# Opportunities for value capture to fund public transport: A comprehensive review of the literature with a focus on East Asia

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## Executive Summary

A good public transport system is often one of the defining features of a city, attracting residents, businesses, and tourists. However, even in the case of the world's great public transport systems, fares do not fully cover costs. Substantial government subsidies are required to build, maintain, and operate most public transport systems. One of the challenges faced by cities is where this money should come from.

An often-discussed option is known as land value capture. Successful public transport systems lead to increasing land values. Value capture is the concept that government should be able to capture at least part of this increase in land value along public transport corridors, and use these funds to subsidize the system.

Our goal is to use findings from the existing literature to shed light on when and how value capture strategies could be used to finance public transport systems in East Asian cities. We review three related strands of literature: evidence of the land development impacts of public transport, estimates of land value increases attributable to public transport, and case studies of the use of value capture mechanisms to finance public transport. We then draw upon this literature review to identify specific recommendations for the implementation of value capture in a variety of contexts.

***Land development impacts of public transport***

All else equal, the more easily people and goods can access a given location, the more desirable that location is for both people to live and for businesses to locate. This added increment of location desirability should help to promote development in public transport station areas. However, empirical studies have found that public transport alone is not enough to spur significant land development in North American and European cities. The following five factors were found to contribute to the likelihood that a new public transport station will promote land development:

- the increment of accessibility offered by a new public transport station
- the overall rate of growth and demand for development in the city
- the relative ease of land assemblage in the station area
- zoning incentives and constraints in the station area
- the extent to which the station is integrated into the urban fabric

This leads directly to the following policy conclusion: ***If*** public transport investments are being made in a city, ***then*** city planners should make a concerted effort to ensure that as many as possible of these factors are going to support public transport. These efforts should substantially enhance the returns to the city on the public transport investment - both in terms of land value and public transport ridership.

The empirical literature on the development impact of public transport in East Asia is unequivocal in its main finding - major public transport investments absolutely impact land development in these cities. This is because the first two bullet points above usually support public transport in Asia. First, car use per capita in East Asia is a fraction of that in North American and European cities, and public transport dependence is thus substantially higher. A new public transport station in Asia, therefore, offers a larger increase in accessibility than one in North America or Europe. Second, many East Asian cities are experiencing extraordinarily rapid growth, allowing that growth to be channeled along public transport corridors.

Despite the relative success of East Asian public transport in promoting development, there remains room for improvement - especially in the area of coordinating policies and actions between the city government and the public transport authority. Thus, the main policy conclusion above remains relevant for East Asia.

***Land value increases attributable to public transport***

The increase in value attributable to public transport is a function of the type of service (e.g. bus, rail, BRT), the distance from the property to the system, the quality of the service, and transportation alternatives in the area. Most studies of the land value impact of public transport look at only one type of service and focus on the distance between the property and the nearest station as the main variable of interest.

In the North American and European context, the impact of public transport on land values is usually found to be positive, with the magnitude of this effect influenced by the presence of complementary policies to encourage coordinated land use or to discourage car use. Rail systems have been found to have a much larger effect on land values than bus routes. Investigation of the effect of Bus Rapid Transit (BRT) systems on land value is an emerging area for research. In the East Asian context, the estimated magnitude of this effect is remarkably consistent across cities and studies - a 10 percent increase in distance from a public transport station reduces property values by roughly 1 percent. It is encouraging that these findings are broadly consistent with those regarding the impact of public transport on land development.

***Use of value capture mechanisms to finance public transport***

There are two prerequisites to being able to finance a public transport system using value capture. First, the system must actually generate sufficient value to be captured. Second, the institutional context must enable the local government or the public transport authority to capture this generated value.

In cities with established land or property tax systems, value capture through these taxes is an attractive and administratively simple way to finance public transport. However, many East Asian cities do not have such tax systems in place, and need to rely on other mechanisms to capture the land value generated by public transport investments. One prominent alternative to taxation is to lease or sell land near public transport or to grant development rights in areas served by public transport. However, this is only possible when the government owns land or can buy land at pre-development prices. Another alternative is to use a public-private partnership model to finance public transport. This approach has been successfully implemented where the city can act as a competent business partner to the private sector.

Three premier examples of the successful use of value capture to finance public transport are in East Asian cities: Hong Kong, Singapore, and Tokyo. Each of these cities has used a different set of value capture strategies - Hong Kong has primarily used land sales and leases, Singapore has used strong land use policy, and Tokyo has used privatization of transport service and joint development. Many other cities in the region - particularly in mainland China - look to these cities as models for public transport finance.

***Recommendations for future research***

Based on our review of these three strands of literature, we find that there are three main areas in need of additional study:

1. The findings from the land development literature have not been adequately integrated into most of the empirical studies of the impact of public transport on land value. Incorporating more of the factors that influence land development into these studies should lead to improved estimates of the land value increases that can be expected from public transport in different policy contexts.
2. Studies that estimate land value increases from public transport usually do not include a calculation of the total value generated, and often do not provide enough information so that a reader could perform this calculation. This link is key because it indicates the potential of value capture strategies to finance public transport, and needs to be made more explicit so that cities can use the results of these studies to implement value capture strategies.
3. More studies of the impact of BRT on development and land value are needed.

***Recommendations for value capture implementation***

Value capture can fund public transport systems in cities that can coordinate land use, economic development, and public transport planning such that substantial private value is generated from the public investment.

The best strategies for implementing value capture policies are not the same everywhere. They depend on the particulars of the city's institutional capabilities, as well as the general health of the local economy and the local land development industry. It is also important to note that strategies can often be used in tandem with one another. The value capture mechanism that works best for each city will depend on:

1. The government’s authority to track the value of land and to levy land taxes: Cities that have this authority can consider implementing tax-based value capture strategies, though this may be politically challenging.

2. The government’s ability to assemble and acquire land at a favorable price: Cities that can do this effectively can consider implementing value capture strategies that rely on land sales or leases.
3. The government’s capacity to act as a savvy business partner in land development: Cities that have this capacity can consider using joint development, commercial leasing, and other innovative business mechanisms to capture increases in land value from public transport.

## 1. Introduction

Public transport is viewed by city governments around the world as a top development priority. A good public transport system is often one of the defining features of a city, attracting residents, businesses, and tourists. However, public transport systems are expensive, and it is neither equitable nor feasible for farebox revenues to fully cover system costs. As a result, substantial government subsidies are required to build, maintain, and operate most public transport systems.

One of the challenges faced by cities and their public transport authorities is where this money should come from. Many observers have noted that successful public transport systems lead to increasing land values, which yield windfall profits for people who happen to own land along these corridors. Value capture is the concept that government should be able to capture at least part of this increase in land value along public transport corridors, and use these funds to help pay for the system. While the concept is not new, it has only been successful at raising significant funds for public transport systems in a handful of cases.

The goal of this paper is to use findings from the existing literature to highlight conditions under which value capture could and should be used to finance public transport systems in East Asian cities. First we review the existing literature on public transport's impact on development and on property values to understand the potential for public transport systems to influence land use and land values in a city. We review case studies both inside and outside of Asia, and discuss some of the pros and cons of the methodologies used in previous studies. In the third section, we describe the theory of value capture, the methods of value capture, and review case studies of where value capture has and has not been successful. In the final section, we use the main lessons from all of this literature to draw conclusions about which methods of value capture would be most likely to succeed in the Asian urban context and which complementary factors need to be in place to enhance the likelihood of success. We also identify important questions that the existing literature has not fully answered, pointing the way for future research in this area.

## 2. Evidence on the development impacts of public transport infrastructure

History tells us that transport infrastructure shapes land use across the globe. Where there are no roads, rails, or waterways, cities simply do not grow. However, the extent to which incremental changes in transportation infrastructure can materially shape urban growth is substantially less clear. Introducing a new road into an already-urbanized area may or may not have a measurable effect. The effect of introducing a new public transport line is similarly unclear.

In this section, we first briefly review the theoretical relationship between transport infrastructure and urban growth. We then summarize the main findings from the literature on the specific relationship between public transport investment and urban growth - both physical growth through land use change and economic growth through increases in local GDP.

## 2.1 Theoretical relationships

The hypothesis that even incremental changes in transport infrastructure may encourage both land development and economic growth stems from the concept of the "accessibility" of locations. The more easily people and goods can access a given location, the more desirable that location is for both people to live and for businesses to locate. This added increment of location desirability should lead to development in public transport station areas - both physical land development and redevelopment as well as economic development.

Adding public transport access to an area undeniably increases that location's accessibility by some amount. However, all public transport is not equal, and these changes in accessibility are not felt equally by all potential users of the system. Most notably, those who do not own cars experience a sharp increase in accessibility with added public transport service, while car owners experience a far more subtle change. This is a crucial difference between the existing conditions in North American/European cities and those in most Asian cities, and is one reason to expect that the development impact of public transport will be greater in Asia than it has been in the recent history of North America and Europe.

