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Urban rail transit PPPs: Lessons from East Asian cities

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ABSTRACT

Private sector participation in urban rail transit has proliferated in the past two decades. The large metropolises of East Asia have had decades of experience with private sector participation in the provision of heavy metro services. The design of these public–private partnerships (PPP) are varied. The diverse experiences of Tokyo, Hong Kong, Singapore and Beijing contain valuable lessons for other cities. Using a case study approach, this paper discusses three features of urban rail transit developments in the context of East Asian cities, *viz.*, farebox recovery, land value capture mechanisms, and vertical structure of the industry. Super vertical integration between rail transit and real estate development as land value capture strategy to finance urban rail transit has proven to be successful in Japanese cities and Hong Kong. Singapore's experience illustrates that vertically unbundled PPPs could cut off avenues for cross-subsidisation, reduce information flows as well as economies of scale and scope, introduce principal agent problems, and result in underinvestment in capital stock and maintenance. We conclude that (i) a combination of high farebox recovery ratios and successful land value capture contributed significantly to the development of urban rail transit in East Asia cities; (ii) given the complexities and high costs of heavy metros, the optimal structure is a vertically integrated public-owned and driven system, with the public sector entering into selective partnerships with the private sector where risk sharing is clearly defined and allocated.

1. Introduction

The number of urban rail transit systems built and under development have increased dramatically in recent years. The most rapid growth has occurred in China where 23 cities built new transit lines between 2003 and 2014 (Zhang et al., 2016). In 2016, 51 urban rail transit projects were reported to be in progress in China, with rapid growth in the number of projects forecasted for the future (Wu, 2016).

Until the 1990s, most cities (with the exception of Japan) have used the state provision approach. Along with the growth in the number of urban rail transit systems, public-private partnerships (PPPs) have proliferated in the past two decades (Chang, 2013; de Jong et al., 2010; Phang, 2007; Yuan et al., 2010). Several of these are light rail-light metro initiatives (Mandri-Perrott, 2010). This trend towards private sector participation follows that of utilities and other transport infrastructure sectors where capital investments are hugely expensive. The PPP approach in urban rail development however involves consideration of numerous complex strategy issues.

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In a PPP, the government remains the key partner and enters into a formal contractual arrangement with a private sector partner. Very often, this is motivated by the possibility of bringing private financing into the project. Fares, quality of service and safety regulations are often embedded into the contract. The private sector brings both financing as well as the benefits of commercial practices to enhance performance and contribute to the sustainability of the urban rail transit system. The private sector provides specialised expertise, garnered from global experience, which is often lacking in the local public sector. This reduces learning costs, can be more efficient thus leading to lower costs. However, the public sector might not know how to structure and/or manage the PPP relationship, the government can lose control over key decisions and transaction and governance costs can be much higher.

In the urban rail transit sector, the actual performance of PPPs as compared to the public sector has been mixed (Amaral, 2008; Jain et al., 2008; Vining and Boardman, 2008; Iossa et al., 2014; Hong, 2016; Millones, 2010). Given the challenges posed by PPPs, there are cities that have preferred not to enter into these partnerships. Regardless of mixed performance and in spite of complexities, urban rail PPP is a growth industry and the private sector has built up much expertise in the past two decades. In East Asia, there are numerous cities with large populations, high population densities and reliance on heavy metros. Cities such as Tokyo, Hong Kong, Beijing, and Singapore all have different heavy metro PPP models.

The focus of this paper is on three features of urban rail transit PPPs in the context of East Asian cities, *viz.*, farebox recovery, land value capture mechanisms, and vertical structure of the industry. The activities that could be vertically integrated (or separated) in urban rail transit include the following: civil works; tracks, power distribution and signals; rolling stock; infrastructure maintenance; train operations and maintenance; as well as property development around stations. These three distinctive features that make real transit different in East Asia are analysed in Section 2. Section 3 analyses how policy decisions regarding these important aspects of urban rail help explain PPP design and performance in Tokyo, Hong Kong, Singapore and Beijing. Section 4 draws lessons from these case studies for other cities considering PPPs.

2. Distinctive features of urban rail transit development in East Asian cities

East Asian cities (and countries) differ from most western cities (and countries) in size of metropolitan areas and population densities. The capital and large cities of East Asia typically have populations well above 5 million, high population densities, motor vehicle restriction measures in place, and high proportion of trips made by public transport. Public transport mode shares in Hong Kong, Singapore, Seoul and Tokyo are in excess of 50 percent (Choi and Loh, 2013). These characteristics are favourable for large scale urban rail developments, in particular heavy metro development. Mega populations and high train densities have several implications for urban rail transit operations. In this section, we discuss three distinctive features of East Asian urban rail transit that differentiate them from those in most U.S. and European cities, *viz.*, high farebox recovery, successful land value capture, and vertical structure of urban rail transit companies.

2.1. Fare revenue

Fare revenue and fare elasticity of transit demand are important aspects of urban rail transit sustainability. How fares are structured and adjusted affect transit demand, quality of transit services, profitability, as well as subsidies required for the system. The difference between operating costs of rail and passenger fare revenues, ranges from 29 to 89 percent for U.S. urban rail transit systems (Parry and Small, 2009). It is generally rare for rail transit fare revenues to cover operation and maintenance costs in cities of most Western developed countries and government subsidies are important in financing both development and operations.

In the transport literature, the theoretical basis for subsidising transit operations on efficiency grounds is well established: scale economies and externalities. Scale economies result in marginal costs of supply being lower than average costs. The sources of these economies arise from the high fixed costs of urban rail as well as the 'Mohring effect' where passengers' waiting time or access costs decline as service frequency or route density increases (Mohring, 1972). Higher passenger density also permits higher vehicle occupancy thus reducing transit provider's costs (Parry and Small, 2009). The second argument for transit subsidies is that the external costs from automobile use is not fully internalized through environment or fuel taxes and congestion pricing.

In a study using 2002 transit data from three large metropolitan areas, *viz*. London, Los Angeles and Washington, Parry and Small (2009) suggest that substantial transit operating subsidies (beyond 50% of operating costs) can be warranted on efficiency grounds. At higher levels of incomes and corresponding higher time costs of commute, optimal transit subsidies and quality of transit service are correspondingly higher. This arises from the shift in demand to automobile use with higher incomes, and in a context when congestion and pollution from automobile use are not fully internalized.

The above efficiency arguments advanced for subsidising transit operations are however not as strong or valid in the context of East Asian cities. Population and transit densities in many East Asian cities are high enough to support transit systems without the need for operating subsidies, i.e. the 'Mohring effect' is minimal. Farebox recovery ratios are in excess of one for transit systems in Tokyo, Taipei, Singapore, Shanghai and Hong Kong (Singapore Land Transport Authority, 2011). In central Tokyo and Hong Kong, for example, public transport mode share is in the region of 90 percent and public transport services operate without direct government subsidy (see Section 3). Governments have also been able to implement curbs on automobile ownership and usage through a wide range of instruments which include vehicle ownership quotas, parking restrictions, congestion pricing, restrictions on usage as well as fuel taxes (Phang, 2014). In cities where the congestion and polluting costs of motor vehicle usage are fully internalized, the externalities argument for subsidising public transport is less valid. Instead, peak period crowdedness in train carriages is a major problem in several cities and several operators have started time-based fare pricing strategies such as peak surcharges and off peak discounts or fare free services to manage peak hour ridership demand (Gwee and Currie, 2013).

Litman (2016) cites empirical evidence that rail transit fare elasticities for major cities tend to relatively low, in the −0.18 range (−0.1 during peaks and −0.46 during off-peak). In East Asian cities, fare elasticities of public transport ridership are even lower if there is little inter-modal competition and low car ownership rates. A study by Abe and Kato (2016) estimates fare elasticity of public transport for Tokyo to be insignificant at −0.099 in the short run and −0.164 in the long run. With insignificant fare elasticities of demand, fare revenues in East Asian cities are an important source of revenue for transit systems. Fares can be raised to increase revenue to cover costs without the loss of passengers. Various fare adjustment systems have been devised in East Asian cities (see Section 3 below) to enable transit agencies to raise fares periodically to cover rising costs and general inflation. The fare inelasticity of demand also requires that fares be regulated to ensure that monopoly or market power is not abused and that fares remain affordable for lower income commuters.

2.2. Land value capture for financing of urban transit development and operations

The idea of land value capture (LVC) dates back to Ricardo (1821), with George (1879) being the strongest advocate. As the demand for a particular plot of land is derived from its facilitation of economic activities, land value is not only determined by its intrinsic value or the original productivity of land, but also by other factors including population and economic growth, investments in infrastructure and local services, as well as land use regulations. Land use planners can increase land value by allowing a change in land use or permitting an increase in density (plot ratio or floor area ratio (FAR)). Governments can increase land value by investing in infrastructure, providing local services and/or improving local amenities.

