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Managing the accessibility on mass public transit: The case of Hong Kong

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Abstract: Public transit services (PTS) improve mobility and accessibility, and reduce car dependence. Ideally, PTS also should be financially sustainable, with affordable fares and expedient quality. The success of PTS in improving accessibility is reflected by their level of patronage: do travelers choose to use them in lieu of their private cars? PTS in Hong Kong are renowned for their quality and profitability, superbly addressing the accessibility needs of the city; they carry over 90 percent of the area's 11 million daily trips. A comparison of the per capita train-car and bus-vehicle kilometer run of PTS in Hong Kong with those in London and Singapore, however, suggests that it is not purely the supply that affects the use or accessibility of PTS in Hong Kong. By tracing and analyzing the development of PTS in Hong Kong over the past two decades, we found evidence that the high level of accessibility on mass public transit in the territory can be attributed to several factors: land use policies that encourage the development of compact, high-density townships, accompanying transport policies that grant high priority to the development of mass transit facilities, and additional government actions that ensure the financial viability of privately operated PTS, especially the innovative approach of integrating the development of public transport facility and property so as to exploit their synergy. In this paper, we study and highlight elements that contribute to the development of high accessibility on mass public transit in Hong Kong.

Keywords: Public transport; Sustainability; Public transport policies.

1 Introduction

Public transit services (PTS) are important assets to any major city. They improve mobility and accessibility while reducing car dependence and hence the need for further highway expansions. For PTS to be attractive alternatives to private cars, however, their performance in terms of waiting time, travel time, transfer time, point-to-point

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connectivity, etc. must be satisfactory to the public. Ideally, PTS also should be financially sustainable, with affordable fares and expedient quality. In the end, the success of PTS in improving accessibility is reflected in their level of patronage: do travelers choose to use them in lieu of their private cars?

PTS in Hong Kong are renowned for their quality and profitability, superbly addressing the accessibility needs of the city. Not only do PTS in Hong Kong provide virtually complete coverage of the territory, they also carry over 90 percent of the area's 11 million daily trips. From a user's perspective, according to the Travel Characteristics Survey in 2002 (Transport Department, 2003), the mean journey time for public transport trips (excluding taxi trips) was 43 minutes, more or less unchanged over the past ten years despite substantial increases in the number of longer-distance cross-district trips (about 50 percent or 1 million more) as people have migrated to suburban areas. This mean journey time was about the same as that of bus journeys in London, but was 20 percent to 70 percent shorter than rail journeys in London (Transport for London, 2005). Furthermore, in Hong Kong, the mean walking time between the origin (destination) and the location of boarding (alighting) the first (last) mechanized transport was only four minutes and the time needed to transfer between different mechanized transport modes or trip legs was three minutes (Transport Department, 2003). As for fares, it costs on average about HK$0.35[1] per minute[2] to ride the Mass Transit Railway (MTR) in Hong Kong. Relative to the median monthly income of HK$10,000 (Census and Statistics Department, 2006), that cost is about 10 percent lower than the average per minute cost of sample trips on the Tube around Central London, or 60 percent lower than the Mass Railway Transit in Singapore, based on the median monthly income of £2,092 in London (Office for National Statistics, 2006) and the median monthly income of SGD$1,064 in Singapore (Singapore Department of Statistics, 2006). Incidentally, the accessibility on public transport is so good that most people in Hong Kong do not own private cars; they do not need to. Hong Kong's car ownership of 50 cars per 1,000 people is only about 10 percent of the United States', despite a comparable level of gross domestic product (GDP) per capita.