## 2.2 Findings from the empirical literature

It is almost impossible to identify the "pure" effect of public transport on land or economic development. There are two main reasons for this. First, new public transport investments are often accompanied by complementary land use policies - such as changes in station-area zoning - that specifically target land development. Second, we expect the impact of public transport on land development to be a medium- to long-term effect for the simple reason that land development is a medium- to long-term endeavor. However, over a period of multiple years or even decades, a multitude of other factors will also change in any given location. Isolating the effect of a particular public transport investment on development, therefore, requires controlling for both local land use policy changes and for all other changes to the development environment that occur over the medium- to long-term. It is for this reason that the literature focusing on the effect of public transport on land development usually takes a case study approach to the question, relying primarily on qualitative research methods.

The main lesson from the empirical literature on this topic is a strong consensus that public transport alone is not enough to spur significant land development. Public transport may be one factor in promoting development, but a number of other factors must also be present (Knight and Trygg 1977, Huang 1996, Cervero and Landis 1997, Gospodini 2005, Cervero 2009). Some of these additional factors pertain to conditions at the station locations, and others are conditions that must be present in the region served by the public transport. These factors have been identified to be the following:

*Increment of accessibility offered by a new public transport station:*
The increment of accessibility is some measure of an area's increase in accessibility due to the new station for the average resident, worker, or visitor to the area. This will depend on the physical extent of the new public transport system, the percentage of "captive" riders living or working in the vicinity of the station, and the level of congestion on existing transport systems serving the station area. The greater the increase in accessibility caused by a new station, the greater the impact of that station will be on land and economic development in the station area.

*Overall rate of growth and demand for development in the city:*
Land and economic development depend on growth. Public infrastructure investments serve mainly to channel that growth to certain neighborhoods or industries in an urban environment. In a rapidly growing city, then, the impact of a new public transport system on land and economic development is likely to be greater than it would be in a city that is not growing.

*Relative ease of land assemblage in the station area:*
Land development is easier to plan and more profitable for developers on large land parcels. Downtown public transport station areas may be already fully developed, with each land owner holding only a small parcel of land. This makes it difficult to assemble the large land parcels needed for substantial redevelopment of a station area. Land development in the vicinity of stations located in the urban periphery may not present this challenge. Therefore, suburban stations may have a larger effect on land development than downtown stations.

*Zoning incentives and constraints:*
Land use policies that are complementary to public transport station-area development can increase the effect of new stations on land development. These policies can include marketing of air rights above stations, increasing allowable floor area ratios for development in station areas, offering density bonuses and increasing allowable densities in station areas, or providing incentives for physical integration of the station with surrounding new development - via direct station access from offices and apartment buildings.

*Physical characteristics of the station area:*
Public transport stations that are integrated into the urban fabric, with convenient pedestrian and bicycle access, as well as car parking (where appropriate) will have a larger effect on land development than those that are placed in less central and conveniently accessed locations (e.g. expressway medians or former freight rail right-of-way).

This lesson leads directly to the following policy conclusion: ***If*** public transport investments are being made in a city, ***then*** city planners should make a concerted effort to ensure that as many as possible of the above factors are going to support public transport. These efforts should substantially enhance the returns to the city on the public transport investment - both in terms of land value and public transport ridership (Huang 1996, Cervero and Landis 1997). Policy packages that are called "Transit-Oriented Development" (TOD) generally include a subset of these complementary land use policies.

The remainder of this section will review selected case studies of specific cities and public transport systems, first from North America and Europe, and then from Asia.

**2.3 Studies of North American and European cities and their public transport systems**
Knight and Trygg (1977) looked at selected cities in North America in an early attempt to identify the land use impacts of public transport systems. Their work is largely qualitative, drawing on existing studies as well as on their own observations. The focus is on rail systems in San Francisco, Toronto, and Philadelphia, though Knight and Trygg also draw comparisons with public transport systems in Washington D.C., Chicago, New York, and Cleveland.

This paper effectively framed the subsequent literature on the relationship between public transport investment and urban development by identifying six key research questions, and providing preliminary answers to each of them. Here, we summarize Knight and Trygg's findings by highlighting each of their key questions, their answers, and providing a brief update on subsequent research findings where applicable.

*Q1: Can an urban public transport system promote overall economic or population growth?*
A1: The simple answer given here is "no", at least in the North American context. This result has been confirmed many times since 1977, and is now commonly held to be true.

*Q2: Can an urban public transport system increase densities and/or focus development along certain corridors in a city?*
A2: Yes, public transport systems can help to spatially "channel" growth, even though overall metropolitan growth is unaffected. The extent to which this happens - and if it happens at all - depends on many other factors (see next question).

*Q3: Which aspects of a public transport system's physical setting and land use policies in the area affect its impact on development?*
A3: Knight and Trygg identify four categories of factors that influence public transport's impact on development: local land use policies, regional development trends, availability of land for development, and physical characteristics of the station-areas. For public transport to substantially affect land use, they conclude that all four of these factors must be aligned.

*Q4: Do different public transport technologies have different impacts on development?*

A4: As of 1977, no studies had been conducted of the development impacts of public transport technologies other than heavy rail. Although researchers have since begun to ask this question, a clear answer has yet to emerge from the literature. This is likely due to the fact that the development impacts of all kinds of public transport are highly dependent on numerous other factors. Since these other factors are different for every case, it becomes virtually impossible to clearly identify the "pure" effect of public transport - never mind compare across cities and public transport systems to arrive at a robust estimate of how different public transport technologies (i.e. urban heavy rail, commuter rail, light rail, or busway) impact development differently.

*Q5: Do urban public transport systems promote CBD growth or suburban growth?*

A5: Through 1977, the evidence on this mainly supported CBD growth, if any growth was seen at all.

Q6: How quickly can we expect to see development impacts of public transport?

A6: Evidence suggested that the development impacts of public transport take several years to become measureable, although in one case there was evidence of an anticipatory effect of public transport service on local development.

Since 1977, substantial additional research has been conducted in this area. Huang's 1996 literature review effectively updated Knight and Trygg's work, incorporating the results of many of these additional studies, but coming to many of the same conclusions. Huang's review adds new findings to the question of whether different public transport technologies have different development effects. Looking at studies of light rail systems in Calgary, Edmonton, Portland, and San Diego, Huang concludes that the development impacts of light rail hinge on the same factors that Knight and Trygg identified for heavy rail systems: regional growth pressure, complementary local land use policies, and station locations that are suitable for development. Since almost all studies of the development impact of public transport are qualitative, Huang was unable to draw any quantitative conclusions about differences in development impacts between light and heavy rail.

Cervero and Landis (1997) looked carefully at the impact of the BART system on population, employment, and land uses in the San Francisco Bay Area. The BART system opened in 1973 with 72 miles of heavy rail in an octopus-like pattern to serve the Bay Area. Despite extremely high car ownership levels, the Bay Area is well-suited to public transport for basic geographical reasons. The city of San Francisco itself is situated at the tip of a peninsula, surrounded on three sides by the San Francisco Bay. This means two things. One, the city is densely developed (due to lack of land, rather than due to land development policy) and easy to serve by public transport. Two, there are a limited number of bridges across the San Francisco Bay to the city center, causing frequent and sometimes severe traffic congestion and delay for car commuters. The BART trains offer a different route across the Bay - one that is not impacted by vehicle traffic and is therefore more reliable than the bridges in terms of timing.

Despite this promising setting for public transport to impact land development, Cervero and Landis (1997) found that the BART system had only a modest effect, even 20 years after the system opened. The reasons for this are many, but chief among them is the fact that the BART system extends regionwide, but land use control is in the hands of the myriad of small local communities that it serves. Some of these communities have purposely worked to densify and mix land uses in station areas to maximize the benefit of the system. Other communities have actually taken the opposite approach, prohibiting densification for fear of attracting lower income residents.

Gospodini (2005) conducted a study of 12 European cities, coming to similar overall conclusions as those that have already been summarized here - public transport investments can lead to land development and redevelopment, but whether or not they actually do so is determined by a large number of other factors that are not necessarily related to the public transport investment.

These explorations of the land use impacts of North American and European public transport systems are only partly relevant for the Asian context. The reason for this is twofold. First, car ownership levels in both North America and Europe are higher than those in most of Asia, so most public transport riders are “choice” riders rather than “captive” riders. In the Asian urban context, this level of car ownership is practically unheard of. Second, many Asian cities are rapidly-growing urban areas, while most cities in Europe and North America are growing only slowly. This creates an opportunity in Asia to channel the large amount of urban growth that is happening toward corridors served by public transport.

### 2.4 Findings from the empirical literature on Asian cities

In contrast to the studies reviewed earlier, the empirical literature on the development impact of public transport in Asia is unequivocal in its main finding - major public transport investments absolutely impact land development in Asian cities. However, there are only a handful of English-language studies written on development impacts of public transport in Asia. The three studies we focus on here are recent analyses of the land development impacts of public transport in Shanghai, Beijing, Hong Kong, and Taipei.

Pan and Zhang (2008) assert, “In Shanghai, rail is a magnet that attracts new development … The rail system is therefore shaping urban expansion and restructuring Shanghai.” (p 16) There are two main explanations for these divergent findings. First, Asian cities - especially Chinese cities like Shanghai - are experiencing extraordinarily rapid growth. Second, existing roadway infrastructure and car use per capita in Asian cities are a fraction of the levels seen in North American and European cities, and public transport use is thus substantially higher in Asia. Taken together, these two key differences between many Asian cities and those in North America and Europe mean that public transport infrastructure built today in Asia is more likely to channel metropolitan growth along its corridors.