To help finance public sector investment in local infrastructure and other amenities, governments can use LVC instruments which can be broadly classified into either tax or fee-based or development-based. The tax or fee-based category captures the increment of land value through instruments such as property tax, betterment tax or tax increment financing. The property tax is one of the most important revenue sources for most developed countries. In the late nineteenth century, George (1879) had argued that as investment in public goods can increase the aggregate land value by at least as much as the investment cost (under certain conditions), a 100% tax on land value is not only efficient, but also the only tax necessary to finance public expenditure (George's single tax proposal). Although George's original land tax proposal was flawed, the merits of the property tax are well recognised by economists (Friedman, 1978; Stiglitz, 1977). Property taxes can be introduced or increased to fund local infrastructure and services with minimal distortions to the land market. The disadvantage however is that most property tax systems do not have clear links between infrastructure and public service improvements and the tax rate. Not surprisingly, attempts to capture land value by linking the property tax rate to improvements are often opposed by those affected.

In contrast, development-based LVC often create opportunities for public, private, and even residents to share in the increment of land value during the development and sometimes operation process. The government can increase land value by providing new infrastructure, or changing land use regulations. Private as well as other stakeholders may also provide funds and resources to participate in the development process. Both the public or private sectors can capture land value increment by selling or leasing land, development or land use rights to other parties. It would be possible for stakeholders to negotiate to share the value increment based on their respective share of contributions. The revenue sharing schemes are case dependent and agreed to in advance by all stakeholders.

Development-based LVC can be further categorised into sale of land or land leases, and retained developments. Receipts from sale of land or land leases can be used to cover capital investments for urban rail investments. The urban rail authority can also retain ownership of real estate developments that generate long term streams of revenues from leasing or rental of retail, commercial and residential space as well as from parking charges. This provides for a steady long-term revenue stream that can be used to subsidise operating expenses. By linking contributions to benefits, development-based LVC leads to less fiscal distortion and has greater public acceptance.

Local governments all over the world have implemented various LVC instruments to finance urban development projects. Walters (2012) summarized the wide range of tax or fee-based LVC instruments and experiences of U.S. cities. In developing countries, governments tend to use development-based LVC instruments as property tax systems are usually inadequate. In mainland China, local governments acquire agriculture land at a relatively low costs, convert the land into urban use by building infrastructure and then sell leases or land use rights (of up to 70-years) of the re-zoned land to developers through auctions and tenders. In India, local governments rely on town planning schemes to acquire up to 40% of agricultural land from owners. Local governments reserve a portion of the acquired land after building public infrastructure, and then sell the land via auction to cover development costs (Sanyal and Deuskar, 2012). Cities in Brazil are mostly heavily urbanized with few opportunities for development-based LVC. Instead, local governments capture land value by selling air rights. For example, the public sector in Sao Paulo defines the basic FAR (generally from 1.0 to 2.0) and maximum allowable FAR (from 1.0 to 4.0) based on location and land use. Developers can enhance the density of development projects by paying local governments for additional allowable FAR (Suzuki et al., 2015).

In theory, urban rail investment can increase land values by reducing residents' commuting cost, increasing accessibility and strengthening agglomeration benefits (Alonso, 1964; Cervero et al., 1998; Chatman and Noland, 2011). Several empirical studies in both developed and developing countries have shown that urban rail transit investments result in higher property values near stations (Cervero and Landis, 1993; Duncan, 2011; Zhang and Wang, 2013; Zheng and Kahn, 2008).

The land value enhancement benefits to existing property owners brought about by urban rail systems tend to be very significant in East Asian cities given the large numbers of transit commuters and high densities. The overall higher density of land use and increase in population that are permissible from the development of urban metros constitute another important agglomeration benefit of urban rail systems in land scare cities. In traditional cost benefit studies for evaluation or urban rail projects, travel time

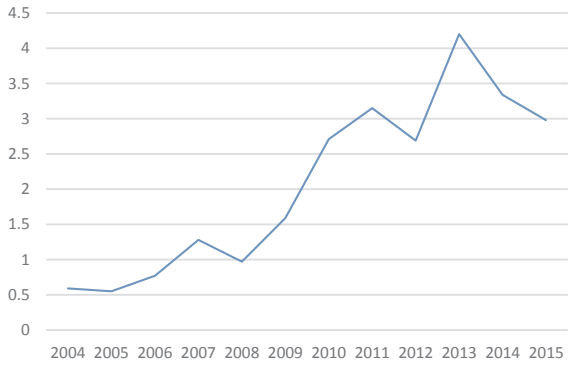

Fig. 1. China's aggregate land leasing revenue (2004–2015, RMB trillion).
Source: Ministry of Land and Resources, People's Republic of China. Access at: http://www.mlr.gov.cn/.

savings is a major component of benefits. Travel time savings become capitalized as land value enhancement and the latter is therefore not included as a benefit item as it would theoretically lead to double counting. Also the benefits from land value enhancements and increased land use density along the rail corridor are regarded as transfers as there could be corresponding reductions in density/land values elsewhere in the city. However, in the case of land scarce and large East Asian metropolises, by allowing for higher density developments, urban rail leads to a relaxation of a very real supply side space constraint where agglomeration economies are important (Phang, 2000, 2003).

Several East Asian cities have recognised this important benefit of urban transit and LVC techniques are often applied to finance urban rail project construction (and sometimes for operation and maintenance costs as well). Cities such as Tokyo and Hong Kong apply the LVC technique directly to finance their urban transit development projects, while in Singapore and mainland China, the capture of land value from rail infrastructure projects is indirectly via government ownership of land and sale of long term land leases to developers.

Most transit systems in the world run operation deficits. In contrast, railway companies in Hong Kong and Tokyo make substantial profits (see Section 3 below for the case studies). Both cities apply LVC instruments to cover a significant proportion of transit investment, operation and maintenance costs (Cervero, 1998; Cervero and Murakami, 2009). The public sector in most cities in Mainland China build and operate entire urban rail systems. A few cities such as Beijing, Shenzhen, and Hangzhou have applied PPP models with operations of PPP lines contracted to private companies.

In mainland China, revenue from land leasing for many cities account for between one third and two thirds of the annual budget. Fig. 1 shows the increase in aggregate land leasing revenue from RMB 0.59 trillion in 2004 to RMB 3.34 trillion in 2015. However, this increase is not sustainable for two reasons: first, land resources on the fringes of urban areas are scare and will be exhausted in the near future. Secondly, land leasing revenues are largely dependent on the real estate market. Recessions and government interventions to cool housing markets could reduce land leasing revenues (Chang, 2014).

As the property tax and capital gains tax systems are not well established in China, most of the land value increment from urban rail system developments were previously captured by households. With the decline in land leasing revenues, several cities have started to apply fee-based and development-based LVC for urban development. Since 2011, Shanghai and Chongqing have introduced property taxes. The property tax rate in Shanghai is 0.6% of value. The first residence purchased by a local resident household (with Shanghai hukou) is exempted from this tax.[2] The property tax rate in Chongqing ranges from 0.5% to 1.2%, depending on the magnitude of value increment of purchased properties in the past two years.[3] Although there is no clear schedule, more Chinese cities are likely to introduce the property tax when land leasing revenues decline further in the future.

Besides tax-based LVC efforts, Chinese cities such as Nanchang have implemented development-based LVC. Nanchang, the capital city of Jiangxi province, has a population of 5.3 million in 2015. Due to rapid urbanization, the city government plans to build five metro lines by 2020. The construction of the first line began in 2012; operations started in September 2015 with a route length of 29 km and 24 stations. The construction of the second line started in 2013 and it is expected to begin operations in late 2016. To finance the metro system, the city government is applying the Hong Kong LVC model (see Section 3 below). The state owned subway company acquires land at relatively low prices through exercise of eminent domain. After acquisition, the city land use planners increase the FAR and change land use around and above stations. The development rights are then sold to developers to finance construction costs. The subway company can also develop retail, residential units and provide other public amenities and services in the areas near and above the metro railway stations. Revenues from rental or sale of leases of these properties are used to cover investment and operating costs (Suzuki et al., 2015). It is still premature to conclude that the LVC practice in Nanchang has worked well. If it is successful, more mainland Chinese cities will likely follow the development-based LVC model for urban rail systems in the

[2] Shanghai's tax policies can be found at the Shanghai government website at: http://www.shanghai.gov.cn/nw2/nw2314/nw2319/nw10800/nw11407/nw25262/u26aw24523.html.

