014)[7]

[7] http://www.bangkokpost.com/print/435063/

The paragraph highlights a section from a local English newspaper, the Bangkok Post.

Moreover, the effect may come out as negative also due to the way the variable is coded. Both construction and announcement are represented as if they do not prolong. For example, the number of counts for constructed stations will become zero on the period operation starts. An illustration of this is shown in Table 7 (in the Methodology section) with the case of Bangsue district (District 1).

Station concentration: lagged and non-lagged model

Table 9 shows the estimated coefficients and p-values for Models 3 and 4. The variables of interest are the average number of stations in a district that is announced, under construction and operating. Comparing the two models in general, there is significance change in the announcement effects, the operation effects, the change in population density, and the department store coverage.

The population density variable, *ln(pop_dens)* is significant at the 5% level in Model 3 but not significant in Model 4. Both Models 3 and 4 shows a negative effect. Model 3 suggests that within a 4-year period, as population density increases by 1%, average land value decreases by approximately 7.5%. On the one hand, population density may reflect the demand for land in an area. On the other hand, it may also partially reflect the type of housing present. According to the BMA's[8] categorization of community types, those 'low-grade' neighbourhoods (i.e. slums, public housing) are mostly one of the most densely populated neighbourhoods. Moreover, the correlation between the change in population density and the low-grade community ratio is also negative; test results show a correlation coefficient of -0.1831.

[8] Bangkok Metropolitan Administration

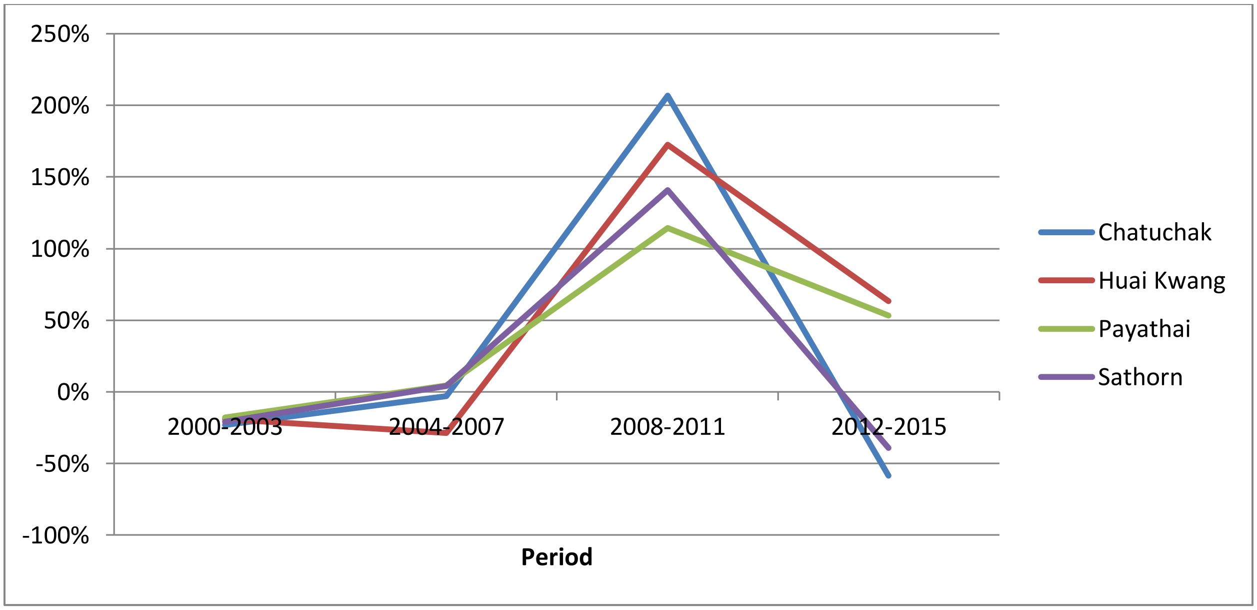
Table 9 Estimated coefficients and p-values for Models 3-4 (station concentration)

		Station concentration	
	Models / Variable	Model 3	Model 4 (Lagged)
Transport accessibility	c_announce	0.6727525 (0.067)	
	c_announce_1		-0.1533012 (0.731)
	c_construct	0.0269932 (0.945)	
	c_construct_1		-0.4502996 (0.357)
	c_operate	0.6228472 (0.163)	
	c_operate_1		0.9375422 (0.035)
Market trends	ln(income)	-0.1086283 (0.763)	-0.1505459 (0.651)
Neighbourhood characteristics	ln(pop_dens)	-0.7491685 (0.040)	-0.449784 (0.189)
	ln(house_dens)	1.535113 (0.001)	1.271214 (0.002)
	community	-0.3685932 (0.249)	-0.4091886 (0.168)
Amenities	ln(student_dens)	0.0727459 (0.466)	0.0571766 (0.521)
	deptstore	0.3536824 (0.091)	0.2563873 (0.206)

The department store coverage (deptstore) is significant at the 10% level in Model 3 but not in Model 4. Both models suggest a positive effect on the change in land values. Model 3's coefficient can be interpreted as follows. Within a 4-year period, when the coverage of department store increases from 0% to 10% (per square kilometre) in a district, average land values increases by 3.5%, all else held equal. These results also are aligned with that of Models 1 and 2. This somehow confirms the presence of a department store as an amenity for the district.