Another difference we see is in methodological approaches to the research question. Unlike the studies we review from North America and Europe, two of the papers we review here use a quantitative framework to estimate the impact of public transport on development (Gu and Zheng 2008, Pan and Zhang 2008). The variable used in both studies to quantify land development is floor area ratio (FAR), defined as the ratio of the total built floor area to the land parcel area. FAR is a commonly used measure of building density, and is one of the factors that is directly regulated through zoning law. Looking at land use around Shanghai's rail stations, Pan and Zhang find that the area in an inner ring around stations has a higher percentage of non-residential land uses compared to an outer ring around stations. They also find weak evidence that the average FAR is higher closer to stations than farther away.

One of the lines studied by Pan and Zhang was developed along the right-of-way of an existing freight rail track. They find that the impact of this line on station-area land use is substantially less than that of the other two lines in their study, mostly because the line is flanked by warehousing and industrial uses that have yet to be redeveloped. This is consistent with findings from North American and European public transport systems. The difference in Shanghai, however, is that because the city is growing rapidly, Pan and Zhang are confident that this area will be redeveloped in the near future to take better advantage of the new passenger rail service.

Gu and Zheng (2008) focus their analysis on the No. 13 rail line in Beijing. They find that the effect of public transport on FAR and land values is different in different types of neighborhoods along the line. Specifically, they segment the line into three neighborhoods, two of which are close to Beijing's CBD, and one of which is a suburban area. Residential development in the suburban area along the No. 13 line is more spatially correlated with the rail stations than is development in the urban area along the line. Although their estimates are based on a small number of parcel-level observations, they find that along the suburban segment of the line, the FAR of new housing projects decreases by 1.0 for every 3.3 kilometers of distance from a station. Along the urban segment of the line, there was not a statistically significant effect.

This methodological difference between the two studies conducted in China and all of those conducted in Europe and North America raises the question of under what conditions a quantitative approach to this research question makes sense. One key assumption necessary to employ this sort of quantitative modeling of the relationship between public transport amenities and land development is that land development is mainly a product of market forces and is not greatly impacted by local land use policies.

In North American and European cities (as well as many other cities in Asia, such as Taipei, Taiwan), land use is regulated through zoning laws that apply to groups of parcels at a time. Thus, the same zoning classification is likely to be imposed on all parcels in a given public transport station area. Often local governments will changes the zoning classification for an area in order to better coordinate land use with a public transport investment. In this case, it is not reasonable to use a quantitative approach to estimate changes in land use characteristics that were induced by the presence of a new station. Any observed changes are as likely to be the result of the change in land use laws as the introduction of the station, and it is impossible to distinguish between these through quantitative analysis.

Despite being characterized by intensive government control of land use, it is plausible that land development in Chinese cities is more accurately represented by market forces than is land development in European and North American cities. In mainland China, urban land is state-owned and leased to developers for long periods (generally 50-99 years, depending on the land use). Land use characteristics such as FAR are regulated on a parcel-by-parcel basis through direct negotiation between the developer and the local government (Gu and Zheng 2008). Although that negotiation is likely to be influenced by the presence of a public transport station, bargaining on each parcel is more likely to lead to an outcome that approaches what might occur under a scenario of purely market-based land development.

Zhang (2007) looks at opportunities for transit-oriented development (TOD) in the Chinese urban context. He finds that although many public transport corridors in China are already meeting many of the Western objectives of TOD such as high station-area development density and ridership levels, important opportunities for improvement remain. Most importantly, Zhang is concerned that in most cases, public transport is not purposefully integrated with urban land development in mainland China. This lack of land use-public transport system coordination has not yet had disastrous effects in most places because the strong overall economic growth experienced by urban China to date has naturally channeled enough development toward public transport corridors that the systems are considered successful.

However, Zhang asserts that urban China has already paid a price for neglecting to coordinate public transport with land use planning. For instance, Zhang cites specific examples from Beijing in which public transport investments could be used more efficiently and particular station areas could be substantially safer with better land use planning. He then provides specific suggestions for implementation of a version of TOD that is appropriate for the Chinese context. Importantly, Zhang highlights using a value capture approach to help finance Chinese public transport systems.

## 3. Evidence of the effect of public transport systems on land value

Since public transport increases accessibility, willingness to pay for nearby properties should increase as well. Land rent theory predicts that land prices decrease with distance (and hence travel cost) from the central business district (Alonso 1964, Muth 1969). Transportation technologies such as highways, rail, bus, and metro stations that connect to the central business district and other parts of town can reduce the effective distance between areas and increase property values. The increase in value attributable to new transportation infrastructure should be a function of the type of service (bus, rail, highway), the distance of the property to the new infrastructure, the quality of the service, and transportation alternatives. In this section we review the existing literature estimating the price premium attributable to BRT and other urban mass transportation systems in developed and developing city contexts.

**3.1 Empirical estimation methodologies**

Studies on the impact of transportation infrastructure on land values use a variety of methods. The empirical strategies exploit temporal variation (how properties were values before after an improvement), cross-sectional variation (how much of a premium do properties near public transport sell for), or both. Researchers from different disciplines give different names to empirical strategies, but most strategies are based on quasi-experimental designs such as:

- Before/after study designs
- Control region comparisons
- Hedonic regression (cross-sectional)
- Hedonic regression with fixed effects (cross-sectional or panel)
- Propensity score matching
- Spatial Regression

Additionally, studies vary in the number of robustness checks, control variables, and data sources.

***3.1.1 Before/After Study Designs, Control Region Comparisons and Difference in Difference Models***

Before/after study designs, in their simplest form, compare land values before a transportation improvement to land values after a transportation improvement. In this case we refer to the transportation improvement as a 'treatment'. Using a linear model, we can write the regression:

$$P_{it} = \alpha + \beta D_t + \varepsilon_{it} \qquad i = 1, \ldots N \;\; t = 0,1$$

where: $P_{it}$ is the price of parcel *i* at time *t,*

$D_t$ is a dummy variable that equals zero before the treatment and one after the treatment,

$\alpha$ is a constant, and

$\varepsilon_{it}$ is an idiosyncratic error term.

The parameter we are interested in is $\beta$, the impact of the treatment (the transportation improvement) on property values. For identification of $\beta$, we require the strong assumption that the group remains comparable before and after the treatment; that $\alpha$

does not change. Often this is not the case with property values. The appreciation of land values over time confounds the impact of the treatment, as well as any other trends the city may be experiencing. For this reason, researchers may compare the change in property values in the treated region to an untreated control region for a differences-in-differences approach. Following Cameron and Trivedi (2005), we can write the new regression as:

$$P_{it}^{j} = \alpha + \alpha_1 D_t + \alpha^1 D^j + \beta D_t^j + \varepsilon_{it}^{j} \quad i = 1, \ldots N \;\; t = 0,1 \;\; j = 0,1$$

Here, *j* is the group subscript and $D_t$ is as defined previously. The dummy variable $D^j$ equals one if the parcel is in the treated group, and zero otherwise. The third dummy variable is $D_t^j$ which equals one if and only if the parcel is both in the treated group and the time period is after the intervention. The price of land in the treated areas of the city, before the treatment, can be written as:

$$P_{i0}^{1} = \alpha + \alpha^1 + \varepsilon_{i0}^{1}$$

since $D_0 = 0, D_0^1 = 1$ and $D^1=1$. The price of land in the treated areas of the city after the treatment is:

$$P_{i1}^{1} = \alpha + \alpha_1 + \alpha^1 + \beta + \varepsilon_{i1}^{1}.$$

Thus we can write the change over time in the price of land for the treated as:

$$\Delta P_i^1 = P_{i1}^1 - P_{i0}^1 = \alpha_1 + \beta + \varepsilon_{i1}^1 - \varepsilon_{i0}^1.$$

This change is comprised of a time trend $\alpha_1$, the impact of the treatment, $\beta$, and the change in the unobserved error terms. We can write the price of land in the untreated group before the intervention as:

$$P_{i0}^{0} = \alpha + \varepsilon_{i0}^{0}.$$

After the intervention, the price of land in the untreated group is:

$$P_{i1}^{0} = \alpha + \alpha_1 + \varepsilon_{i1}^{0}.$$

The change in land value for the untreated group over time is:

$$\Delta P_i^0 = P_{i1}^0 - P_{i0}^0 = \alpha_1 + \varepsilon_{i1}^0 - \varepsilon_{i0}^0.$$

Both first differences contain the time trend $\alpha_1$, and hence by subtracting $\Delta P_i^0$ from $\Delta P_i^1$ ,we find*:*

$$\Delta P_i^1 - \Delta P_i^0 = \beta + (\varepsilon_{i1}^1 - \varepsilon_{i0}^1) - (\varepsilon_{i1}^0 - \varepsilon_{i0}^0)$$

Assuming that $E\left[(\varepsilon_{i1}^1 - \varepsilon_{i0}^1) - (\varepsilon_{i1}^0 - \varepsilon_{i0}^0)\right] = 0$, we can use the sample average $\Delta P_i^1 - \Delta P_i^0$ as an unbiased estimate for $\beta$. This method assumes that the treated and control regions are comparable in everything but the treatment. However, if the control region experiences a negative shock, comparisons between the treated and control will lead to an inflated estimate of the effects of the treatment. Similarly, a positive shock to the control region could lead to a downwardly biased estimate of land value appreciation due to the transportation infrastructure. Thus, a differences-in-differences estimate may be sensitive to the choice of the control region. Two ways to mitigate this impact are 1) to compare the trajectory of land values in the treated area to the trajectory of land values in the city as a whole, or 2) try to control for observable changes by putting those variables directly into the regression. If managers are expecting a particular region to expand and choose to place stations there to serve future demand, then estimates of the effect of public transport on property values in this area could be biased. In this case the researcher would need to instrument for public transport locations, but most studies do not deal with the potential endogeneity.