[3] Chongqing's tax policies can be found at China's State Council Information Office website at: http://www.scio.gov.cn/xwfbh/gssxwfbh/xwfbh/chongqing/document/857648/857648.htm.

future.

2.3. Vertical structure

Vertical separation in network industries refers to the institutional separation of the infrastructure from the operations. A large body of literature exist that analyses the experience with vertical separation (e.g. Vickers, 1995; Sappington, 2006), with considerable attention devoted to reforms in the electricity, gas and telecommunications sectors. In Europe, the vertical structure of railways has also been a source of theoretical and policy debate as well as experimentation in the past two decades (Marcucci, 2002). From the 1950s, the most common structure in the rail sectors of most countries (other than Japan) was a single, state-owned enterprise. The restructuring of rail in a number of countries began after the vertical separation, and subsequent or simultaneous privatization of the telecommunication, electricity, and gas industries beginning in the 1980s. However, while separation was considered an unequivocal success in the electricity and telecommunication sectors, it remains a controversial issue in the railway sector. Overall, the findings are that the merits of vertical separation for railways are inconclusive and dependent on circumstances and the way the system is managed (Drew and Nash, 2011).

In the urban rail sector, relatively little attention has been paid to the vertical structure of the industry. For many large cities, intercity or suburban railways also constitute an important segment of urban rail transit. This analysis therefore draws also from the relevant literature on the structure of the railway sector. Similar to the railway sector, urban rail transit infrastructure can be separated as a monopoly, and either owned or regulated by the government. Competition can be introduced into the operations of trains through competitive tendering. The breaking up a vertically integrated monopoly opens up the industry to competition and PPPs which can enhance performance. However, such separation requires the infrastructure owner to supervise the coordination of track and trains when different companies are involved.

Amaral and Thiebaud (2015) identifies four main modes of vertical structure for European railway sector:

- *Full unbundle:* full separation between infrastructure manager (IM) and railway undertakings (RU).
- *Unbundle with delegation:* separation between IM and RU, where IM delegates infrastructure maintenance and operational management to a RU.
- *Unbundle with holding:* separation where a holding company owns the IM and the RU.
- *Full bundle:* a unique firm operates infrastructure management and rail services.

Various vertical structures can be found in urban transit systems and in PPP designs. Horizontal separation could involve regional separation of operations, such as with different lines being awarded to different operators. Tables 1 and 2 present different combinations of vertical integration/unbundling and privatization. Table 1 shows metropolitan areas which operate vertically integrated systems. Row A of Table 1 shows examples of vertically integrated and state-owned systems such as the system in Paris. Similarly, most urban rail transit systems in the US are vertically integrated and state-owned. Shanghai and Taipei have resisted vertical separation and privatization and are fully public sector owned and operated.

Row B of Table 1 shows cities where the urban rail system is operated by a combination of public and private companies, such as in Tokyo and Seoul. The Tokyo system is a mixed system with some lines operated by the public sector and others by private vertically integrated companies which are conglomerate companies. Row C of Table 1 shows the Hong Kong MTR which is a privatised vertically integrated regulated monopoly in Hong Kong. It is a hybrid ownership company that is majority owned by the Hong Kong government and also listed on the Hong Kong stock exchange.

Both Tokyo and Hong Kong are exceptional in the degree of vertical integration as well as extent of privatization - both cities have vertically integrated privatized companies which are also involved in real estate developments served by rail transit. The advantages of vertical integration from rail to real estate development is evident from the discussion on LVC in the previous section and from the growing literature on transit oriented development. This organisation form was already utilised from the early twentieth century in Japan where both urbanization and urban rail development were driven by private railway companies which were able to develop real estate as a non-rail profit centre. During the post-war high growth period, Japanese private railways developed into powerful

Table 1
Vertically integrated urban rail transit systems.

Structure	Finance & build infrastructure	Finance and own rolling stock	Maintain infrastructure	Operate train services	Examples
A. Public sector vertically integrated	Public sector				US cities, Paris, Shanghai, Taipei
B. Coexistence of public and private vertically integrated, horizontally separated companies	Public sector Private sector conglomerates				Tokyo, Seoul
C. Privatised as vertically integrated monopoly including real estate development	MTR is listed on the stock exchange but Hong Kong government is the majority shareholder				Hong Kong

Table 2
Heterogeneity in separation structure of urban rail transit systems.

Structure	Infrastructure ownership and finance	Finance and own rolling stock	Maintain infrastructure	Operate train services	Examples
A. Public sector owns all assets, private sector operates and maintains	Public		Private		Stockholm, Latin American cities
B. London Infraco PPPs	Private	Public	Private	Public	London (2003–2010)
C. Predominately public sector owned and operated, with limited PPPs for selected lines/functions	Public	Some lines are run by private operators, others by public sector; this allows for useful performance comparison of lines operated by the public sector			Beijing, Hangzhou, Shenzhen Seoul, London, Bangkok
	Private DBFOs (selected lines)				
D. Public sector owns infrastructure assets, private sector owns rolling stock, operates and maintains	Public	Two private train operators			Singapore (2000–2016)

conglomerate corporations with wide range of real estate developments near stations (Cervero, 1998).

In contrast to the super-vertical integration of urban rail transit in Japanese cities and Hong Kong, vertically separated systems have been adopted in several other cities. Table 2 illustrates the heterogeneity of vertical and horizontal separation that have been utilised to facilitate PPPs in urban rail transit. Row A of Table 2 shows examples of systems where the public sector owns rail infrastructure and rolling stock assets and privatise operations and maintenance functions as in Stockholm. Stockholm's T-bana was a pioneer in vertical separation. Stockholm's metro operating concessions are designed to be of relatively short durations (5–10 years); the public sector company owns the infrastructure as well as trains, the operating company is responsible only for operations. In the mid-1990s, three separate operating franchises for three lines were offered for bidding on short 5 year contracts. In 1999, the model was changed to a 10-year operating franchise for unified operation of the system, with the French transport company CGEA winning the bid (White and Ball, 2002). In 2009, Hong Kong MTR won the concession to run the Stockholm metro for 8 years, with a possible six-year extension. The Latin American concessions which required the private sector to make or administer substantial investments were of longer durations of 20–25 years (Phang, 2007, 2009).

Row B of Table 2 shows the London Tube PPPs where in 2003, London separated out ownership of the infrastructure and awarded them to two private companies to upgrade and maintain. The infraco PPPs for the Tube ended in costly failure, with Transport for London (TfL) acquiring the failed concessionaire Metronet in 2007 (Vining and Boardman, 2008) and the second PPP contractor Tube Lines in 2010. The failed London infracos (2003–2010) remain the sole example of vertical separation where the urban rail transit infrastructure was separated and privatized through PPPs.

Row C of Table 2 shows mixed systems for cities which have experimented with PPPs selectively. The government remains the key driver but introduces PPPs for one or more lines. The government may retain ownership and financing of infrastructure and may award one or more lines to the private sector to operate. It may award a line to be built as a Design-Build-Finance-Operate PPP while retaining the existing system within the public sector. As such, some lines are operated by the public sector while other lines are operated by PPPs. There are numerous examples of such mixed systems where PPP operations co-exist alongside public sector operators. Cities with such mixed systems include Beijing, Hangzhou, Shenzhen, Seoul, London and Bangkok.

In China, Beijing Line No. 4 was the first rail transit PPP which was built in time for the 2008 Olympics (Chang, 2013). The private sector partner is the Hong Kong MTR. Beijing No. 4 Metro Line PPP has become the model followed for other urban rail PPP projects in China, such as in Hangzhou and Shenzhen. In 2009, the Seoul Metropolitan City government granted a PPP to build and operate Line 9 (one of nine Seoul lines) to a consortium of private companies (Hong, 2016). The other Seoul lines as well as Korea's urban rail transit systems in another five cities are owned and operated by the public sector. Vertically integrated Design-Build-Finance-Operate PPP strategy to procure new lines (especially light rail-light metros) has also been used in several other cities such as London and Bangkok (Phang, 2007, 2009; Mandri-Perrott, 2010).

In contrast to mixed public and PPP rail systems shown in Row C of Table 2, Row D shows the case of Singapore which has relied exclusively on private sector companies to operate trains services (see Section 3.3).

How are we able to understand and explain the mixed empirical evidence for vertical structures in the urban rail transit sector as show in Tables 1 and 2?