The operation effects (c_operate and c_operate_1) became significant at the 5% level in its lagged form as seen in Model 4. Model 4 suggests that once the coverage of operating stations within a district increases from 0% to 10% (per square kilometre) ***in the current period***, the average land values increases by 9.26% in the upcoming period. The operation effect in Model 3 is not significant but otherwise is smaller than that of Model 4. This shows again that an overestimation of impacts may occur with the assessors.

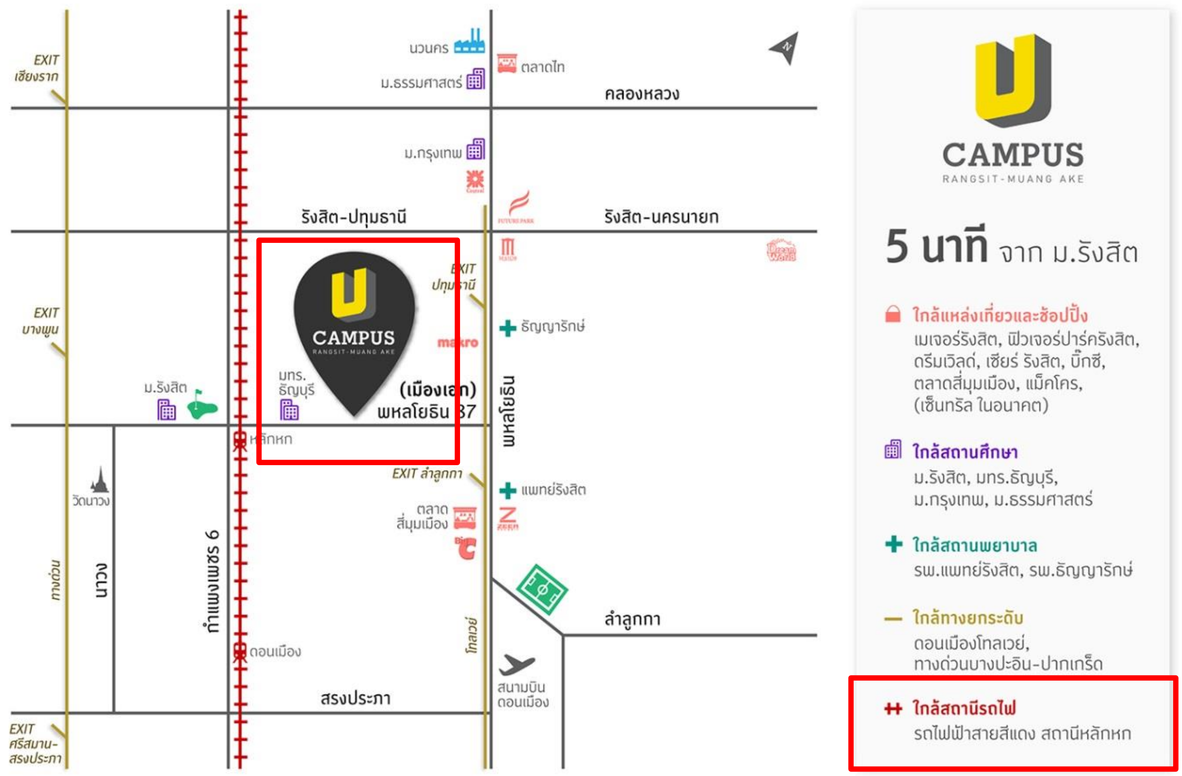
Figure 2 Assessed land value changes per period for the Chatuchak, Huai Kwang, Payathai, and Sathorn districts



Thus far, the operation effect is the only transport accessibility variable that is significant in more than one model (both in the lagged form). This could have been the result of the huge uplift in average assessed land value growth of the period 2008-2011 as compared to the previous period. These events are partly explainable and could be due to the MRT Blue Line's official opening in 2004. The operation effects are highly significant in the lagged models which mean that the assessors may have included this information in the period 2004-2007 which then is reflected in the strikingly high growth in the following period (2008-2011). The Chatuchak district holds four MRT Blue Line stations and according to Figure 2, land value grew by 207%. The Huai Kwang district has three stations of the MRT Blue Line which also opened in 2004, the district show 173% growth rate in land values. These interpretations do not infer sole causal relationship but it is only an observation in attempt to explain results. Sathorn and Payathai districts are already highly accessible districts with four and two BTS lines (respectively) already operating since 1999 and are also home to the central business districts.

The announcement effects are significant in its non-lagged form as in Model 3. The results suggest that as the coverage of announced stations within a district increases from 0% to 10% (per square kilometre), the average land values increases by 6.73%. The results correspond to that of Bae et al. (2003) where the Hong Kong real estate market also responds positively to line announcements. The striking result is that in Model 4, if the coverage of announced stations within a district increases from 0% to 10% (per square kilometre), the assessor predicts a negative effect for announcements in ***the next period***. This effect is insignificant and therefore interpretations must again be handled with precaution. The assessor may expect prolonged nuisance from construction and thus degraded the land values but in reality, the market may react positively towards the construction of a new station. According to CBRE Thailand (2012), a leading international real estate consultancy firm established in Bangkok, states how the announcement of new BTS/MRT developments have affected the consumer's decision process in investing in properties. Proximity to BTS/MRT stations are now one of the key factors to determine the demand for property. Moreover, real estate advertisements explicitly promote the existence of ‘future’ rail transit stations to attract customers. This is reflected in Image 2. An advertisement for a condominium located close to Rangsit University advertises its proximity to the future MRT Red Line station. The text ‘Close to MRT Red Line, Lak Hok station’ is highlighted in red on the right-hand side. This supports the market’s positive reaction to station announcements.