#### *3.1.2 Hedonic Regression*

If panel data is unavailable, researchers can control for observable differences between treated and untreated areas using a hedonic model. This method is valid to the extent that the researcher has controlled for the relevant determinants of housing price and to the extent that parameters are uniform across properties. Hedonic regression allows the researcher to decompose a good into characteristics and estimate the contributory value of each characteristic (Rosen 1974):

$$P_i^j = \alpha + x_i'\delta + \beta D^j + \varepsilon_i^j$$

Here, $x_i$ is a vector of observable neighborhood and parcel level characteristics such as building age, lot size, location aspects such as distance to CBD, environmental aspects such as air and noise pollution, urban amenities such as parks and shopping, school districts, crime, transportation facilities, and city characteristics. The dummy variable $D^j$ indicates whether or not a parcel is in the treated area, which means yet again that $\beta$ is the policy parameter that measures the property value impact of the transportation improvement. Some studies model the transportation improvement not as a zero/one intervention, but instead estimate how much property values change with distance from the transportation improvement. In this case, $D^j$ would be the measure of distance rather than a dummy variable. In either case, hedonic models can be combined with panel models.

#### *3.1.3 Fixed Effects/Repeat Sales Models*

When panel data is available, time-invariant but unobservable neighborhood or parcel effects can be controlled for by using a fixed effects model. A fixed effects model simply assumes that there are unobservable individual- or neighborhood-specific attributes that contribute to price. These are modeled by making $\alpha$ vary across observations, $\alpha_i$:

$$P_{it}^{j} = \alpha_i + x_{it}'\delta + \beta D_t^j + \varepsilon_{it}^j.$$

The fixed effect, $\alpha_i$, can be on the individual parcel level or a neighborhood level. Differencing between time periods allows the fixed effect to be removed while still allowing for estimation of the time-variant parameters such as $\beta$, the impact of the treatment.

Using a fixed effects model requires panel data, although the organization of the panel allows for some flexibility. A panel composed of multiple observations of individual parcels is the most restrictive panel, and is referred to as a repeat sales model. In this case the researcher can compare the difference in appreciation between properties within and outside of the treatment area. This requires a lot of data, and an active real estate market to generate enough repeat sales. Other researchers (Chalermpong 2007, Gibbons and Machin 2005) have constructed panels with the unit of observation sales in the neighborhood, using $\alpha_i$ to capture neighborhood specific attributes.

#### *3.1.4 Propensity Score Matching*

Propensity Score Matching is another quasi-experimental technique that exploits some of the same variation as the hedonic model and has been used to study the impact of public transport on property values. Simply comparing the price of parcels with and without public transport access would lead to a biased estimate of the impact of access because of covariates correlated with both the property value and public transport access. Ideally, parcels with the same set of covariates could be compared across public transport statuses to estimate the impact. Implementing this would be next to impossible because of dimensionality problems, so propensity score matching is used. Parcel characteristics are used to estimate how similar they are (the propensity score). Often this is done with a logistic regression with the dependent variable being the probability of being near public transport. Next, the price of parcels with similar propensity scores but different levels of public transport access are compared to estimate the impact of public transport (Dehejia and Wahba 2002). It is essential that the propensity score reflects only pre-determined variables, those that have not been influenced by the arrival of public transport.

#### *3.1.5 Spatial Dependence*

A researcher may be worried about spatial dependence. Spatial dependence can take the form of spatial autoregressive lags and spatial error dependence (Anselin 2006). If spatial dependence is an underlying feature of the data, using OLS will result in biased or inefficient estimates. Not all studies have enough data to control for spatial aspects, but only a subset of those reviewed for this report even acknowledge the possibility of spatial associations between neighboring property prices. This is curious omission since the very nature of the research of the impact of public transport on nearby property values assumes a spatial structure.

In spatial autocorrelation models, the price of parcel *i*, may be a function of characteristics of the parcel and the price of neighboring parcels *j=1,…J*:

$$P_{it} = \rho \sum_{k=1}^{K} w_{ik}^{1} P_{kt} + x_{it}'\delta + \varepsilon_{it}$$

Here $w_{ij}$ describes the interaction between parcels, while $\rho$ is the autoregressive coefficient. The spatial weights can be specified using inverse distances or accessibility measures. We have suppressed the fixed effects and difference-in-difference regressors for simplicity. If the data are spatially correlated in this way, but spatial weights are not employed in estimation, OLS estimates will be biased. Anselin (2006) describes various diagnostic techniques to test for spatial autocorrelation.

Another concern is that the error terms might be correlated spatially, and that the spatial weighting procedure identified above may not fully correct this. In this case, instead of (or in addition to) using spatial weights explicitly in the model of price, spatial weights become part of the error term:

$$P_{it} = x_{it}^{'}\delta + \varepsilon_{it}$$
$$\varepsilon_{it} = \lambda \sum_{k=1}^{K} w_{ik}^{2} \varepsilon_{kt} + \xi$$

where $\lambda$ is the autoregressive component and $\xi$ is a white noise component. Using OLS instead of a spatial error model will result in unbiased but inefficient parameter estimates (i.e. the standard errors will be incorrect). In this case, estimation should be based on a maximum likelihood or generalized method of moments approach.

Incorporating spatial structure into a model does not necessarily require more data than estimating the impact of public transport since researchers are often already using GIS-based tools to obtain variables such as distance to public transport or distance to the CBD. Ignoring spatial structure is itself an assumption that $\rho$ and $\lambda$ both equal zero. In their work on the value of public transport in Seoul, Kim and Zhang (2005) find that not correcting for spatial autocorrelation leads to a 16% overestimate of the impacts of public transport on land values.

### *3.1.6 Stability of Estimates and Functional Forms*

The estimates in the next section vary substantially not just in identification methodology but also in their functional form assumptions (i.e. linear vs. log-linear vs. log-log forms). Work by Redfearn (2009) suggests that some of the variation in estimates may result from different functional form assumptions. Redfearn found that when using various functional forms relating distance to public transport and property values, the resulting estimates tended to be unstable - likely due to specification error. Instead, he proposes a locally-weighted regression approach. An area for future research is the relative merits of various functional forms in this context.

### 3.2 Findings from the empirical literature

With regard to their impact on land value, the most frequently studied public transportation systems have been rail-based systems and conventional bus systems. While rail systems have generally been shown to have a positive impact on land values (RICS 2002), bus routes have not. This may be because buses that run in mixed traffic have a lower amenity value than rail. It may also be because a bus route can be easily changed and hence developers and property owners may not be willing to make costly investments based on the location of the route.

As Bus Rapid Transit (BRT) expands from successful projects in Latin America, Asia, and Australia, the impact of these systems on land value has become an emerging area for research. Similar to fixed guideway rail systems, BRT uses dedicated busways to transport passengers and bypass traffic. Because of this, BRT offers many of the benefits to passengers of heavy and light rail at a fraction of the cost. It has not yet been shown conclusively that BRT can have the same impact on land values as rail, but there have been a handful of studies that investigate this question in Latin America, the United States, and Korea. We first review this work. Second, we look more broadly at the impact of public transport on land values in Asia and in the developing nation context. The methodologies vary between studies, as do the data availability and measures of accessibility.

#### *3.2.1 BRT-specific studies*

Most of the literature on the effects of BRT on a city is centered on the TransMilenio in Bogotá, Colombia. Bogotá's TransMilenio is one of the world's premier examples of a full-featured Bus Rapid Transit system. Buses on the main trunk routes are physically separated from the rest of traffic. This allows for a higher capacity and travel speed compared to traditional buses. Feeder buses are used to expand the reach of the system.

The literature on the capitalization of BRT amenities into property values finds that access to the TransMilenio increases property values and that this bump in property values decreases with distance from the public transport stop. Rodriguez and Targa (2004) is the first English language study on the impact of the TransMilenio on property values. Rodriguez and Targa use a before/after comparison with a control region, finding that monthly rental prices decrease 1.3% for every additional minute of walking time from the BRT. In terms of property value (not rental rate), this translates to an additional US$439 to $653 for each 0.1 kilometer of distance to the station.

Mendieta and Perdomo (2007) use a spatial hedonic pricing model to estimate the impact of the TransMilenio in Bogotá. The authors calculate the total impact of the TransMilenio to be 627 billion Colombian pesos, and they estimate land price-distance elasticities of -0.36 to -1.13. Using the same data, the authors use a propensity score matching methodology to estimate the impact of public transport on property values. Only discrete changes can be estimated using propensity score matching, so the authors estimate the impact of being within 0.5 km of a TransMilenio station. They find a high price premium, between 5-17%.