In the vertical integration literature of the firm, two leading theories are the transaction cost approach of Williamson (1975, 1985) and the property rights approach of Grossman and Hart (1986). Hart (2003) also highlights the close parallel between the theory of the firm and the theory of privatization in the aspect of vertical integration as both are concern with whether to regulate a relationship via an arms-length contract or via a transfer of ownership. While the theory of firm takes an 'incomplete contracting' perspective in which inefficiencies arise because it is hard to foresee and contract for all possible outcomes for the long term, the focus of the theory of privatization has focused more on moral hazard and asymmetric information.

The arguments in favour of vertical separation, using Williamson's theory, include the following: separation facilitates competition in the non-monopoly segment. It follows the practice in other transport sectors, such as separation of airport from airlines, railway tracks from railway companies. It allows companies to specialise and it facilitates greater transparency of capital costs for

regulatory purposes. It also facilitates privatization (which, according to Preston (2002), should be considered a political rather than an economic advantage in the British context).

However, from both the transaction costs and property rights perspectives, there are equally strong arguments against vertical separation. Both theories emphasize incomplete contracts and opportunistic behaviour from relationship-specific investments. With a fragmented system, there could be loss of economies from higher coordination costs. If there is greater asset specificity and holdup is costly (which is certainly the case for urban rail transit), then vertical integration should be favoured from the transaction costs perspective. The property rights approach on the other hand focuses on incomplete contracts resulting in bargaining power bestowed by ownership and control of key assets. The ownership of assets becomes a way of allocating residual rights of control not specified in the incomplete contract and thus affects ex ante investment incentives. Safety and quality of service could also be compromised if transfer of ownership via privatization affects incentives to invest.

Helm and Thompson (1991) have argued that where industries have sunk costs, if price cap regulation is utilised, it may contribute to under-investment. This applies to capital investment in new lines, station redevelopment, track capital investment as well as rolling stock investment. There could be information asymmetry between regulators, infrastructure owners and multiple train operating companies that can be undesirable. The failure of Railtrack in Great Britain as well as the failure of the London Underground Infracos serve to illustrate the challenges of vertical separation in privatization of railway and urban transit, respectively.

Amaral and Thiebaud (2015) use the French rail sector example to identify *coordination costs* as a drawback of separation. They develop a model to explain why inefficient outcomes may arise when vertically separated firms have to commit *ex ante* on quantities. Their results indicate that credible and effective price regulation can overcome the limits of separation on the infrastructure side. However, if the market is not flexible enough, and as the downstream market becomes more competitive, it may be harder for railway undertakings to sustain an equilibrium with high output.

White and Ball (2002) review practices in Europe and find the dominant structural model for European Metros to be the vertically integrated monopoly entity. For cities with more than one metro company, separation tended to be horizontal rather than vertical. There are examples of part of services being vertically separated, with a number of different models ranging from limited tendering to open competition for operations or infrastructure.

Japanese cities have had experience with both vertically integrated and vertically separated urban rail transit systems. In a study of the vertically separated Kobe rail transit system, Mizutani and Shoji (2004) conclude that vertically separated systems do not have significant advantages over vertically integrated systems in terms of maintenance costs of infrastructure.

In their survey of railway structural separation policies in 23 OECD countries from 1994 to 2007, Mizutani and Uranishi (2013) find massive (passenger-freight and regional) horizontal separation to have been adopted in UK and Japan, vertical integration to be the structure of choice in Japan while vertical separation is the common policy in the European Union. Many variations of vertical separation exist including functional accounting separation, organisational separation of rail and infrastructure, or organisational separation involving a holding company. They find that passenger-freight separation appears to lower a railway's costs, while the effects of vertical separation is dependent on train density of a railway organisation. Vertical separation with lower train density tend to reduce total cost of a railway organisation but as train density increases, vertical separation causes total costs to increase. In particular, governance costs for unbundled systems increase rapidly with higher density of usage as operations become more and more complex. The policy implication is that rail organisations with higher train density should choose to be vertically integrated to lower costs, while it may be preferable for those with lower train density to choose vertical separation.

The role of technology intensity in driving vertical integration could be another explanatory factor. This argument draws from Acemoglu et al. (2010) whose focus is on the relative importance of technological investments between a producer and supplier in a bilateral relationship in the context of manufacturing firms. Their framework highlights that backward vertical integration gives greater investment incentives to the producer, while forward vertical integration encourages supplier investment. A higher importance of producer's technology intensity should increase the probability of backward integration, and a higher importance of supplier's technology should reduce that probability.

These insights for vertical structure of firms in the manufacturing sector can provide insights into variations in vertical structure and urban rail PPP designs that have developed in different cities. In the urban rail transit sector, we can consider the producer to be the real estate owner or developer, the supplier to be the urban rail service provider. In cities where real estate density is much lower, such as Stockholm and other European cities, the technology intensity as well as LVC benefits of real estate developments are diffused and may not be greater than the technology intensity of urban rail services, thus reducing the benefits and probability of integration. In East Asian settings, the very high density of real estate developments and large LVC benefits imply high technology intensity of the real estate producer relative to urban rail service provider and increases the probability of vertical integration between real estate and urban rail service provider. The real estate company integrates backward to own the railway company (the upstream supplier) to encourage investment in rail accessibility.

3. PPP design and performance of urban rail in selected East Asian cities

Despite several common characteristics, East Asian cities have adopted different models of private sector participation in urban rail development and operations. In this section, we review the experiences of Tokyo, Hong Kong, Singapore and Beijing to illustrate different PPP approaches, with particular focus on fare revenue risks, land value capture strategies and vertical structure of the rail sector and their impact on performance of the urban rail sector.

3.1. Tokyo

The Tokyo-Yokohama metropolitan area is the largest urban agglomeration in the world with an estimated population of 38 million. Covering a land area of 8500 square kilometres, the average population density is around 4400 per square kilometres (Demographia, 2016). Rail is the primary transport mode and the Tokyo rail network consists of more than 3500 kilometres of dense and highly integrated commuter rail and subway lines. Tokyo is served by 48 rail transit companies operating public, semiprivate, private and privatised passenger lines (Suzuki et al., 2015). The subway system is primarily run by two operators – Toei Subway which is owned by the Metropolitan Bureau of Transportation, and Tokyo Metro which was privatized in 2004. The subway system is only a fraction of Tokyo's heavy rail transit network. The privatised East Japan Railway Company (JR East) is the biggest rail operator in Tokyo. Several other private railway companies also operate in Tokyo, of which the major ones are Keiyu, Keio, Keisei, Odakyu, Tobu, Seibu, and Tokyu.

Fare regulation: Rail operators require a government licence to operate and all fares and fare adjustments require the approval of the Minister of Land, Infrastructure and Transport. The Ministry approves a fare cap or ceiling based on the full cost recovery principle plus a yardstick competition scheme. The rail fare should cover costs and private railway companies are not expected to receive subsidies. Under yardstick regulation, the Ministry benchmarks costs using three categories of rail services: major private railways, Japan Railways, and subway systems (Shoji, 2005).

As rail fares are regulated and kept at affordable levels, railway companies found it necessary and were also encouraged by the government to expand into other businesses in order to remain profitable. Private conglomerates such as Tokyu, Odakyu, Keio and Seibu started as railway companies and developed into rail based conglomerates with businesses in real estate development, retail, bus operations, hotels, sports stadiums, amusement parks, electrical power generation, etc. (Cervero, 1998). This has allowed Tokyo's railway companies to cross-subsidise low profit railways and bus enterprises with profits from real estate development. The strengthened balance sheet from real estate profits allow rail expansion financing on favourable terms and within the consortia themselves, if necessary.

Land value capture: As land and most railway companies are private-owned, the instruments used for urban rail development are consensus and market-based. Although different LVC techniques are applied in different cases, the two main instruments used are through *land readjustment* and *urban redevelopment schemes* (Suzuki et al., 2015). Land readjustment is usually applied in urban fringes, where property rights are fragmented. The development entities acquire irregular agriculture land at lower prices but return smaller but fully serviced residential and commercial land parcels to the original owners. The 'surplus' land is used to develop public services such as roads, open space, sidewalks or sold to developers to cover part of development costs. Generally, the government will need to subsidise some development costs, however, there are substantial land acquisition cost savings. The land readjustment method is more horizontal based without significant increase in FAR. After one or two generations, the original urban edge could become sub-centres of cities.

New infrastructure is needed to facilitate high density districts in more central areas of the city. Development entities apply LVC through the urban redevelopment schemes to finance urban transit. Urban redevelopment LVC is more vertically based. The city planner generally increases the FAR for the redevelopment land and change the land use to mixed use. The new development projects will accommodate the original land owners, but also provide more residential, commercial or office space for sale or lease. The revenue can be used to cover redevelopment costs. Development entities need to offer strong economic incentives to original landowners, and more stakeholders will be involved. Certainly, the LVC through redevelopment scheme is more complex and time-consuming as compared to land readjustment. The income contributions from LVC (real estate, business services, etc.) vary among transit companies, mostly ranging from 20 to 60 percent (Suzuki et al., 2015).