Image 2 U Campus condo advertisement



Source: http://www.grandu.co.th/ucrm/webpage_en/location.html

The construction effects are not significant in both Models 3 and 4.

The variable change in income per capita is not significant in any of the models. It also shows a negative sign which is rather not intuitive. In this case, the income per capita is a proxy for market trends or the economic condition for each district. According to several studies (Gatzlaff and Smith, 1993; Cevero and Duncan, 2002; Hess and Almeida, 2004), land values are supposed to increase if the economy is going well.

However, as mentioned in the Methodology section, the income per capita variable has missing values during the years before and up to 2005, and 2010 to 2014. Therefore, the 2006 and 2010-2014 values were predicted using the growth in GPP. This may have caused inconsistency in the data once transformed into 4-year averages.

Figure 3 Distribution plot for the growth in income per capita

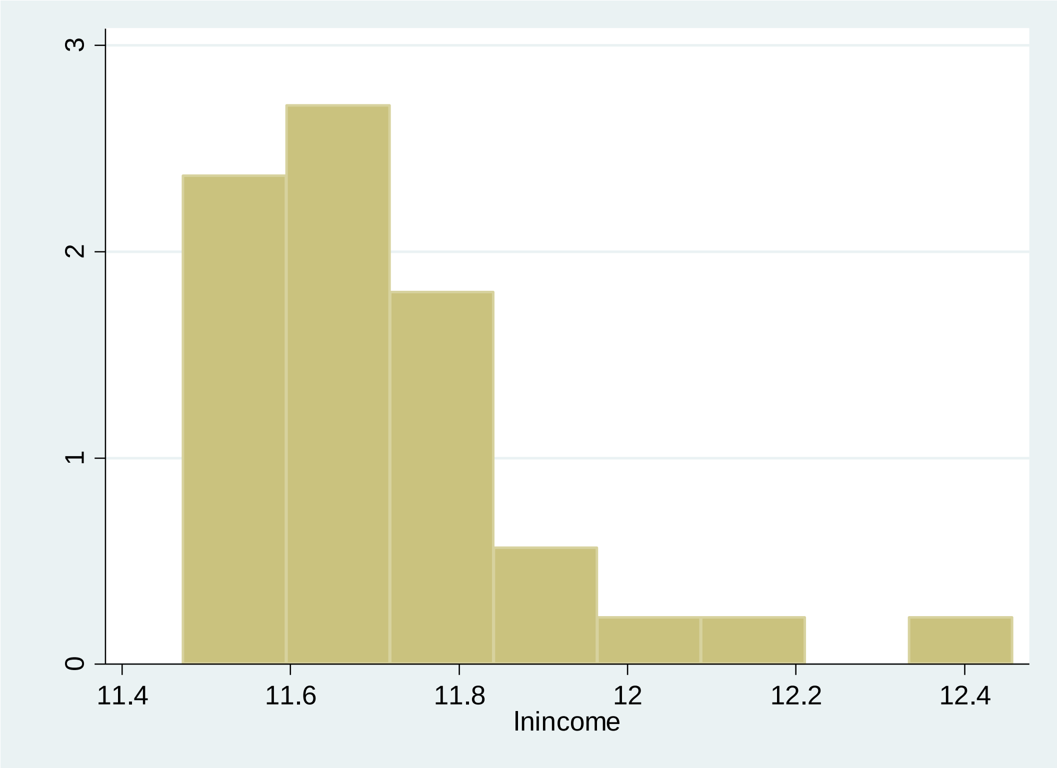
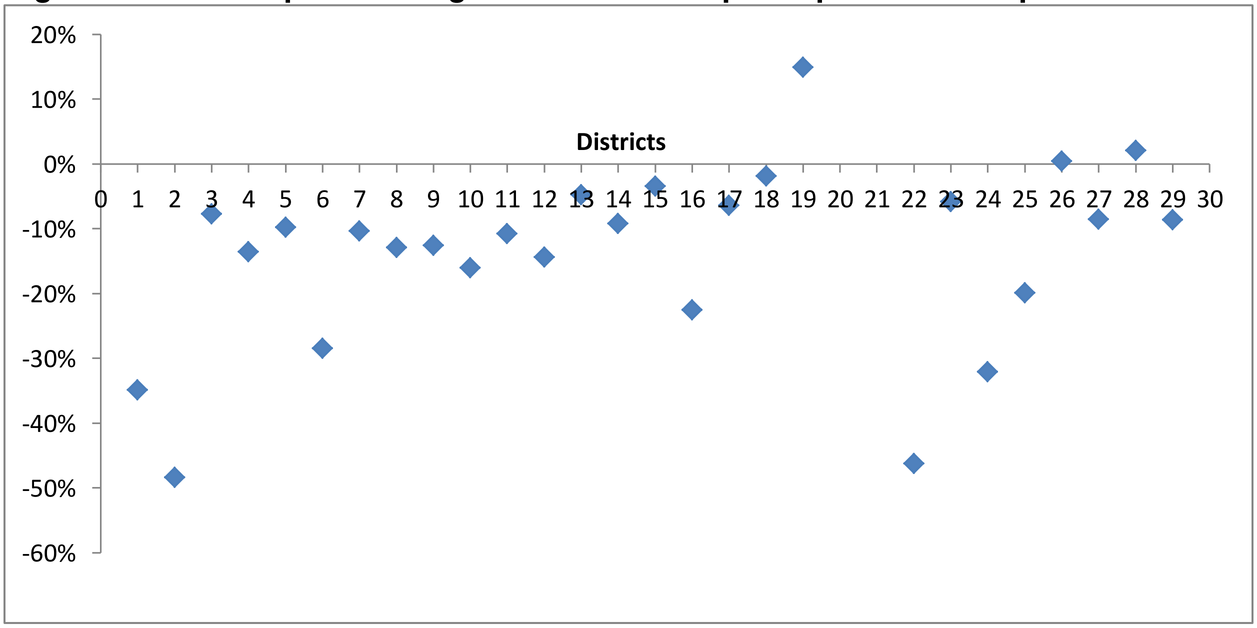