Rodriguez and Mojica (2008, 2009) find mixed evidence of BRT impacts on land values in Bogotá. This may be because they do not use a full hedonic model but instead compare a 'control' area to an area served by a BRT expansion. They seem to find that the value of being near the BRT increases when the service area expands, but the study design does not allow them to conclusively identify the effect.

Munoz-Raskin (2010) uses a data set that varies over time and space to estimate the impact of the BRT on properties within a 10 minute walk of trunk and feeder lines. The author finds that properties near the BRT trunk and feeder lines are worth less than properties in the city as a whole. However, this is likely due to the fact that feeder lines are located in outlying, relatively poor areas of the city. Within a 10 minute walk to the trunk lines, properties are valued at 4.8% higher than properties outside a 10 minute walk to a feeder line.

Outside of Bogotá, there are a limited number of studies done on the impact of BRT on real estate prices. Cervero (2004) performs a study on Los Angeles and finds that the BRT had a small negative impact on residential land prices and a small increase in commercial. Cervero and Kang (2009) study BRT in Seoul, South Korea. While their focus is not how much BRT increased land values, they do find that BRT has a strong impact on land values within 120 meters of the nearest bus stop for commercial, and 90 meters for residential properties. Having a BRT station increases property values by 5-10% in Seoul.

| **Table 1: Impact of Bus Rapid Transit** | | | | |
|---|---|---|---|---|
| **Authors/Year** | **City** | **Identification Strategy** | **Corrections for Spatial Dependence?** | **Result** |
| Rodriguez and Targa (2004) | Bogotá, Colombia | Hedonic Price Function | Yes. | 1.3% for every additional minute of walking time US$439 to $653/ 0.1 km closer to the station |
| Mendieta and Perdomo-Calva (2007) | Bogotá, Colombia | Hedonic Price Function | Yes. | Increase of 1 km from the metro results in a 7-8% decrease in price. |
| Perdomo-Calva et al. (2007) | Bogotá, Colombia | Propensity Score Matching | No. | A property within 0.5 km had a 5.8-17% price premium. |
| Rodriguez and Mojica (2008, 2009) | Bogotá, Colombia | Hedonic Price Function; Before/After with a Control | Yes. | Inconclusive |
| Munoz-Raskin (2010) | Bogotá, Colombia | Hedonic Price Function, Pooled-OLS with Year Dummies | No. | Inconclusive |
| Cervero and Duncan (2002) | Los Angeles, USA | Hedonic Price Function | No. | Negative capitalization for residential areas. |
| Cervero and Kang (2009) | Seoul, South Korea | Hedonic Price Function | No. | A property within 120 m had a 5-10% price premium. |

### *3.2.2 Studies of metro, light rail and bus in Asia*

Due to the paucity of studies on BRT, we turn to studies that link property values to metro, light rail, and bus services. Most of these studies have been done using detailed dataset from North America and Europe. The Royal Institute of Chartered Surveyors (RICS) wrote an exhaustive report on the impact of public transport on land values in the United States, the UK, Europe, Japan and Australia, reviewing approximately 150 studies (RICS 2002). They find the impact of new public transport systems is generally positive, but the relative magnitudes are influenced by the presence of complementary policies to encourage changes in land use or discourage automobile use. Their report highlights the variation in methodology across studies and is a useful reference.

Since the RICS report, some important studies have been done in North American and Europe. Debrezion et al. (2007) do a meta-analysis of the impact of public transport stations on residential and commercial property values. They find that BRT has a lower capitalization impact than metro or light rail. They also find a higher impact of public transport on commercial rather than residential property values but they find that a given station impacts a smaller area when placed in a commercial area rather than a residential one. Gibbons and Machin (2005) estimate the impact of a new line on the London Underground on surrounding properties. They use a DID model based on the postcode unit level to identify the impact on the difference in property values for the postcode versus changes in property values for the city as a whole. Finally McMillen and McDonald (2004) use a hedonic approach combined with a DID model to examine an expansion of Chicago's public transport line. They use a dataset of repeat sales on individual properties to look at how much a house sells near the new line sells for before the announcement and after the announcement of the new line. They find a significant anticipatory effect that increases housing values on average by $6,000.

While the methodologies from North American and Western European studies are useful, our interest is in Asia. Thus we focus on the smaller number of studies primarily from East Asia, but with one example from Turkey and one example from Chile. As land markets have liberalized, and a number of novel strategies have developed to acquire data and measure the value of urban amenities, new studies have come out measuring the impact of public transport and urban amenities on property values in many east Asian countries. Many studies estimate the impact of public transport as part of a larger study (Zheng and Kahn 2008, Sue and Wong 2010, Ding et al. 2008), or control for public transport while studying another aspect of urban life (Jim and Chen 2009). Other studies focus specifically on public transport (Chalermpong 2007, Kim and Zhang 2005, Lin and Hwang 2004) even looking at a particular line (Wang 2010, Wang and Wang 2008, Bae et al 20003). Most studies in this literature use a cross section approach, although some will do a repeated sales analysis using repeated sales from the same apartment complex.

Sue and Wong estimate the impact of public housing quality on land values. While their intention was not to estimate the impact on land values of public transport, they controlled for public transport as a part of their regression design, and thus obtained the estimate reported in Table 2. The studies on Beijing share similarities in that they both controlled for Chinese specific land market characteristics such as 'decoration' and in which quadrant of the city the property was located. Cervero and Murakami (2009) look at the price premiums attributable to three different metro stations and include information on accompanying transit oriented development (TOD). The other studies use variation of a hedonic housing model to estimate the impact of public transport on housing prices. Looking at Table 2, some patterns emerge. Clearly there is a positive impact of metro and bus access on property values. Overall a 10% increase in distance from a public transport station reduces property values by roughly 1% although this varies by study and methodology.

**Table 2: Impact of Metro and Bus Services in Asia**

| **Authors/Year** | **City** | **Type of Public transport** | **Identification Strategy** | **Controls for Spatial Dependence?** | **Result** |
|---|---|---|---|---|---|
| Anderson et al. (2010) | Tainan, Taiwan | High Speed Rail | Hedonic Price Function | No. | Negligible or no property value premium. |
| Wang (2010), Wang and Wang (1008) | Shanghai, China | Metro, Line 8 | Hedonic Price Function | No. | A property within 0.5 km had a 3% price premium versus a property more than 4 km from a metro. A property between |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 0.5-1 km had a 1.3% price premium. |
| Sue and Wong (2010) | Singapore | Metro, Bus | Hedonic Price Function and Regression Discontinuity Design | No. | Bus interchanges within 0.3 km increase prices by 4-9%, Positive impact from metro |
| Cervero and Murakami (2009) | Hong Kong | Metro | Hedonic Price Functions on individual stations | No. | A property within walking distance of certain stations had between 4.7-15.7% price premium. |
| Jim and Chen (2009) | Hong Kong | Metro | Hedonic Price function | No. | A property within 0.5 km had a 4.5% price premium. |
| Zheng and Kahn (2008) | Beijing, China | Metro, Bus | Hedonic Price Function (pooled cross-section) | No. | Increase of 10% in distance from urban subways reduces home prices by 0.8-1.6%; for suburban subways it is 0.1-0.4% and for bus stations 0.3-0.8% |
| Ding, Zheng, Guo (2008) | Beijing, China | Metro, Bus | Hedonic Price Function (pooled cross-section) | No. | Use a weighted accessibility function, increase of 1 unit accessibility to urban metros increases property values by 2.4%. |
| Pan and Zhang (2008) | Shanghai, China | Metro | Hedonic Price Function | No. | Increase of 1 km from the metro results in a 10% decrease in price. |
| Chalermpong (2007) | Bangkok, Thailand | Metro | Hedonic Price Function | Yes. | A 10% increase in distance from the metro results in a 0.9% decrease in price. |
| Choy et al. (2007) | Hong Kong | Metro | Hedonic Price Function | No. | A property within a 10 minute walk to the metro had a HK$100,000 price premium |
| Kim and Zhang (2005) | Seoul, South Korea | Metro | Hedonic Price Function | Yes. | $7.54-5.88 per meter closer to public transport station in urban areas, $1.69 for suburban. |
| Wang (2005) | Taipei, Taiwan | Metro | Hedonic Price Function | Yes. | Increase of 1 km from the metro results in a 2-3% decrease in price. |
| Lin and Hwang (2004) | Taipei, Taiwan | Metro | Hedonic Price Function | No. | Decrease of 77,000 Taiwan Dollars for ever 100m away from the new line. |
| Bae et al (2003) | Seoul, South Korea | Metro, Line 5 | Hedonic Price Function (pooled cross-section) | No. | Increase of 1 km to line 5 results in a 3% decrease in price. |

Andersson et al. (2010), Cervero and Murakami (2009) and Debrezion et al (2007) demonstrate the importance of context on property value changes. Andersson et al. find that high speed rail in Taiwan has little to no impact on property values, likely because of the high fare. A monthly commute between Taichung and Tainan on high speed rail would cost $775 US per month, or 70% of the median monthly wage in Taiwan. Cervero and Murakami stress the importance of accompanying transit oriented development, and find that it can double the impact of public transport on property values for a subset of properties in Hong Kong. With this in mind, we examine the impact of public transport on property values outside of Asia in the next section and discuss the link between the values presented in Tables 1 and 2 and the amount of value that could potentially be captured by local governments.