Industry structure: In summary, the Japanese urban rail transit development explicitly recognises the land value increment benefits brought about by rail. City planners have successfully implemented the co-development of rail and new communities that involved private sector consortiums of various sizes. Most are vertically integrated, providing service operation on infrastructure they owned. Most also engage in a multitude of other businesses in the vicinity of rail lines to increase their rail ridership. This has allowed the positive benefits created by rail to be internalized to directly fund rail development. Fares are regulated and private consortiums are able to cross-subsidise their less profitable rail business with other more profitable businesses that rely on the passenger movement generated by the railway line. The physical integration of rail stations with the surrounding real estate development is also much more seamless when both are jointly owned. It is apparent from rail and real estate developments in Tokyo that the motivations for relentless super vertical integration are much stronger when firms are private rather than public.

3.2. Hong Kong

Hong Kong is one of the most densely populated place in the world. By 2015, 7.32 million residents lived in a total land area of 1108 square kilometres. As 80% of the city is mountainous, the built up area only accounts for 24% of the total land area, and only 7% of that area is for residential uses (Planning Department of Hong Kong, 2015). Due to the limited land and high population density, the government promoted public transportation and controlled the growth of private cars by charging various fees and taxes as well as limiting car parking spaces (Tang and Lo, 2008). By 2015, there were 567,886 licensed private cars in the city (Transportation Department of Hong Kong, 2015), and this number is only 7.8% of Hong Kong's population.

Over 90% of daily trips are by public transport which includes buses, urban railway, tramways, ferries etc. The average daily number of passenger trips by public transportation was 12.6 million in 2015, with around 43% of those trips by rail (Transport Department of Hong Kong, Annual Transport Digest 2016). The government plans the urban rail transit system, while the railway

lines are built and operated by the Mass Transit Railway Corporation Limited (MTRCL), a quasi-private transit company with 75% of the company's shares owned by public. To date, the railway network in Hong Kong includes 11 lines with route length of 249 km and 158 stations.

Fare regulation: Profits from rail transport operations are mainly from fare revenue, and these have grown steadily over the years. The adult fares range from HKD 3.6 to HKD 52.6 depending on distance. Fares for the Airport Express Line are significantly higher. Concessionary fares are usually half the adult fare applied to child and senior citizen. MTRCL has also offered concessionary fares for the disabled since 2009. The fare rate is adjusted every year, based on three factors: fares to reflect Hong Kong's economic conditions, address public concerns on affordability, and generate sufficient revenues to support railway operations. The government imposes a fare adjustment formula that caps the overall annual fare increase based on the following formula:

$$\text{Fare Adjustment Rate} = (0.5 \times \text{CCPI}) + (0.5 \times \text{NWI(TS)}) - \text{Productivity Factor}$$

where:

- CCPI is the year-on-year percentage change in composite consumer price index.
- NWI(TS) is the year-on-year percentage change in nominal wage index for the transport sector.
- Productivity Factor is a pre-determined factor (set at 0.6% for 2013 to 2017).[4]

In 2015, the median monthly income for all employees in Hong Kong was HKD 15,500 (Hong Kong SAR Government Census and Statistic Department, 2015). The 2015 average fare rate per trip for domestic service and Airport Express were HKD 7.49 and HKD 60.42 respectively.[5] The current fare rates are considered affordable for most residents.

Land value capture: Land is owned by government and developers acquire leasehold land for development through public auctions or tenders. Urban transit development projects come under the Rail Plus Property (R + P) system rather than leasehold system. The MTRCL acquires the development right over the land around or on top of railway stations with a market price before 'rail', and sell or lease the completed development projects at the market price after 'rail' (Cervero and Murakami, 2009). Through implementing R + P programs, MTRCL has been able to capture the land value increment due to the accessibility and agglomeration benefits brought by railway projects. MTRCL often builds a partnership with private developers for property development in the catchment area of railway stations. Both parties share development revenues and costs, and the sharing schemes are negotiated on a case-by-case basis. As a result, near 60% of MTRCL's annual net profits in recent years has been from LVC.

Industry structure: Hong Kong's R + P urban transit organisation structure can be considered to be modelled after Tokyo's super-vertically integrated railway conglomerates – except that the MTRCL is the owner and operator of the entire railway network. Historically, there were two railway operators in Hong Kong - the Kowloon Canton Railway Corporation (KCRC) and MTR Corporation (MTRC). The KCRC primarily provided transit service for the suburban area and accommodated the growing population in new town developments (Jain et al., 2008). MTRC provided efficient transit services mainly in the urban area. Although owned by the government, both corporations operated under prudent commercial principles and often undertook real estate development over stations and captured the land value increment. By the end of 1990s, MTRC had become one of the most efficient and profitable railway systems in the world.

To further promote efficiency and introduce market discipline to the running of railway, the government made preparations to partially privatize MTRC in 1999. In February 2000, the legislature approved the Mass Transit Railway Ordinance under which all the asset and liabilities of MTRC would be vested into a limited company MTRCL, which was awarded an exclusive franchise for 50 years.[6] The government was required to hold at least 50% of shares in the next 20 years. In October 2000, the privatized MTRC was listed on the Hong Kong Stock Exchange. The offer price was set at between HKD 8 to HKD 9.38 and the price soared to HKD 13 on the day the stock began trading (Ho, 2001). Through selling 20% of the company, the government raised over HKD 10 billion.

The government still holds 75% of the company's shares as of September 2016. As the biggest shareholder, the government can direct the PPP firm to work for the broader public interests. The government can appoint the CEO and determine the board composition. The Stock Exchange of Hong Kong has also granted a special waiver for MTRCL not to be strictly in compliance with the rule applicable for other commercial entities for transactions involving the government. The partial privatization also facilitated MTRCL's entrepreneurship and overseas involvement in metro construction and operations.

In 2007, KCRC was merged with MTRCL, and the entire railway network was integrated into the quasi-private firm. Since then, MTRCL has become one of the most important entities in Hong Kong; it provides high quality transit services, promotes Transit Oriented Development as well as new town development, and shapes the landuse landscape in Hong Kong. The recent stock price of MTRCL (Aug-Oct 2016) was around HKD 43 per share.[7] The company's revenues are from fares, LVC, and its global business operations. Table 3 summarizes the main sources of MTRCL's profits.

MTRCL's profits from LVC include property development, property rental and management, and Hong Kong station commercial

[4] See Hong Kong SAR Government Transport Department website at: http://www.td.gov.hk/filemanager/en/util_uarticle_cp/fam%20-%20consultation%20paper%20-%20e%20-%20final.pdf.

[5] MTR Annual Report 2015 at Hong Kong MTR website: http://www.mtr.com.hk/archive/corporate/en/investor/MTR_2015%20Annual_Eng%20analyst%20(slide)%20Final.pdf.

[6] Details of the arrangements can be found in the legislative council brief (Mass Transit Railway Bill), see http://www.legco.gov.hk/yr99-00/english/bc/bc01/general/bc01_brf.htm.

[7] See MTRCL website at: http://www.mtr.com.hk/en/corporate/investor/shareservices.html.

Table 3
Hong Kong MTRCL: Operating profit contributions (2011–2015).
Source: MTRCL Financial Highlights. Access at: http://www.mtr.com.hk/archive/corporate/en/investor/images/MTR042_Operation%20Profit.pdf.

	2011	2012	2013	2014	2015
Transport Operation (HKD Billion)	6.2	6.5	6.7	7	7.2
Property Development (HKD Billion)	4.9	3.2	1.4	4.2	2.9
Property Rental and Management (HKD Billion)	2.5	2.8	3.1	3.4	3.7
Commercial Business (HKD Billion)	3.1	3.3	4.1	4.5	4.8
Global Business	0.4	0.6	0.8	0.8	0.6
Others	0.1	0.1	0.2	0.2	0.1
Total Profits (HKD Billion)	17.2	16.5	16.3	20.1	19.3

business. Profits from property development varies each year, depending on the scale of development projects. Profits from property rental and commercial business in stations have increased steadily along with the size of MTRCL's property portfolio. Overall, profits from LVC contribute 50–60% share of total profits in recent years, with the revenues also dependent on the health of the real estate market.