Figure 4 A scatter plot of the growth in income per capita between periods 3 & 4



Moreover, the distribution of the *lnincome* variable is also not normal and highly skewed to the right (refer to Figure 3). Within the data itself, the growth between periods 3 and 4 (2004-2007 and 2008-2011) shows strange values (refer to Figure 4). For example, the Chatuchak district's (District 2) land value lost almost half of its original value. One explanation for this may be the major political shock in 2010 where a serious protest shutdown many of the important districts. The number of tourists had decreased dramatically during those periods. Since the Chatuchak district originally holds a lot of tourist visits, it may be that this shock is partly the reason of the outlying results.

The low-grade community ratio (community) variable is also not significant in any of the models. However, the signs are negative which is intuitive. The variable comprise of the number of low-grade neighbourhoods divided the total number of neighbourhoods within a district. The definition for low-grade neighbourhoods is based on the BMA's definition, and so slums, rural areas, and public housing types of communities are included in this variable. They are densely populated neighbourhoods that are low in demand due to high crime rates and low quality housing. On average, approximately two-thirds of the districts are comprised on low-grade neighbourhoods.

The student per square kilometre variable is not significant in any of the models. The direction of effects on land values is positive which aligns with expectations. The variable is expected to represent part of the amenities present in an area. The reason for insignificance may be that students do not have to necessarily live in the same district where their school is located. And thus, the presence of a school in an area would not affect the district's land value as much. This supports the findings of Punpuing and Ross (2001) who found that 43% of the people in Bangkok travel across districts to reach their work places and schools. Moreover, they have found that the choice of location for residences and workplaces are rather inelastic decisions.

6. Limitations

Before concluding this paper, the limitations present in the model must be elaborated.

Assessed land values vs. transaction price

The first limitation relates to the data of the dependent variable; assessed land value data. Even though yearly transaction data would have been ideal, the information is not available in far-stretched time period and is not consistent. Therefore, assessed land values from the Treasury Department are used. Although it bears some relationship with the market value, it is still a projection made in the beginning of the period and an expectation of future values.

District-level vs. Parcel-level data

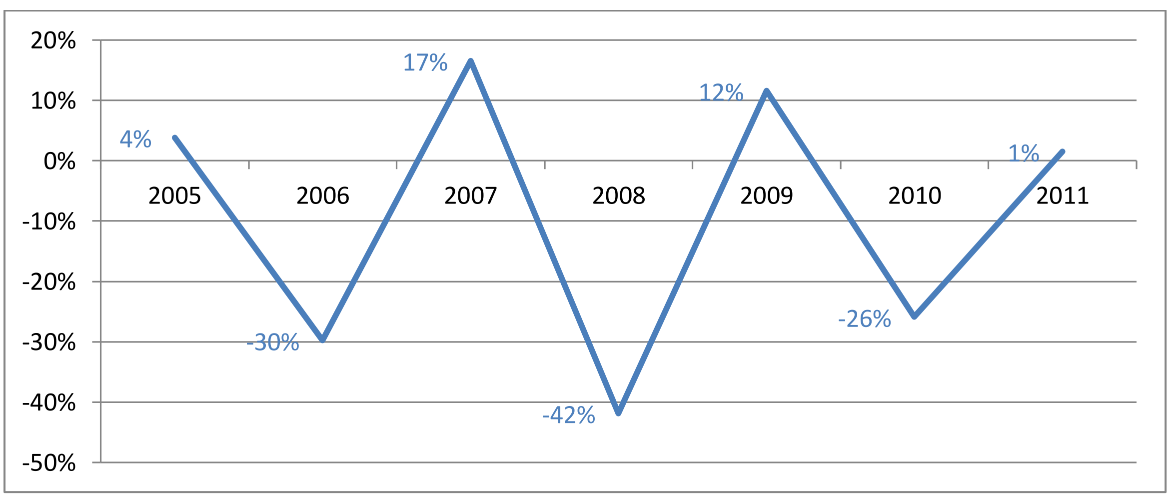
A limitation to the land value data is that only sub-district to district level data is available but not at the parcel level. Consequently, the transport accessibility variables came in the form of counts (number of stations) instead of distance to stations as commonly used in other studies (Bae et al., 2003; Hess and Almeida, 2007; Chalermpong, 2007; Chalermpong and Wattana, 2009; Vichiensan et al., 2001; Chatman et al., 2012; Malaitham, 2013). It was then impossible to quantify the effect as premiums with respect to change in distance but only in terms of 'presence of stations'. Therefore, this effect could have been quantified in a more detailed and meaningful representation. Other amenity variables such as student per square kilometre and department store coverage could have been coded as distance to schools or distance to department stores. When these variables are calculated with respect to distance to a land parcel, the study could then adopt spatial regression models common in recent studies of urban rail transit impacts (Chalermpong, 2007; Chalermpong and Wattana, 2009; Vichiensan and Miyamoto, 2010; Vichiensan et al, 2011; Chatman et al., 2012; Malaitham, 2013). The spatial dimension is important since the effects of urban rail transit on land values is proven by many studies to diminish as distance increases.