### *3.2.3 Studies focused outside of Asia*

Besides the studies mentioned in RICS, there have been a few more done in North America and Western Europe. Three studies, two in Santiago, Chile and one in Istanbul, Turkey were all that were found to represent the value of public transport in the rest of the world. The first study in Santiago (Galilea et al. 1988) did not try to quantify the impact of the metro on Santiago; they simply document the increase in prices by looking at property trends between areas with a metro and those without. Agostini and Pamucci (2008) use a difference in difference model to estimate the impact of anticipation of a new metro line. Celik and Yankaya (2006) collect data from real estate agents in Istanbul to find a 10% increase in distance from a metro leads to a 0.6-1.9% decrease in property price.

**Table 3: Impact of Metro and Bus Services in Turkey and Chile**

| **Authors/Year** | **City** | **Type of Public transport** | **Identification Strategy** | **Controls for Spatial autoregression and autocorrelation?** | **Result** |
|---|---|---|---|---|---|
| Agostini and Pamucci (2008) | Santiago, Chile | Metro | Differences in Differences with Hedonic Controls. | No. | Anticipation of a new line led to 4.2-7.9% increase for properties within 1 km. |
| Celik and Yankaya (2006) | Istanbul, Turkey | Metro. | Hedonic Price Function. | No. | A 10% increase in distance leads to a 0.6-1.9% decrease in price. |

### 3.3 Link between estimating capitalization rates and quantifying total capitalization

Results from the research summarized in Tables 1, 2, and 3 indicate that access to public transportation often has a positive and significant on land value. This suggests that value capture could be used to finance additional public transportation projects. However, these results establish only the marginal or average impact of investments in public transport on land values. These estimates may or may not reflect other complexities of property value changes, and translating these numbers into the total amount value generated by the public transport systems is not straightforward.

Studies that try to parse the impact of public transport on land values in various ways show that the impacts of public transport systems on land values vary depending on where in the city the land in question is located. For instance, one study of the land value impacts of urban amenities in Beijing, found positive premiums for urban metros but much smaller premiums for suburban stations (Zheng and Kahn 2009). A meta-analysis of 57 previous studies showed that the impact of public transport on land values depends on both location and on whether the property is residential or commercial (Debrezion et al. 2007).

The level of service, extent of the network, and fares will also influence the level of capitalization. As was seen in Taiwan with high speed rail, expensive services may not be capitalized into land values (Andersson et al. 2010). In theory, the total amount of value that can be attributed to a public transport improvement should be the value of land in the city with the improvement minus the value of land in the city without the improvement.

Taking a very simple case, we discuss problems of misspecification in a city where the only difference in property values stems from differences in public transport access. If public transport uniformly increases property values within walking distance, then we should expect to see property values such as in the top left diagram of Figure 1 [located at the end of this report draft], where properties not within walking distance sell for a lower price ($\alpha$) than properties within walking distance. Alternatively, the Alonso-Muth models applied to public transport suggest a decreasing bid-rent function from the center of the public transport stop until the stop is no longer accessible. Properties closer to the stop are worth more than properties farther away from the stop. If we assume this is a linear function that allows access to areas a certain distance away, we would expect to see a pattern of property values such as in the top right diagram in Figure 1, where distance decreases the price premium until the price of properties a certain distance away is simply $\alpha$. If we believe that there might be some negative externalities located at the public transport stop (e.g. noise, extra traffic) then we might expect the highest values to be a few meters from the stop and then declining thereafter, as shown in the bottom left diagram in Figure 1. One problem with the distance-based specifications is that often researchers simply put in a variable relating distance to public transport without trying to identify $\alpha$. This establishes that there exists a price premium for public transport, but does not allow the researcher to calculate the price premium.

In all of the cases in Figure 1, the value of public transport is the area under the land value curve over space with public transport minus this area without public transport. In the case of the top left diagram, this is trivial to calculate. In the top right and bottom left diagrams, the total value of public transport is easy to calculate since $\alpha$ is identified. In the bottom right diagram of Figure 1, however, $\alpha$ is not identified, making it impossible to estimate the value of public transport.

## 4. Value capture for public transport finance in urban Asia?

There are two prerequisites to being able to finance a public transport system using value capture. First, the system must actually generate sufficient value to be captured. Second, the institutional context must enable the local government or the public transport authority to capture this generated value. In the previous sections we showed evidence that public transport systems can generate value. In this section we take this idea further and discuss how local governments may capture this value. We describe the most prominent mechanisms used to capture property value increases to finance public transport systems and then present case studies from the literature of successful and unsuccessful attempts by cities to implement value capture mechanisms. Finally, we discuss which of these value capture strategies are most likely to be successfully implemented in the Asian context, taking into account both estimates of the potential value added of public transport systems and the institutional opportunities and challenges present in Asian cities.

### 4.1 Theoretical basis for value capture to finance public transport

The optimal use of value capture mechanisms to finance transportation improvements depends on the type of transportation improvement. For highways with constant long run average costs, the revenue from the optimal toll exactly covers the cost of constructing and operating the optimal capacity (Mohring and Harwitz 1962). Thus, in the case of roadway finance, direct user fees (tolls) are preferred to land value capture from the standpoint of economic efficiency.

It is important to note that this result does not apply to public transport finance. Public transport may promote social equity goals, reduce traffic congestion, and reduce the negative environmental externalities of personal automobile use. Additionally there are economies of scale with public transportation systems. Equity goals, automobile-related externalities and economies of scale in public transportation provide a rationale to set direct user fees (fares) below construction and operating costs and to subsidize public transport systems using government funds (Small and Verhoef 2007).

A common practice is to use general municipal funds to subsidize public transport systems. This constitutes a subsidy from areas without public transport to areas with public transport. Land value capture funds come from the urban neighborhoods that actually benefit from the improved public transport access, and therefore do not present this location equity issue. In many cases, funds from land value capture combined with fare revenue can fully fund a public transport system while keeping fares low to encourage ridership.

Value capture mechanisms can have substantial implications for the spatial growth pattern of a city. Some strategies for value capture can serve to promote transit-oriented development. One pathway for this to happen is through providing favorable terms for property developers near public transport. Another pathway is through levying land-based taxes that make it less attractive to hold vacant land near public transport for purposes of speculation.

Other strategies for value capture can have the opposite effect, promoting urban sprawl or even "leapfrog" development. This can occur if the government is attempting to capture more value than has actually been generated by overpricing of land, fees, or taxes in the vicinity of the public transport system. This will lead to the perverse result of development occurring far from the system rather than adjacent to it. Another instance when value capture can promote sprawl is when governments use the strategy of acquiring cheap land, providing public transport service to the area, and then capturing value by selling or leasing the land for development. The issue here is that properties outside the center of the city are easier to acquire cheaply and may represent a higher return on the investment than those closer to the city center. In this case, although the development will occur near the public transport system by design, the new public transport infrastructure may not be located to maximize its value to the city as a whole.

**4.2 Institutions and value capture**

In many parts of the United States and Europe, local public goods are already financed by land and property taxes that are based on the current assessed value of the land or property. This makes value capture through these taxes an attractive and administratively simple way to finance public transport improvements. Once a project and its financing structure have been approved, assessments can be made through the existing property tax structure. Even in this situation, however, challenges remain.

Land and property taxes are tremendously unpopular with the tax-paying public in many parts of the world - especially in the case of residential properties. Bahl and Martinez-Vasquez (2007) provide three reasons that this is true. First, these taxes are levied on the potential income generated from holding the land. If the land is not sold, however, this potential income does not translate into liquid funds with which to pay the tax bill. Second, the tax is levied on the value of an asset that has not necessarily been recently sold, and therefore does not have a determined market value that can be agreed upon by all. Finally, it is more obvious to taxpayers exactly how much they pay in land and property taxes compared to consumption or income taxes. This is because income taxes are often paid through paycheck withholding, and consumption taxes are paid in small increments, often simply rolled into the price of goods. In contrast, land and property taxes are often collected in one or two large payments per year.

Given these challenges, alternative value capture mechanisms must be used in areas without pre-existing land and property taxes, poorly functioning tax collection systems, or extremely low tax rates. Fully-functional property tax systems do not exist in many parts of the world - including many parts of Asia. For instance, China has twelve land and property taxes, but even taken all together, they do not raise significant revenue. The main reasons for this are that the tax rates are low, the taxes are levied only when there is a property transaction, and residential properties are exempt (Ding 2005). China's central government is currently considering the possibility of allowing property asset taxation in some areas, though detailed information about exactly how and when this will happen has not been released (see, for example, Cookson and Anderlini 2010).

One prominent value capture alternative to taxation is to lease or sell land near public transport improvements or to grant development rights in areas served by public transport. However, this is only possible when the government owns land or can buy land at pre-development prices. Another alternative is to use a public-private partnership model to finance public transport. This approach has been successfully implemented where property rights and contract law is well-developed. There are a number of examples in Asian cities where each of these alternative value capture mechanisms have been implemented. These are described below in section 4.4.