The third part of the company's profits is from its global business. From 2007, MTRCL began providing railway services in Mainland China and cities in other countries. By the end of 2015, MTRC was operating 11 railway lines in Beijing, Shenzhen, Hangzhou, London, Stockholm, and Melbourne under various PPP arrangements. Another 4 lines in Beijing, Stockholm and Sydney are under construction and preparation (MTR Annual Report 2015). Indeed, revenues from its global business accounted for over 30% of total revenues since 2010. As MTRC needed to provide equity investment in several PPP lines, its profits from global operations are relatively small and exposed to exchange risks. As more lines begin operations, MTRC's global business is likely to contribute more significantly to its profits.

Overall, the financial performance of MTRCL is robust and sound. Its business portfolio is diversified through LVC and through its global business. The local fare revenue is relatively stable without much risk. LVC profits are currently 60% of total profits, though LVC profits are dependent on the health of the real estate market. MRTCL's excellent financial performance has generated benefits for the general public in the form of affordable fares as well as contributions to government coffers. As the biggest shareholder, the government still holds over 4.434 billion shares in 2016. Based on the annual dividend per share since 2000, we estimate that the government received a total HKD 51 billion in nominal dividend income.[8]

Besides direct financial benefits for the public, MTRCL has also generated social benefits though the magnitude of this is hard to quantify. Urban rail trips as a percentage of all public transport trips increased from 31.4% in 2001 to 42.5% in 2015.[9] The increased ridership on MTR is associated with a reduction in air pollution, road congestion, and energy consumption. The Transit Oriented Development (TOD) promoted by MTRCL increased density and reduced sprawl. The improved accessibility and amenity created in TOD districts led to appreciation in land values. Cervero and Murakami (2009) provide evidence of rent premiums around three MTR stations. Rent premiums is a good measure of the highest and best use of land development created by MTRCL.

In summary, the success of MTRCL depends on the super vertical integration of the R+P system. At the city level, the extraordinary density requires an efficient transportation system. By integrating transport and land use planning, railway was viewed as the backbone of the public transit system. Indeed, MTRCL serves as the intermediary between the public and private. Due to its dominant public position, it serves broader public objectives on town planning, promotes TOD, and provides transit services at affordable rates. Through R+P, MTRCL integrated the railway into residential and commercial developments. This integration creates synergy between property development and railway patronage. MTRCL captures the land value increment through property development and management, and provides better accessibility for residents living in properties adjacent to stations. Several modern shopping malls within stations are attractive for both local and non-local consumers. Both residents and consumers in turn increase the patronage of MTRCL. The enormous value created by MTRCL has to be attributed to public sector dominance in this super vertically integrated PPP design.

3.3. Singapore

Singapore is an island city-state with a land area of about 718 square kilometres and a population of 5.5 million. It was a former British colony which became self-governing in 1959, joined the Malaysian federation in 1963, and became an independent republic in 1965. Singapore was the first city in the world to introduce road congestion pricing in 1975 and a motor vehicle ownership quota in 1990 (Phang, 2014). The resulting high costs of motor vehicle ownership and usage has resulted in public transport being the default mode choice for the majority of commuters.

Fare affordability, quality, and reliability of public transport services are therefore very important for the majority of residents and accorded much policy attention. The rail network, currently about 200 km, will be extended to 280 km by around 2020. The Land Transport Authority (LTA), a Ministry of Transport agency, plans, finances, builds and owns the rail infrastructure. Train

[8] The dividend history of MTRC can be found at: https://www.mtr.com.hk/en/corporate/investor/shareservices.html.

[9] The share of railway trips in total public transit trips is calculated from data in government reports for various years. Access at: http://www.td.gov.hk/en/publications_and_press_releases/publications/free_publications/annual_transport_digest/index.html.

Table 4
Singapore's Public Transport Council fare cap regulation.
Sources: Looi and Choi (2016, pp. 93–99), Phang (2016), Gomez-Ibanez and Gan (2016) and Singapore Public Transport Council (https://www.ptc.gov.sg/).

Year	Fare cap formula	x%	Fare cap	PTC approved increase%		
				Bus	Rail	Overall
1998	CPI + x	2.0%	4.0	Nil	Nil	Nil
1999			1.7	Nil	Nil	Nil
2000			2.4	1.5	2.4	1.7
2001		1.5%	2.8	1.3	Nil	1.0
2002			2.5	2.2	2.5	2.3
2003			1.1	Nil	Nil	Nil
2004			2.0	Nil	Nil	Nil
2005	0.5 CPI + 0.5 WI – x	0.3%	2.4	2.4	2.4	2.4
2006			1.7	1.7	1.7	1.7
2007			1.8	1.8	Nil	1.1
2008		1.5%	3.0	0.7	0.7	0.7
2009			4.8	−1.9	−1.3	−1.6
2010			−2.5	−3.1	−1.9	−2.5
2011			2.8	1.6	0.3	1.0
2012			No fare increase due to fare review			
2013	0.4 cCPI + 0.4 WI + 0.2 EI - x	0.5%	6.6[a]	3.2		
2014			2.8[b]	2.8		
2015			−1.9	−1.9		
2016			−5.7	−4.2[c]		
2017						

Notes: CPI refers to the change in the consumer price index in the preceding year.
WI refers to the change in the national average monthly earnings in the preceding year, adjusted for any change in the employer's contribution to the Central Provident Fund.
cCPI refers to Core CPI which excludes items such as housing prices, cost of private transport, and items accounted for in the Energy Index.
EI is an energy index for tracking energy cost changes.
[a] Combined cap of 2012 and 2013, 3.2% awarded in 2013 with 3.4% rollover to 2014.
[b] 2.8% comprises 3.4% rollover from 2013 plus −0.6% for 2014.
[c] With −1.5% rollover to 2017.

operating and maintenance (including infrastructure maintenance) licenses have been awarded to two companies, SMRT and SBS Transit.

Fare regulation: Transit fares (for both rail and bus) are regulated by the Public Transport Council (PTC), an independent public agency established by parliament in 1987. Since 1998, the PTC has utilised a price cap formula to regulate fare increases of transit operators. However, transit operators are still required to submit annual fare revision applications to the PTC each year, with the PTC having the discretion to approve the amount and structure of the increase. The price cap formula and the value of 'x' is valid for a fixed number of years and subject to periodic review. Table 4 shows the changes to the formula and to 'x', the resulting fare cap and the allowed fare adjustments over time.

Until the restructuring of the public transport sector beginning in 2015 to a government contracting model, the two private licensed transit operators were required to bear full fare-box revenue risks, with minimum standards for service delivery and universal service obligations regulated by the government agencies. In addition to fares being capped by the formula, actual fare increases are approved by the PTC and for the 14-year period, between 1998 and 2011, approved fare increase equal the cap permitted by the fare formula in only two years, 2005 and 2006 (see Table 4). Fare adjustment arrangements in Singapore exposed private sector operators to full revenue risks as well as policy risks when allowed fare increases often fell short of the cap. The PTC also face the regulatory challenge of having a single price cap to regulate two firms with different cost structures as the modal mix of bus and train as well as operations differed.

Land value capture: Like the Hong Kong government, the Singapore government is also the largest landowner and auctions land to private developers periodically through its government land sales programme (Phang, 1996; Hui and Ho, 2004). Unlike Hong Kong's MTRCL which is also a property development company, the Singapore operators did not have the same access to transit oriented real estate development opportunities. Singapore does not apply development based LVC directly for urban transit development - if we were to use a narrow interpretation. Instead, the public sector captures the land value increment largely through fee-based LVC including land leasing, property tax and development charge. Land sales revenues are channelled to a specific fund - "past reserves", and reserves are not permitted to be used to finance the current government's expenditure without the permission of the President.[10] The reserves are invested and 50% of net investment returns is taken into the government's general budget for spending. The rail infrastructure is built and owned by the LTA. The government finances LTA's budget including rail projects from its general budget

[10] The fiscal constraint on the current government was put in place in 1991 when the Singapore Constitution was amended to include an Elected President who, among other responsibilities, would have financial responsibilities regarding Singapore's reserves (Centre for Liveable Cities, 2014).

and there is therefore no direct link between urban rail financing and LVC.

Industry structure: In the late 1990s, Singapore restructured from a fully state-owned urban rail transit system to one where the ownership of infrastructure was separated from rolling stock and operations. In 1998, capital was injected into the state-owned operator SMRT to buy over the operating assets, and its licence to operate train services was extended via a new 30-year licence and operating agreement (LOA). In addition, a lease and maintenance agreement (LMA) was established between the SMRT and the LTA for the infrastructure such as stations, tracks, viaducts, and depots (Looi and Choi, 2016).