Moreover, the specific characteristics of the land parcel or property could not be controlled. With parcel-level data, aspects like the size of dwellings, age of properties, the number of bedrooms can be taken into account. In addition, the generalization of sub-district level land values to 'per district' averages was made arithmetically (the number of sub-district prices divided by the number of sub-districts within an area). A weighted-average would have increased the accuracy of results because each sub-district also is different in terms of size and population. But unfortunately, these data at sub-district level was not available.

4-year averages

One limitation to this data is that they came in 4-year averages. This may have caused the effects of station announcements, construction and operation to be misled. For example, the BTS Sky trains started its operations in 1999 but the effects are counted within the 1996-1999 period. If yearly data was available, the accuracy of results could be better. Moreover, the income per capita growth has many extreme values when transformed to its 4-year average. For example, if the yearly growth rate is considered as seen in Figure 5, Chatuchak had seen both growth and decline during the year 2005-2011. But once the 4-year average is calculated, the overall growth rate is -48%. If the yearly movement could have been observed, the results may become less biased. This also applies for all the other variables.

Figure 5 Chatuchak district's income per capita growth for 2005-2011



Data inconsistency

Some inconsistencies also exist in the data. Firstly, the district-level data of the type of communities used to construct the low-grade community ratio. Originally, there are 5 types of communities as defined by the Bangkok Metropolitan Administration (BMA), in 2013, however, a sixth group was added which affected the community type ratio. Secondly, the income per capita growth has many extreme values which may have also misled results.

Small sample size

Even though originally assessed land value data came with 104 observations (after transformed into 4-year averages), its control variables had some missing values in some periods. In the end, the model only took 69 observations to calculate the effects. This limitation discredits the reliability of the results greatly. If parcel-level data was available, there would be much more observations to work with.

Accessibility variables

Information about the transport accessibility per district is rather limited. For example, the number of bus stops or the number of taxi stops may have been include to take into account the whole connectivity of the transportation system. Chalermpong (2007) and Malaitham (2013) also proved the importance of the proximity to the main arterial roads on Bangkok's property values. Specifically, if parcel-level data is available, the distance to these accessibility points can also be included. Unfortunately, these data are not available.

7. Conclusion

In conclusion, there is some evidence to say that urban rail transit impacts are capitalized into land values within the Bangkok Metropolitan Region (BMR). Specifically, the realized impacts are reflected in the operation variables. If within the period of 4 years, one additional urban rail transit station opens up in a district, on average, the land values in that district will increase by 10.2% in the next 4 years. Or, if the coverage of operating stations within a district increases by 10%, on average, land values will increase by 9.26% (the same time frames as the previous interpretation is applied).

This study gave focus to the separate effects of announcement, construction, and operation of urban rail transit station – an area less touched in existing literature. The results from the study suggest the construction as an individual effect do not alter land values. The announcement effects are significant only in the third model although at the 10% level. Due to the small sample size and several data limitations, these effects should be re-examined for further study.

The impacts of many other factors are proven to be fairly surprising. One of the amenity variables, students per square kilometre, is not significant in any of the models but leaves perhaps a different measurement method for the presence of schools and school quality. The same goes for the income per capita which represents market conditions. For the neighbourhood characteristics, household density is significant and influences land values positively. However, population density is only significant in one of the models. The presence of department stores and household density are extremely significant in the models. Within a 4-year period, the increase in coverage of department stores in a district by 10% can increase average land values within 3.1% and 4.3%. As mentioned, the department stores have been a revolution in the retail industry of Eastern societies. Therefore, this particular amenity effect is worth extending for further research since it has not been explored in many studies. As mentioned, the department stores have been a revolution in the retail industry of Eastern societies.

Effort has been put in attempting to fill in the gaps from previous research by extending some control variables less explored, examining the separate effects of announcement, construction, and operation of rail transit stations. Moreover, the extends from only looking at cross-sectional data by observing long-term effects by observing variations over time through panel data. In all, the study should be able to create added value in research.