### 4.3 Value capture mechanisms explained

When the potential for land value capture to finance public transport exists, the mechanism used has important implications for efficiency, equity and the structure of a city. In this section, we identify and explain how the most common value capture mechanisms work. Note that the terminology used in the literature for value capture mechanisms is not entirely consistent across sources. We have attempted to present the most commonly used and intuitive definitions here.

Value capture mechanisms fall into two main categories: those that produce large lump-sum payments at one point in time, and those that result in an ongoing stream of revenue. This distinction is important because the two categories of value capture mechanisms have different implications for whether the captured value is likely to be an accurate estimate of the actual increase in value. In the case of one-time funding sources, private sector actors pay a single lump sum that is meant to capture the total expected value of the public transport system as capitalized into the piece of land they are using. If the expected value is correct, this is a fair system for all. However, if the expected value turns out to be substantially higher (lower) than the realized value, then the private (public) sector reaps these uncertainty-based gains. In the case of ongoing funding sources, payments are incremental, and will naturally self-correct over time as the capitalized market value of the public transport system is revealed.

#### *4.3.1 One-time funding sources*

One time funding sources are those value capture mechanisms that require a single lump sum payment by property owners, developers, and/or commercial interests in the vicinity of a public transport system. The advantage of these value capture mechanisms is that they can generate a lot of revenue quickly, and have the potential to contribute substantially to the capital cost of public transport. Their disadvantage is that once this money is spent, there is no ongoing source of land value-based revenue to subsidize the operation and maintenance of the system. Value capture mechanisms in this category include the sale of development rights, land sales, joint development of infrastructure with the private sector, and development impact fees.

*Long-term leasing of development rights:*
The local government or public transport agency acquires land in and adjacent to the public transport facility at the going price before ground is broken to build the public transport system. After the system is built (or concurrently), the owner can then enter into long-term leases with developers for ground, air, or subsurface development rights. The added value from the public transport system is capitalized into the lease price. Because these are usually extremely long-term leases, with payment due in full at the start of the lease period, they supply large lump sums of money at one point in time.

*Land sales:*
The local government or public transport agency acquires (re)developable land in the vicinity of the public transport facility at the going price before the public transport system is built. After the system is in place, the owner can sell the now higher-value land on the open market, capturing the added value in the transaction. Similar to long-term leases, land sales provide large lump sums of money at one point in time.

*Joint development:*
A form of public-private partnership (PPP), joint development is a partnership between the private sector and the local government or public transport agency to build a real estate project on land controlled by the public sector. The local government or public transport agency captures value by requiring the private developer to build a portion of the station amenity as part of their real estate project, thereby reducing their capital costs. While joint development has been used successfully to help cover public transport system capital costs, its success is likely to be limited to the most profitable station areas. The public sector will often need to fund extensions to areas that may be important to serve but do not have significant development potential. Note that as defined here, joint development mechanisms of value capture do not provide cash money to the public sector. In some cases, however, long-term leasing of development rights is also termed “joint development” in the literature (e.g. Cervero 2009).

*Development impact fees:*
Developers working in the vicinity of a public transport system pay extra fees for the privilege of building new real estate projects. The rationale for these fees is that they help to pay for the expansion of the public transport service that is necessary to serve the people who live and/or work in the new development. These fees are due in full at the outset of the real estate development project, and serve as a sort of one-time tax. Although this mechanism seems sensible on the surface, it can have the unfortunate consequence of discouraging development in public transport-rich areas if the fees are higher than what developers perceive as the amenity value of the public transport system.

#### *4.3.2 Ongoing funding sources*

Ongoing funding sources are those value capture mechanisms that require recurring payments by those entities benefitting from the public transport system. The advantage of these mechanisms is that they can be a sustainable source of revenue to subsidize the ongoing operating costs of the system. In some cases, they can also be used as a form of collateral to secure a loan for system capital costs. Value capture mechanisms in this category include location benefit levies, tax increment financing, betterment taxes/special assessments, and leasing of commercial space in and around stations.

*Location Benefit Levy (LBL)/Land Value Tax (LVT):*

An LBL/LVT is a tax on the value of land in the vicinity of a public transport amenity. Note that this mechanism is a tax on the land only, and that this is distinct from a conventional property tax, which takes the land plus the buildings and other improvements as the basis for taxation. An LBL could be structured to be in addition to existing property taxes with the stated purpose of financing the location benefit (in this case, access to the public transport system), or it could replace the land-based portion of the property tax. Rybeck (2004) argues that LBL/LVT can create incentives for compact development. This is because owners of more valuable land near public transport systems would need to pay higher taxes, raising the cost of leaving properties vacant or under-developed.

*Tax Increment Financing (TIF):*

The mechanism of TIF is most commonly used in the United States, operating through the existing property tax system. Tax increment financing does not add any new taxes to an area, but instead allocates any increase in total property tax revenues toward public investment within the designated TIF district. These public investments can include public transport infrastructure, but TIF funds are more often used for real estate redevelopment purposes to fight urban blight. Some argue that the use of TIF is unfair to communities outside the district since it results in the removal of property tax growth in TIF districts from the general tax rolls (Medda 2007).

*Betterment taxes/special assessments:*

Districts benefiting from a public transport improvement may choose to self-impose an additional tax to help finance the improvement. These special assessments are generally approved through some form of vote by the group that will be paying the tax. This group could be local landowners, local residents, or local businesses. The taxes are usually meant to finance a portion of the local infrastructure investment rather than to subsidize the system operating costs. Therefore, although they are a funding source that continues to provide a stream of revenue over a period of time, special assessments often have “sunset” dates and are not in place indefinitely.

*Leasing of commercial space in and around stations:*

The public transport agency or local government develops and retains ownership of the commercial space in and around stations, and leases it out to businesses at market prices. This space is often quite valuable, since a well-used public transport system produces a natural customer base.

**4.4 Selected global experience of value capture for public transport finance**
Many studies have shown that sufficient value is generated by public transport systems that *if they had been implemented*, value capture mechanisms *could have* contributed substantially to financing these projects (e.g. Rybeck 2004, Riley 2001, Alterkawi 1991, Smith and Gihring 2006). While encouraging, this information is unhelpful to the city official aiming to implement value capture to finance a new public transport system. It does not shed light on how to maximize the value that is generated, and it does not provide guidance about how to equitably and effectively transfer a portion of this value from private to public coffers. In the remainder of this section, we focus on actual implementation of value capture mechanisms. We highlight examples of success and we discuss instances where there was room for improvement in public transport system and/or value capture implementation. For an excellent set of additional examples and further discussion of the use of value capture to fund public infrastructure (not limited to public transport), see Peterson (2009).

The poster child for the use of value capture to fund public transport is the Hong Kong Mass Transit Railway Corporation (MTRC). The MTR system in Hong Kong is fully constructed, operated, and maintained without a financial subsidy from the government. In fact, the MTRC is a publicly traded corporation that earns profits for its shareholders, chief among them the government of Hong Kong. This railway serves approximately 20 percent of transit trips in Hong Kong - a city where the transit mode share is close to 90 percent of all trips (Zhang 2007). Cities throughout Asia are currently studying the MTRC business model with the hope of adapting it for use elsewhere.

Hong Kong’s MTRC model is known as Rail + Property (R+P) whereby the corporation concurrently develops property and the MTR system. To enable this, the Hong Kong government does provide an indirect subsidy to the MTRC in the form of land provision at favorable rates. The MTRC obtains land from the government at pre-MTR rates and sells or leases those lands at post-MTR rates. Because Hong Kong is such a dense and public transport-rich city, new rail stations add substantial value to surrounding land, especially for commercial uses. Over the last decade, almost half of MTRC operating revenue came from property development activities, rather than the corporation’s core business of providing rail service (Tang and Lo 2010).

The MTRC’s successful strategy relies on a combination of the value capture mechanisms of land sales, joint development, long-term leasing of development rights, and leasing of commercial space in and around stations. This strategy can be applied in cities where the government controls a large portion of the land and can provide the necessary land at favorable rates. Mainland Chinese cities are prime candidates for using the MTRC model, since the State formally owns all of the land, only leasing it out for private development.

The story of the financing of Guangzhou's metro system makes clear that government control of land is necessary but not sufficient to insure the success of the R+P business model. Before beginning to build its metro system in 1993, the Guangzhou Municipal Government specifically set out to use the R+P model of railway infrastructure finance. However, the government's policies and actions were not fully supportive of public transport-coordinated property development, and the partially-implemented R+P model was unsuccessful.

For the first metro line, the government worked with the Guangzhou Metro Corporation (GMC) to designate 27 parcels of land along the corridor for joint development projects, and set up "project companies" to facilitate these public-private partnerships. Due to a combination of unlucky timing and a lack of coordination between municipal government land use planning and the GMC, however, the GMC was unable to fully realize the development potential along this metro line. The metro line was built to run through a densely populated area of the city center, and some of the designated joint development parcels were in this area. The municipal government made GMC responsible for the huge expense of demolishing existing structures, compensating and relocating over 20,000 families, and readying the sites for redevelopment. These high upfront expenses forced the GMC to charge high prices for development rights in order to recoup costs, but private sector developers were largely unwilling to pay these prices - especially when redevelopment rights on nearby parcels of land were made available at lower prices. In addition, the Guangzhou Municipal Government concurrently created a new business district - Tianhe - in a different part of the city, rather than coordinating with the metro alignment by encouraging development around the new metro stations. This led to an oversupply of office space in an area of the city that was not served by the metro line, and a resulting lack of demand for development near the metro line (Tang et al 2004).