Studying the supply of PTS in Hong Kong, however, might not reveal the services' superior contribution to the high level of accessibility in the territory. In fact, the supply of PTS in Hong Kong, in terms of train-car or bus-vehicle kilometers run per capita, is comparable to supplies in other major cities having well-established PTS, such as London and Singapore (Table 1). In particular, on a per-capita basis, London provides more rail services and more combined rail and bus services than Hong Kong, and the supply of bus services in Singapore is close to that of Hong Kong. Yet neither

[1] Exchange rate: US$1 = HK$7.8

[2] Calculated based on trips on the Mass Transit Railway (MTR) from the Tseung Kwan O (TKO) new town to the urban centers.

the PTS in London nor those in Singapore come close to the modal share as in Hong Kong, as reflected in the percentage of total passenger-km traveled on mass public transit shown in Table 1. These figures suggest that it is not purely the supply, in terms of vehicle- or car-kilometers run per capita, that determines the use or accessibility of PTS in Hong Kong.

Table 1: Rail and bus service supply per capita in 2004.

	Hong Kong	London	Singapore
Rail car-km (million)	255	414	89
Bus vehicle-km (million)	513	450	299
Population (million)	6.9	7.4	4.2
Rail car-km per capita	37.0	56.3	21.0
Bus vehicle-km per capita	74.4	61.2	70.5
Combined rail car and bus vehicle-km per capita	111.4	117.5	91.5
Percentage of total passenger km on mass public transit	82%	30%	47%

By tracing and analyzing the development of PTS in Hong Kong over the past two decades, we found evidence that the high level of accessibility on mass public transit in the territory can be attributed to several factors: land use policies that encourage the development of compact, high-density township; accompanying transport policies that grant high priority to the development of mass transit facilities; and additional government actions that ensure the financial viability of privately provided PTS, especially the innovative approach of integrating the development of transport facilities and property so as to exploit the synergy between them. This paper studies and highlights the elements that have contributed to the development of high accessibility via mass public transit in Hong Kong.

2 Research plan

Three aspects are addressed in this study. Firstly, by way of background, we give an outline of the transport policies of Hong Kong over the past two decades and their resultant impact on the public transport market. This policy outline illustrates the importance of transport policies in shaping the supply of PTS over time, and therefore to supporting improvements in accessibility via public transit. Through this, we also show the difficulties of formulating policies to meet the different interests of various stakeholders. This analysis is mainly conducted through a review of relevant policy documents and statistical reports published by the Hong Kong government. Particular reference is also drawn from our previous study, Tang and Lo (2008a).

Secondly, previous studies have shown that urban density is positively correlated with PTS usage (Kenworthy and Laube, 1999). Unlike private car traffic, for which higher urban density means more traffic generation per unit area and hence more severe congestion, PTS exhibit the well-known Mohring effect: increasing volumes of traffic lead to improved services—higher frequency, lower waiting time, and wider coverage—thus further benefiting both existing and new users (Mohring, 1972). Unfortunately, the global trend has been the reverse of the Mohring effect. Declining density reduces passenger volumes, leading to low frequency PTS, long waiting times, and worse accessibility. Reduction in PTS quality starts a vicious cycle resulting in even lower passenger volumes, greater auto dependence, and further declines in density. The end result is highly subsidized, low-quality PTS that are used mostly by "captive" passengers who have no other transportation options. Research by Wang and Lo (2007) demonstrates that high urban density can lead to better rail service coverage and quality, in terms of shorter headway and closer station spacing, which are essential for initiating the positive cycle of attracting more patronage. The key question is: How high does urban density have to be for this positive outcome to emerge? This density requirement is an important benchmark to recognize. This study investigates the implications of urban population density—the essence of land use policy—on the financial viability of rail transit services, as illustrated through the case study of the Tseung Kwan O (TKO) new town in Hong Kong. The case study makes use of a logit demand split model and the total cost function of transit services (Black, 2005) to estimate the threshold urban density required to fully recover the total cost of operating the rail service serving the new town.