SMRT was listed on the Singapore stock exchange in 2000, becoming the first urban rail transit operator in the world to be privatised through a share issue privatization exercise. The government investment holding company, Temasek Holdings, however, retained majority ownership and control of the company. The restructuring was also horizontal as the concession to operate a new line (the North-East Line) was awarded to the dominant bus company SBS Transit in 1999 through a closed quality tender limited to the two incumbent bus operators (SBS Transit and TIBS). In 2001, the restructuring of the transit industry into a multi-modal duopoly was completed when the rail company SMRT acquired TIBS (Phang, 2007). In 2002, the government further amended the Rapid Transit Systems legislation to strengthen its regulatory powers over rail licensees (Looi and Choi, 2016). This licensing model replaced the earlier LOA contractual arrangement and gave the government legislative powers to modify licence terms and conditions.

Privatization and subsequent leadership changes at SMRT however contributed to weaknesses in the rail system. In 2002, a CEO with retail sector background and no previous experience in urban rail transit operations was appointed. The leadership change led to SMRT's new focus on conversion of previously underutilised spaces at stations to retail and commercial spaces. The result was a significant increase in profits from rental of station properties for SMRT. The increased profitability of the SMRT however contributed to a reluctance by the PTC to grant fare increases for rail (see Table 4). For the decade between 2003 and 2012, there were 2 years of decreases, 4 years of zero increase, 2 years of below 1% increase for rail fares.

Rapid population increases from 4.4 million in 2006 to 5.2 million by 2011 placed a major strain on transit services. Overcrowding in buses and trains, with far longer than expected waiting times during peak hours caused much unhappiness amongst commuters. On 15 Dec 2011, SMRT experienced its first major breakdown affecting about 127,000 commuters. A second major breakdown two days later caused the Prime Minister to launch a Committee of Inquiry (COI) to study the causes and emergency preparedness of SMRT to deal with breakdowns.[11] Amongst other findings, the COI report viewed LTA's regulatory oversight over SMRT's rail maintenance and capital improvement of infrastructure to have been inadequate.[12] Despite greater government attention since to increasing transit capacity and improving rail reliability, service breakdowns continued with 14 major disruptions in 2014 and an additional 29 disruptions in 2015 (Gomez-Ibanez and Goh, 2016).

On 15 July 2016, the government announced that LTA would pay SMRT S$1.06 billion for SMRT's rail operating assets.[13] As part of the agreement, the new licence was shortened to 15 years (Business Times, 16 July 2016). This announcement was followed less than a week later by the announcement that Temasek Holdings, the government's investment holding company, and SMRT's largest shareholder with a 54 percent stake, would spend S$1.18 billion to buy the remaining shares of SMRT and delist the firm (Straits Times, 21 July 2016). The offer was accepted by minority shareholders and SMRT was delisted on the stock exchange from 1 November 2016. Although this was communicated as taking SMRT 'private' through delisting, in effect it was the government resuming 100% ownership of SMRT through its investment holding company.

In summary, the Singapore government was able to capture land value increments from urban rail transit development through sale of state land leases and development charges for land use changes. However, there was no direct link between LVC and rail development as rail capital investments were financed through the government's general budget. The PPP structure vertically separated infrastructure from rolling stock ownership, operations and maintenance, privatising the latter. Strict fare cap regulation exposed the private sector operators to both costs and revenue risks. The rail sector does not capture land value increments directly and operators are also limited and unequal in their ability to cross-subsidise rail operations from rental profits. Frequent train breakdowns from 2011 eventually led to a major and ongoing restructuring of the rail sector. SMRT's sixteen-year history from 100% state-owned to a company listed on Singapore's stock exchange and back to fully state-owned corporation reveals weaknesses in the vertically separated PPP model used and is in stark contrast to Hong Kong's integrated MTRCL which has grown from strength to strength.

3.4. Beijing

Beijing, the second largest Chinese city, has a population of 22 million people in 2015. Like much of China, the city experienced rapid economic growth and urbanization in the past three decades. To facilitate the economic and population growth, the city's transportation system has undergone a major transformation in the past two decades. Its metro network has expanded rapidly since 2000. After winning the bid to host the 2008 Summer Olympics in the summer of 2001, the city government moved quickly to expand the city's metro system. As a result, Beijing's metro system quadrupled in length, from two lines at 54 km in 2000 to eight lines at 200 km by 2008.[14]

[11] These two major breakdowns led to the resignation of the SMRT CEO and the eventual appointment of a former Chief of Defence Force to lead the SMRT.

[12] See COI 2012 report at https://www.mot.gov.sg/news/COI%20report%20-%20Executive%20Summary.pdf.

[13] In a 2008 comprehensive review of the sector, the Land Transport Master Plan had proposed for rail operating licences to be shortened to about 15 years to provide a 'more effective threat of contestability to the incumbent operator', with the LTA owning the operating assets instead of the operators. This new framework was put in place for the Downtown Line operating tender in 2010. The LTA had also begun negotiations with the existing operators to re-purchase their operating assets.

Table 5
Beijing's population growth and metro network expansion.
Sources: Beijing Municipal Bureau of Statistics (http://www.ebeijing.gov.cn/Government/Departments/t1028337.htm); and Beijing Municipal Commission of Transport (http://www.bjjtw.gov.cn/).

	Population (million)	Metro route line (km)	Number of lines in operation	Annual passenger trips (billion)	Metro mode share in total trips
2000	13.6	54	2	0.4	4%
2005	15.4	114	4	0.7	6%
2006	16.0	114	4	0.7	6%
2007	16.8	142	4	0.7	7%
2008	17.7	200	8	1.2	8%
2009	18.6	228	9	1.4	10%
2010	19.6	336	14	1.8	12%
2011	20.2	372	15	2.2	14%
2012	20.7	442	16	2.5	17%
2013	21.1	465	17	3.2	21%
2014	21.5	527	18	3.4	19%
2015	21.7	544	18	3.3	25%

Note: The metro mode share in total transit refers to number of metro passenger trips among daily passenger trips.

During that period of rapid expansion and given increasing urban congestion and air pollution, Beijing shifted its policy to promoting public transportation rather than road expansion. The speed of Beijing's metro construction increased after 2008 due to fiscal stimulus policy adopted by the government in the wake of the global financial crisis. According to official statistics, Beijing's metro network expanded to 18 lines with 554 km of track in operation by 2015. Annual passenger trips for the metro network in 2015 reached 3.32 billion, with the metro mode share exceeding 20 percent of total trips. The city continues to build more metro lines, with a target of 30 lines and 1177 km network in operation by 2020.[15] Table 5 summarizes the city's population growth and metro network expansion since 2000.

Industry re-structuring: To prepare for the Olympics, Beijing restructured its metro regime in 2003. Three city-owned enterprises are responsible for metro investment, construction and operations (Wang, 2005). The Beijing government plays the leading role and is responsible for metro planning, regulation, coordination, and supervision. The Beijing Infrastructure Investment Corporation (BIIC) is responsible for metro finance and investment. As the Beijing government did not have sufficient resources to support massive metro expansion in early 2000, BIIC raised metro development funds through various channels, including bank debt, issue of corporate bonds, private equity, and through a PPP model (Chang, 2013).

To implement the PPP model in Beijing's metro system, the Beijing MTR Corporation (BMTRC) was founded in 2005. The joint venue company comprised three shareholders: BIIC, the China Capital Group (a state-owned enterprise for infrastructure development), and the Hong Kong MTR. As Chinese law requires that Chinese investors must hold at least 51% of the joint venture company, BIIC holds 2% of BMTRC shares, the China Capital Group holds 49%, and the remaining 49% is held by the private sector partner, the Hong Kong MTR Corporation.

The first PPP was implemented for the No.4 line in 2006. The No. 4 line is 29 km long and built at an estimated cost of RMB 15.3 billion. The total investment comprised two parts; the civil works and the rolling stock. The civil works component accounts for two thirds of the total investment, and was financed by BIIC. The second part (cars, signals, power systems) was financed, constructed and operated by the BMTRC. BMTRC bore the entire investment, operation and maintenance costs. After 30 years of operation, BMTRC is required to transfer ownership of the line to the public sector at no additional costs (Wang, 2005). By foregoing the operating revenue, the public sector saves on one third of the initial investment, as well as on-going maintenance and operating costs.

Fare adjustment: BMTRC receives all revenues from fares and advertisements. The public and private sector partners established a revenue and risk sharing mechanism for the operation of the No. 4 PPP line. Chang (2013) described this mechanism in detail. In brief, both partners agreed to a shadow fare price and shadow patronage, with these numbers to be adjusted every three years. Based on these figures, both parties established a revenue floor and ceiling. If the actual revenue is lower than the revenue floor, the public sector will subsidise BMTRC the amount up to the revenue floor. If the actual revenue is above the predetermined ceiling, the public sector partner will share the extra profit with BMTRC. In this way, BMTRC is able to reduce its demand risks - such as revenue risk from unfavourable fare changes and ridership risk from competition from other modes.