Recently, the GMC has extended its business to include advertising and leasing of commercial space inside of metro stations, slowly improving its financial standing. Despite this improvement, successful implementation of the R+P model remains elusive in Guangzhou because the municipal government has not provided highly favorable land rights to the GMC and because there is strong competition in the Guangzhou property development market (Tang et al 2004).

Two other Asian cities that are often cited as successful examples for public transport finance are Tokyo and Singapore. Tokyo is particularly unique in that it has a long history of privately built, owned, and operated railways. There are twelve distinct railway corporations operating in the city, only one of which is publicly owned (Cervero and Murakami 2008). These private corporations claim rail as their "core" business, but most of them in fact earn more of their profits from associated real estate ventures in and around their rail stations. Some of these corporations have branched out even further from rail, and also operate major department stores, construction businesses, education facilities, and other services (Tang et al 2004). The Japanese government has facilitated railway investment through a combination of direct subsidies and low interest loans to help pay upfront capital costs. In Tokyo, the local government has additional policies in place to incentivize public transport ridership. These include vehicle and fuel taxes, road pricing, direct car ownership controls, and tax breaks for public transport users (Tang et al 2004). Although the capital costs of Tokyo's railways do receive government subsidies, the Tokyo system of private operators with associated real estate businesses has successfully reduced the need for the government to subsidize railway operating expenses.

Singapore's model of public transport finance relies not on real estate development per se, but rather on strong government policies that channel development toward the public transport corridors and incentivize public transport ridership. This, plus a duopoly of efficiently-operated public transport corporations, has led to a situation where fares easily cover operating expenses in most years. The Singapore government's Land Transport Authority built and maintains ownership of the physical public transport infrastructure, and uses road tolls and vehicle ownership fees to pay both debt service on these investments and for upkeep. Despite the fact that these tolls and fees are famously high in Singapore, they do not fully cover the cost of the public transport infrastructure, and central treasury funds are also needed (Cervero and Murakami 2008).

Outside of variations on the R+P business model, there have been a number of examples of the use of special assessments, fees and donations to help finance public transport systems. An interesting example is the New York Avenue metro station in Washington, D.C. Approximately one quarter of the financing for the station itself was voluntarily provided by local businesses through a self-imposed special assessment on all commercial properties within 2,000 feet of the new station's entrances. In Bangkok, commercial centers wishing to physically connect to rail stations are charged connection fees and asked to finance the connecting pedestrian bridges (ITDP 2007). Zhang (2007) relates the story of developers in Shanghai who paid all the expenses for construction, maintenance and security patrol for a pedestrian link from a metro station to their shopping center located across the street.

There are many papers written about the possibility of financing public transport systems by capturing their value through land and property tax collection. Cities throughout the world with property taxation institutions in place rely on these taxes to pay for city services of all types, including public transport systems. There are a number of US cities that currently earmark a set percentage of their property tax revenue to help pay for public transport operating costs (Enoch et al 2005). However, this is different from relying on capitalization of a public transport amenity into land values to pay for new public transport infrastructure. General property taxes impact everyone in a city while value capture targets those who directly benefit from an upgrade to the transportation infrastructure.

**4.5 Opportunities for public transport finance using value capture mechanisms in urban Asia**

Drawing upon the main results and experiences we have summarized thus far, here we aim to shed light on the key questions that city officials are asking:

1. Can value capture fund my public transport system?
2. If so, which value capture mechanism should my city implement?”

From this literature review, the following main points arise. When public transport systems are planned and built to offer superior transport service from many origins to many destinations in a city, they can generate substantial location-based value. This value is then capitalized into land values throughout the city, according to each parcel’s proximity to the system. If capturing this value were a simple matter, financing well-planned public transport systems would never be a problem. Clearly, this is not the case.

The challenge of financing public transport using value capture is two-fold. First, the public transport system must be planned well and rolled out according to a schedule that maximizes the social benefit from the system. The city government and the public transport authority must work in concert with one another to spatially coordinate land use plans and economic development initiatives with any new public transport investments. As we saw from the literature reviewed in section 2 of this report, these are the conditions for public transport to generate the largest impact on development. The value capture examples reviewed above also highlight the importance of good and coordinated land use and transportation planning.

Second, the municipal government must have the proper institutions in place to facilitate the use of value capture mechanisms. If a land or property taxation mechanism is to be implemented, the city government needs to have a way to track land or property values over time, and to have the power to levy the proper tax. If a land sales or lease mechanism is to be used, the municipal government must either own the appropriate parcels of land or have the power to assemble and acquire this land at a favorable price. If joint development is the value capture mechanism of choice, the public transport agency or local government needs to be allowed to function as a proper business partner in land development.

In sum, value capture can fund public transport systems in cities that can coordinate land use, economic development, and public transport planning such that substantial private value is generated from the public investment. The value capture mechanism that works best for each city will depend on the capacity of the government to track the value of land and to levy land taxes, the government’s ability to assemble and acquire land at a favorable price, and its capacity to act as a savvy business partner in land development.

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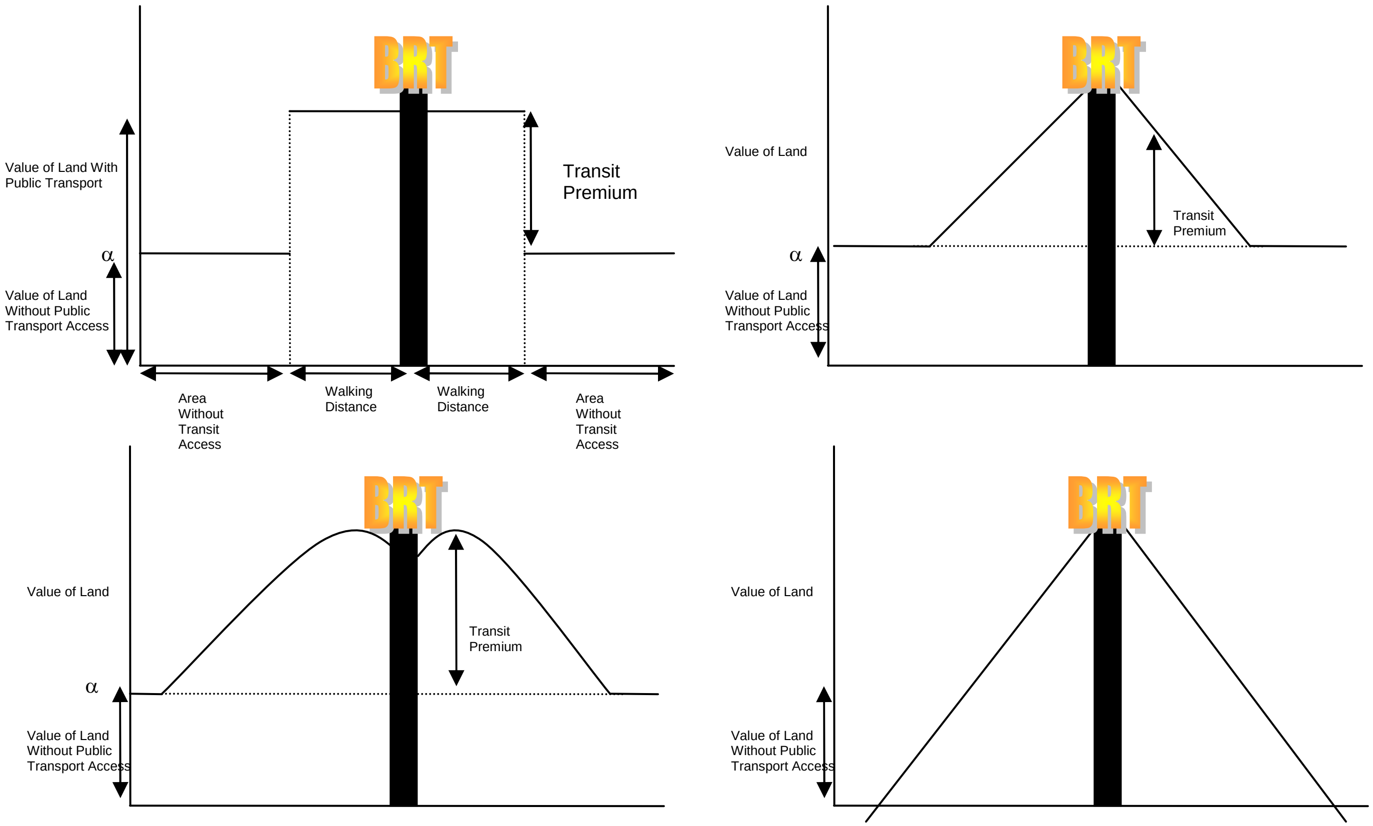


Figure 1: Impact of public transport on property value