Bangkok remains a city still relatively inexperienced in alternative transport modes. In the upcoming decade, the city will likely oversee changes once the whole mass rapid transit system is completed. Studies relating to the impact of urban rail transit surely will provide a better overview for policymakers especially if such investments are able to generate some monetary value to the economy. Since there is some evidence that urban rail transit impacts are positive for the case of Bangkok, outcomes from this study can be referenced for land value capture policies to justify investments of this kind in the future.

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Appendix

1. The Breusch-Pagan LM test results for Model 1

Breusch and Pagan Lagrangian multiplier test for random effects

```
lnlandvalue[pid,t] = Xb + u[pid] + e[pid,t]

Estimated results:
```

	Var	sd = sqrt(Var)
lnlandv~e	.503262	.7094096
e	.0687924	.2622831
u	.107881	.3284524

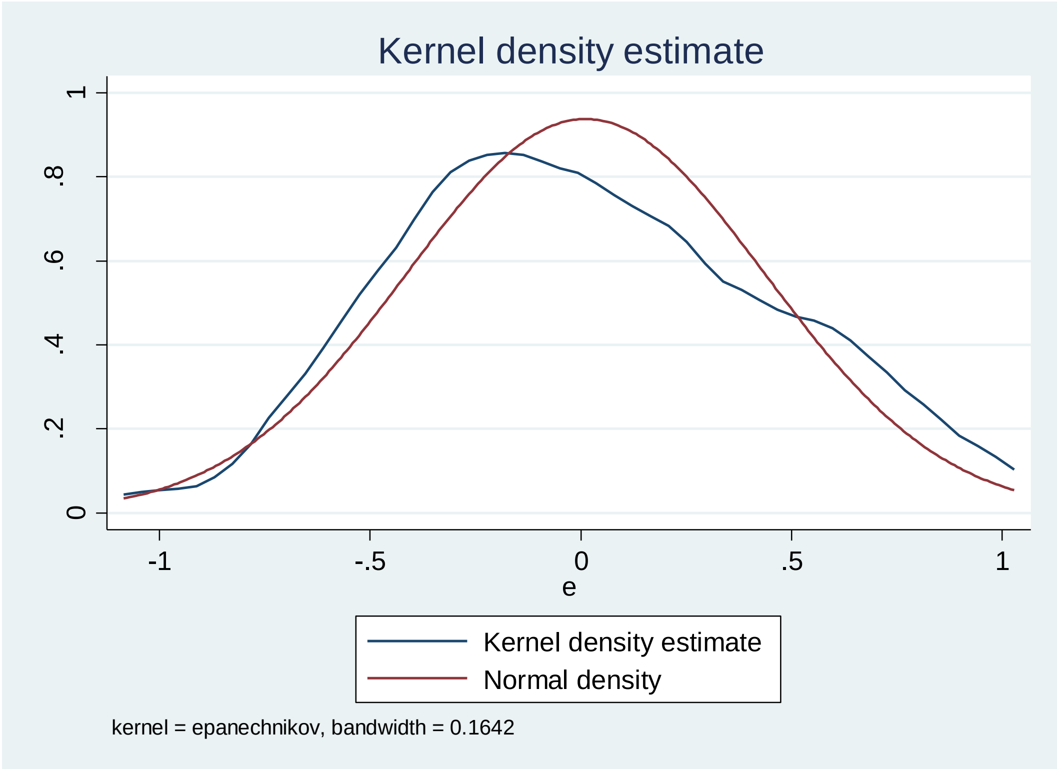
```
Test:   Var(u) = 0
                  chibar2(01) =    13.47
               Prob > chibar2 =   0.0001
```