Thirdly, a remarkable aspect of PTS in Hong Kong is that all services are operated by companies according to prudent commercial principles. The profitability consideration, not surprisingly, has driven the companies to strive for the utmost operating efficiency and continuous service expansion for business growth. Nevertheless, it is important to ascertain if the private operations can manage to achieve financial viability without government subsidies; and if so, how this can be accomplished. To study the financial viability of these privately operated PTS, we analyze the account books of the two leading companies in Hong Kong, i.e., Kowloon Motor Bus (KMB) and MTR, with an aim to assess how they have maintained their profitability while providing quality services over the years. These two companies are selected because they have the highest revenues in their respective sectors. KMB operates franchised bus services in and between the urban and suburban areas of Hong Kong. It is one of the largest bus companies in the world, operating over 4,000 buses on more than 400 bus routes, and serving over 2.8 million passengers per day. In 2005, the market share of KMB was at 25 percent of the public transport market; this is four percent greater than the market share of MTR, which is one of the most heavily utilized mass transit railway systems in the world, operating six lines on 91 kilometers of tracks through 53 stations, and serving over 2.4 million passengers daily. Both KMB and MTR are listed companies with their operating and financial data available with sufficient details in their annual reports. The highly competitive public transport market in Hong Kong requires the two companies to work at their utmost efficiency in order to maximize profitability.

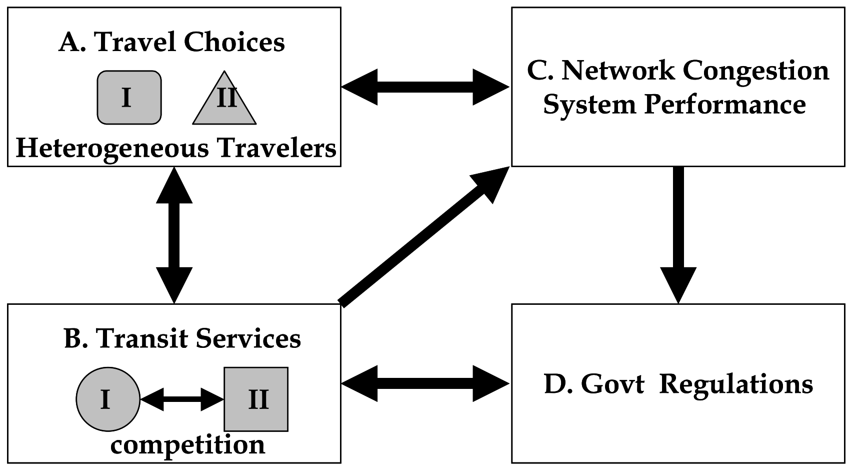
3 Transport Policies In Hong Kong

The provision of PTS in Hong Kong can be viewed as the strategic interactions among four elements as illustrated in Figure 1: (A) travel choices of heterogeneous passengers; (B) transit services provided by the private sector; (C) overall network and system performance; and (D) government regulations to ensure socially desirable solutions. Travelers choose to make multi-modal trips based on the availability of PTS and on the performance of the combined trips in terms congestion level, fare, comfort, etc., also taking into consideration their trip purposes and socioeconomic characteristics. The private sector provides transit services within a set of government regulations while attending to travelers' choices and subject to competitive market forces. On the other hand, network or system performance is a direct result of travelers' multi-modal choices and of services provided by the private sector. Finally, the government provides checks and balances through regulations while ensuring an enticing environment to attract participation and investment in public transport facilities by the private sector. Within this framework, it is apparent that the government plays a key role in regulating competition as well as in maintaining the overall performance of the system. The following sections discuss transport policies in Hong Kong in this light—how they attempt to balance the competitive nature of the transit industry and its welfare effects, highlighting more successful policies as well as lessons learned from less successful ones.