The PPP agreement for the No. 4 line was effective in 2006. In October 2007, the Beijing government adjusted the fare rate to a flat rate of 2 RMB per trip. Since then, the Beijing metro has incurred serious operating deficits. For example, the Beijing government provided subsidies of 3.69 billion RMB to the Beijing metro system in 2012.[16] However, the interests of BMTRC were protected by the PPP agreement, and BMTRC enjoyed profits from the operation of the No. 4 line.

Given the substantial operating deficit and the safety concerns raised by an overwhelmingly large number of passengers, Beijing readjusted the metro fare rate in December 28, 2014.[17] The new fare ranges from RMB 3 to 9 depending on the distance travelled.

[14] Beijing Statistical Year Book 2009.

[15] The National Development and Reform Commission approved Beijing's 2015–2021 metro development plan on Sep 14, 2015. See: http://www.sdpc.gov.cn/gzdt/201509/t20150929_753197.html.

[16] Jingxin News, January 23, 2013. Access at: http://money.163.com/13/0123/02/8LSCMQ0300253B0H.html.

Table 6
Existing PPP lines operated by Beijing MTR.
Source: Beijing MTR website (http://www.mtr.bj.cn/).

	Length (km)	Number of stations	Year operations started	Total investment (RMB Billion)	Private Investment (RMB Billion)	Duration of Operation and Maintenance Licence
No.4 line	28	24	2009	15.3	4.6	30 years
No.4 line extension (Daxing line)	22	11	2010	10.9	0	10 years
No. 14 line	47	37	2013	50.0	15	30 years
No. 16 line	50	29	2016	47.4	15	30 years

The average fare rate was estimated to be RMB 4.3 per trip,[18] an increase of over 115% from the flat 2 RMB rate. However, the number of passengers declined by just 4% in 2015 compared with levels under flat rate in 2014. The government enjoyed substantial savings from the reduction in subsidies for the metro. BMTRC's operating net profits (after tax) increased from 185 million HKD in 2014 to 236 million HKD in 2015, despite a 4% decline in the number of passengers.[19]

Under the PPP arrangement, the private sector was given strong incentives to reduce costs. Chang (2013) provides detailed illustrations of how the BMTRC reduced its financial and operating costs. Cost savings, however, has not been at the expense of quality of services provided. The private sector brought HK MTRC's professional rail management expertise into the operation of the No.4 line. For instance, the actual punctuality rate of the No.4 line was 99.4%, compared with 90% on other public sector operated lines. Beyond the social benefits, Chang (2013) estimated savings at 9.4% of expenses by using PPP model for the No. 4 line. Also, the PPP line was likely to have generated knowledge spill-overs to other public sector operated lines, resulting in cost savings and service improvements through better management. Given the win-win situation for the PPP on the No. 4 line, more PPP lines were implemented by Beijing MTR with similar revenue and risk sharing arrangement between public and private, as shown in Table 6.

In summary, the urban rail PPP model used in Beijing was viewed as successful. The entire metro system is under the control of the public sector. The PPP joint venture company also has a public nature, as 51% of BMTRC's shares are held by public entities. This facilitated the vertical integration of the PPP line into the overall network, and all lines share the same fare scheme to avoid price competition between the public sector and PPP lines. The revenue and risk sharing scheme is also crucial for the success of the Beijing metro PPP arrangement. By transferring the revenue risk, the private sector was incentivise to improve on the quality of service to attract more passengers. Indeed, Hong Kong MTR brought entrepreneurship into metro operations and management, with social and financial benefit spill-overs for the public sector and commuters. However, unlike Hong Kong, there is no explicit link between LVC and rail development. If Beijing further adopts LVC for urban rail development, the PPP model in Beijing will bring even more benefits.

4. Lessons learned from East Asian cities

East Asian cities have had diverse experiences in involving the private sector in urban rail transit development and operations. Tokyo, Hong Kong and Singapore have had decades of experience, while Chinese cities are mostly new-comers. In cities where the public sector does not have the necessary expertise in urban rail development and operations, an experienced private sector partner can help provide expertise, reduce learning and operating costs and improve efficiency. At the same time, public sector companies operating alongside private sector companies are able to learn from the practices of private companies such as has happened in Beijing, Hangzhou, and Shenzhen.

The experiences of East Asian cities in urban transit systems show that urban rail PPP performance is sensitive to successful land value capture. LVC can be an important revenue source to support urban rail development. Many cities in East Asia have favourable conditions to apply LVC instruments to finance urban rail developments given their high population densities. The fundamental difference of LVC instruments as applied in Hong Kong and Tokyo is largely due to differences in land ownership. However, LVC also depends on local public policy contexts given similar land leasehold systems in Hong Kong, Singapore and cities in Mainland China. The experiences of Hong Kong and Tokyo suggest that private participation in development-based LVC could further enhance land values as the private sector has strong incentives to work with the public sector to integrate the development projects with the city's existing and future land use plans. Certainly, successful LVC is also dependent on organisational structure as well as management expertise.

While fare revenue is important, it is subsidiary to other sources of financing over time. In particular, a vertically integrated PPP that extends into real estate development as well as fare adjustment mechanisms impact upon revenue risks and long run sustainability. 'Super-vertically' integrated systems such as have evolved in Japan and Hong Kong have been able to generate multiple streams of revenue for cross-subsidisation of urban rail operations. However, these private-owned and operated vertically integrated systems have evolved organically in a complex historical context that are not easy to replicate in other settings.

[17] China News, December 28, 2014. Access at: http://www.chinanews.com/gn/2014/12-28/6917334.shtml.

[18] Beijing Times, Oct 29, 2014. Access at: http://epaper.jinghua.cn/html/2014-10/29/content_138189.htm.

[19] In 2014 and 2015, the exchange rate of RMB to HKD was around 1:1.22. Figures are from the Hong Kong MTR 2015 Financial Reports. Access at: http://www.mtr.com.hk/en/corporate/investor/financialinfo.html#02.

Table 7
Fare regulation, LVC and vertical structure in 4 East Asian cities.

	Fare regulation	LVC	Vertical structure
Tokyo	Yardstick regulation	Development-based	Super R + P vertical integration
Hong Kong	Price cap	Development-based	Super R + P vertical integration
Singapore	Price cap, operators bear revenue and cost risks. In transition to contracting model for rail and bus operations that will eliminate revenue risks.	Land use fee-based. LVC by government and not by rail agencies.	Vertically separated. In transition to greater vertical integration with asset back-buy by government.
Beijing	Fares determined by government with subsidies. PPP operator is shielded from patronage and revenue risks through use of shadow fare and shadow patronage.	Likely to apply both in future	Vertically integrated public-owned coexisting with vertically integrated PPP lines.

Singapore's experience illustrates that vertical unbundled PPPs could cut off avenues for cross-subsidisation, reduce information flows as well as economies of scale and scope, introduce principal agent problems, and result in underinvestment in capital stock and maintenance. Reliance on farebox recovery alone to finance operations for overly long in Singapore's case also contributed to systemic weaknesses in the urban metro system.

Overall, our case studies show clearly that fare regulation, land value capture mechanisms and vertical structure are not stand alone policy decisions but interact in important ways that impact on rail performance and sustainability. Table 7 summarizes how vertical structure, LVC mechanisms and fare regulation differ in these four cities.

Despite differences in ownership structures, Tokyo, Hong Kong and Beijing have essentially adopted vertically integrated systems. The super-vertically integrated R + P systems ensure that both metro development (as well as operations) and real estate development (and operations) are fully in sync with city planning, which is vital for successful development based LVC. Both vertical integration (city planning level rather than PPP level) and development based LVC work synergistically to maintain or create stable passenger flows, which can increase the fare revenue.

East Asian cities' large populations and high densities imply that systems tend to be heavy metros rather than light rail-light metro systems. Co-ordination of heavy metros operation is highly complex especially given the high train densities in East Asian cities. The technical complexity of large and high density networks favours vertical integration. The super integrated system not only reduces coordination cost, but more importantly facilitates highest and best land use decisions, promotes public transit usage and reduces gridlock, externalities and uncertainty.

The experiences of East Asian cities lend support to arguments that favour vertically integrated rail transit systems as opposed to vertically unbundled systems. How to integrate land value capture and fare adjustment mechanisms, and how the incentives of private sector partners can be better aligned with the public sector partner through these mechanisms need to be considered carefully in PPP design. We conclude that the optimal structure for heavy metros is a vertically integrated public-owned and driven system, with the public sector entering into selective partnerships with the private sector where risk sharing is clearly defined and allocated.

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