2. The Hausman test results for Model 1

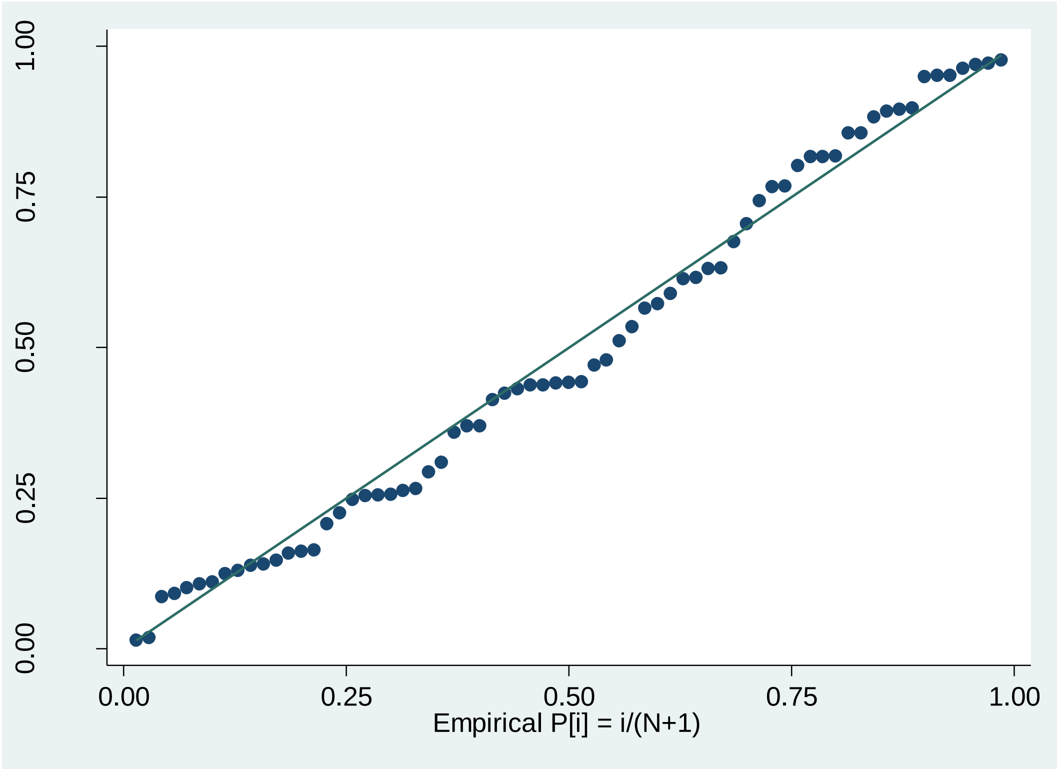
	Coefficients (b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
announceme~c	.0416173	.0576212	-.0160039	.
constructi~c	.0048528	-.0384692	.043322	.0134307
operation_c	-.0882634	.0615694	-.1498329	.0652258
lnincome	-.0363001	-.2759794	.2396793	.3221161
lnpop_dens	-2.565578	-.5686113	-1.996967	1.324486
lnhouse_dens	2.604567	1.311016	1.293552	.6411425
community	.0082564	-.4969713	.5052277	.4681447
lnstudent_~s	1.006974	.043228	.9637462	.6377107
deptstore_1	-.0901582	.4364929	-.5266511	.2441128

```
                          b = consistent under Ho and Ha; obtained from xtreg
           B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(9) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       11.69
                Prob>chi2 =      0.2315
                (V_b-V_B is not positive definite)
```

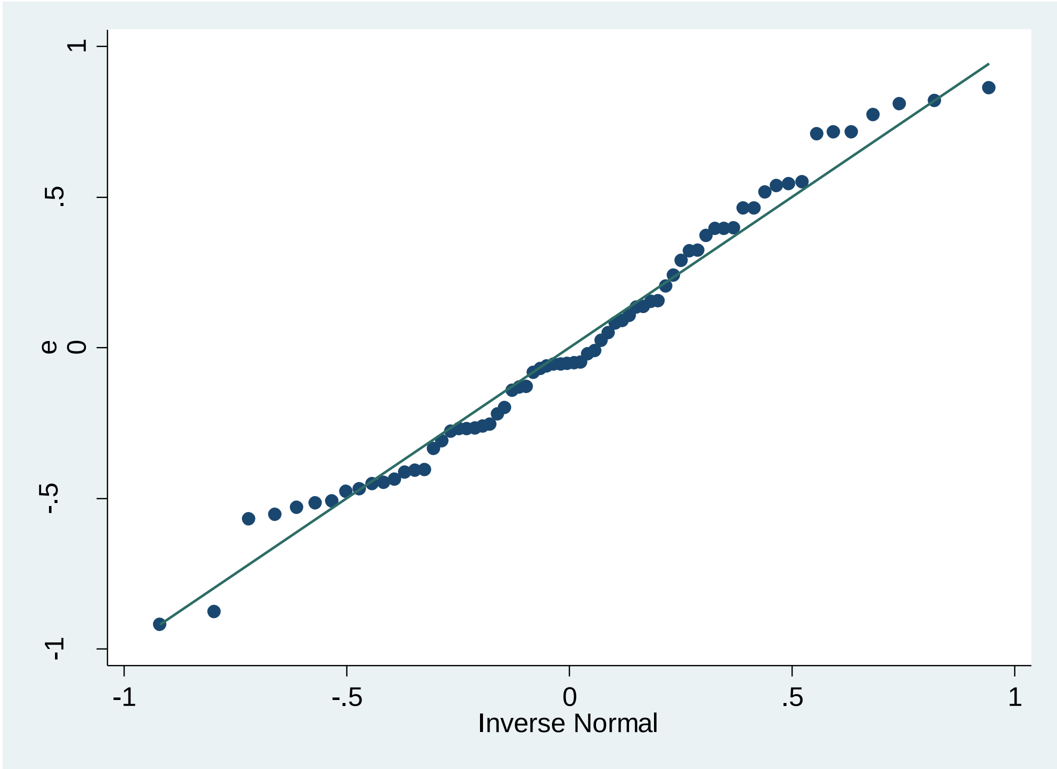
3. Kernel density estimates for Model 1



4. P-plot of residuals for Model 1



5. Q-plot of residuals for Model 1



6. Regression results for Model 1 (non-lagged number of stations)

```
Random-effects GLS regression                   Number of obs      =        69
Group variable: pid                             Number of groups   =        24

R-sq:  within  = 0.3704                         Obs per group: min =         1
       between = 0.6650                                        avg =       2.9
       overall = 0.5981                                        max =         3

                                                Wald chi2(9)       =     61.83
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000
```