3.1 The policy of limiting private car ownership and usage

The limited space and high population density of Hong Kong have long shaped the transport policy of giving priority to mass carriers, especially those off-street modes that do not occupy road space, and controlling the growth of private car ownership. New private cars in Hong Kong are subject to an initial registration tax ranging from 35 percent to 100 percent of the vehicle cost. The high acquisition cost has succeeded in maintaining the ownership rate at around 50 private cars per 1,000 people in the last five years (Transport Department, 2005), compared to more than 480 passenger cars per 1,000 people in the United States. In addition to ownership control, car usage has also been discouraged through a high fuel tax. In 2004, the after-tax price of unleaded gasoline was US$1.54 per litre (or US$5.92 per gallon), higher than many Western

Figure 1: The strategic interactions of major elements in the provision of PTS.



European countries and three times that in the United States at the time (International Road Federation, 2005). At the time of this writing, due to the recent surge in crude oil prices, unleaded gasoline in Hong Kong is priced at US$8.15 per gallon. Furthermore, the limited number of available parking spaces and the consequential high garage and parking charges, especially in urban areas, have discouraged car ownership. Since the 1980s, the Hong Kong government has also studied electronic road pricing as an additional control scheme to reduce car usage, though the scheme has yet to be implemented. These measures have kept the use of private cars at about 10 percent of total daily passenger journeys over the past decade (Transport Department, 1999 and 2003), compared to over 95 percent in the United States (Pucher, 1995). As a result, the substantial demand for public transportation has driven the rapid development of PTS and laid the foundation for the prosperous PTS market in Hong Kong.

3.2 The policy of transit service coordination and protection (1980s)

Over the past two decades, the Hong Kong government has constantly reshaped, and sometimes rectified, its transport policies, especially those pertaining to the provision of PTS, in an attempt to maintain the delicate balance between the welfare of the traveling public and the profitability of the private operators. This is by no means an easy task.

In May 1979, the Hong Kong government published its first White Paper on internal transport policy, which established the central objective of maintaining and improving the mobility of people and goods. The paper considered that this objective could be best met by an integrated, multi-modal system in which public passenger transport should be given greater priority. Furthermore, the development of this integrated system should rest on three principles: First, improvement of the road system; second, expansion and improvement of public transport; and third, more economical use of the road system (Environment Branch, 1979). Accordingly, the Mass Transit Railway (MTR) was constructed in the late 1970s to provide an off-street, efficient transit mode through urban areas. The Kowloon-Canton Railway (KCR) was also electrified in 1982 to provide transit services for the suburban New Territories area and to support the development of new towns for accommodation of the growing population. Both railways were corporatized to operate under prudent commercial principles in accordance with their respective Ordinances, although they were wholly owned by the government. MTR was privatized in October 2000, and since then its shares have been traded on the Stock Exchange of Hong Kong.

This transport policy favoring an integrated public transport system gave priority to the rail mode, and defined other PTS as feeding modes. The policy therefore prohibited direct competition along the rail routes by other PTS, in order to protect rail patronage and secure the return of public investments in the railways. Since the MTR began operating in 1979, the government had curbed bus competition by stipulating that at most half of the newly introduced bus routes could run parallel to MTR routes, that the fares of parallel bus routes be comparable to those of the MTR, and that no routes from the new towns in the New Territories could go to Tsim Sha Tsui (the central commercial district at the south tip of the Kowloon peninsula) or cross the harbor onto Hong Kong Island.

In summary, the prevailing transport policy in the 1980s aimed to maintain an integrated public transport system with well-coordinated services by different modes, with their priorities well defined, so as to minimize wasteful duplication of resources and avoid competition by modes of lower investment but less efficiency against modes of higher priority (Highways Department, 1979). The policy assured that the traffic demand for mass railway transit would not be diluted by other PTS, so the huge public investment in such projects would be paid back within a reasonable return period. In this way, the policy allowed for the creation of a "win-win" situation benefitting both the transport operators and the traveling public. Under this policy, the government was able to rely on the private sector to provide PTS services according to the user-pays principle without direct subsidies.