lnlandvalue	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
announcement	.0572178	.042912	1.33	0.182	-.0268882	.1413238
construction	-.0392387	.0460744	-0.85	0.394	-.1295429	.0510655
operation	.0597265	.0490533	1.22	0.223	-.0364161	.1558691
lnincome	-.2849557	.3872718	-0.74	0.462	-1.043994	.474083
lnpop_dens	-.5629641	.3675539	-1.53	0.126	-1.283356	.1574282
lnhouse_dens	1.307967	.4554046	2.87	0.004	.4153901	2.200543
community	-.4926848	.3054184	-1.61	0.107	-1.091294	.1059242
lnstudent_dens	.0425438	.0941043	0.45	0.651	-.1418972	.2269847
deptstore_1	.4398855	.1948995	2.26	0.024	.0578896	.8218814
_cons	8.956903	5.83591	1.53	0.125	-2.481271	20.39508
sigma_u	.32845241					
sigma_e	.26228314					
rho	.6106237	(fraction of variance due to u_i)				

7. Regression results for Model 2 (lagged number of stations)

```
Random-effects GLS regression                   Number of obs      =        69
Group variable: pid                             Number of groups   =        24

R-sq:  within  = 0.4524                         Obs per group: min =         1
       between = 0.7338                                        avg =       2.9
       overall = 0.6744                                        max =         3

                                                Wald chi2(9)       =     81.82
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000
```

lnlandvalue	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
announcement						
L1.	-.0489854	.0528459	-0.93	0.354	-.1525616	.0545907
construction						
L1.	-.0351683	.0544371	-0.65	0.518	-.141863	.0715264
operation						
L1.	.102313	.0475525	2.15	0.031	.0091119	.1955141
lnincome	-.0873695	.363828	-0.24	0.810	-.8004592	.6257203
lnpop_dens	-.4546525	.3331973	-1.36	0.172	-1.107707	.1984021
lnhouse_dens	1.272498	.3975005	3.20	0.001	.4934116	2.051585
community	-.4576623	.2860427	-1.60	0.110	-1.018296	.1029711
lnstudent_dens	.0549059	.0850114	0.65	0.518	-.1117135	.2215253
deptstore_1	.3231448	.1849308	1.75	0.081	-.0393129	.6856025
_cons	5.887052	5.41631	1.09	0.277	-4.728721	16.50282
sigma_u	.33077329					
sigma_e	.25218396					
rho	.63240512	(fraction of variance due to u_i)				

.

8. Regression results for Model 3 (non-lagged station concentration)

```
Random-effects GLS regression                   Number of obs      =        69
Group variable: pid                             Number of groups   =        24

R-sq:  within  = 0.4089                         Obs per group: min =         1
       between = 0.6415                                        avg =       2.9
       overall = 0.5847                                        max =         3

                                                Wald chi2(9)       =     59.21
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000
```

lnlandvalue	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
c_announcement	.6727525	.3676356	1.83	0.067	-.0478	1.393305
c_construction	.0269932	.3911314	0.07	0.945	-.7396102	.7935966
c_operation	.6228472	.446195	1.40	0.163	-.2516789	1.497373
lnincome	-.1086283	.3600772	-0.30	0.763	-.8143666	.59711
lnpop_dens	-.7491685	.3642384	-2.06	0.040	-1.463063	-.0352744
lnhouse_dens	1.535113	.4542804	3.38	0.001	.6447402	2.425487
community	-.3685932	.3196904	-1.15	0.249	-.9951748	.2579884
lnstudent_dens	.0727459	.0997659	0.73	0.466	-.1227918	.2682836
deptstore_1	.3536824	.2092355	1.69	0.091	-.0564116	.7637765
_cons	6.443115	5.549445	1.16	0.246	-4.433598	17.31983
sigma_u	.41167647					
sigma_e	.26075828					
rho	.71367249	(fraction of variance due to u_i)				

9. Regression results for Model 4 (lagged station concentration)

```
Random-effects GLS regression                   Number of obs      =        69
Group variable: pid                             Number of groups   =        24

R-sq:  within  = 0.4215                         Obs per group: min =         1
       between = 0.7247                                        avg =       2.9
       overall = 0.6605                                        max =         3

                                                Wald chi2(9)       =     71.61
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000
```

lnlandvalue	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
c_announcement						
L1.	-.1533012	.44629	-0.34	0.731	-1.028013	.7214111
c_construction						
L1.	-.4502996	.4888823	-0.92	0.357	-1.408491	.5078921
c_operation						
L1.	.9375422	.4434586	2.11	0.035	.0683793	1.806705
lnincome	-.1505459	.3325702	-0.45	0.651	-.8023716	.5012798
lnpop_dens	-.449784	.3425505	-1.31	0.189	-1.121171	.2216027
lnhouse_dens	1.271214	.4166313	3.05	0.002	.4546314	2.087796
community	-.4091886	.2967698	-1.38	0.168	-.9908466	.1724695
lnstudent_dens	.0571766	.0889814	0.64	0.521	-.1172238	.231577
deptstore_1	.2563873	.2029283	1.26	0.206	-.1413447	.6541194
_cons	6.572148	5.09995	1.29	0.198	-3.423571	16.56787
sigma_u	.37120697					
sigma_e	.25724477					
rho	.67556486	(fraction of variance due to u_i)				

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