Coordination can be defined as the pursuit of an overall objective through administrative rather than market processes (Tyson, 1995). In the context of PTS, coordination means convenient inter- and/or intra-modal transfer and avoidance of direct competition that may adversely impact the transport operators and users (Denant-

Boemont, 1999). The transport policy of coordination, however, was later criticized as protecting the existing large operators while failing to motivate them to improve their services. The Hong Kong government's second White Paper, published in 1990, responded to these concerns by initiating a strategic change in transport policy, relaxing restrictions on competition among different modes.

3.3 The policy of service proliferation and competition (1990s)

The second White Paper on Transport Policy (1990) emphasized the following areas: first, encouraging healthy competition between modes by applying the inter-modal coordination policy more flexibly; second, developing a balanced transport network in which mass carriers like bus and rail formed the backbone of the system; third, improving transport infrastructure, including new roads and railways; fourth, expanding and upgrading public transport services; and fifth, managing road usage through strategies such as controlling growth in the number of private vehicles and giving priority to public transport (Dimitriou, 1992; Transport Bureau, 1999). The guiding principle was to derive maximum benefit from investments in transport infrastructure and improved public transport services through healthy competition between modes. The White Paper stated explicitly that it was not the government's policy to reduce competition from other forms of transport in order to make the railways more viable, and that railway capacity was not the sole factor to be considered in determining the level of bus and other services along major rail corridors (Transport Branch, 1990). This White Paper obviously revealed a strategic change in the transport policy and laid the political foundation for increases in both rail and bus services in subsequent years.

In 1994, echoing the transport policy of expanding the railway infrastructure as a means for improving mobility, the Hong Kong government issued the first Railway Development Strategy, which set out development plans for four new rail lines or extensions. These new rail lines were opened for use in the early 2000s. At the same time, the government relaxed regulations on bus services with an eye to improving their quality through competition. Following the start of open tendering for new franchised bus routes in 1991, new franchised bus companies hence entered the market. The government also relaxed the restriction on franchised bus services running parallel to railway lines; the policy of line protection for the rail services was essentially abolished. Accordingly, the competitive operating environment shaped by this policy succeeded in encouraging franchised bus operators to improve their services. The White Paper also reinforced the role of other, less-efficient transport modes, stating that the supplementary role of non-franchised bus and public light bus services should be maintained. In particular, the former should continue to be used to help meet peak hour demand and provide certain categories of scheduled services for students, employees and residents' groups, and the latter to serve areas, routes or hours for which patronage did not justify the provision of higher capacity modes (Transport Branch, 1990).

PTS in Hong Kong in the 1990s were substantially improved through service expansion and encouragement of modal competition. This policy of service proliferation and competition was welcomed initially by users, at the expense of negative externalities: unnecessarily frequent direct services were put on profitable routes from major residential estates to the central commercial districts; the large number of buses converging to these commercial districts caused severe congestion along main corridors and trunk roads; the shorter waiting times and greater convenience of point-to-point services were not able to compensate for increases in journey times due to congestion. On the other hand, the improved services were unable to generate substantial increases in patronage, mainly due to the fact that 90 percent of all passenger journeys in Hong Kong were already being carried by PTS, leaving little room to generate more public transport trips from private cars. The oversupply of PTS put the financial viability of operators and new mass transit projects at risk. Typical of the negative effects of this oversupply was the withdrawal of Stagecoach (the major shareholder of Citybus) as a result of severe competition with another franchised bus company, New World First Bus (NWFB), that runs on parallel routes in Hong Kong Island; the withdrawal of Stagecoach ultimately led to a merger of the bus companies in 2002 and consolidation of their services (Tang and Lo, 2008a).

3.4 The policy of service rationalization and consolidation (2000s)

In October 1999, the government of Hong Kong published "Hong Kong Moving Ahead," which outlined a revised set of transport strategies for the future: first, better integration of transport and land use planning; second, better use of railways as the backbone of the passenger transport system; third, better public transport services and facilities; fourth, better use of advanced technologies in transport management; and fifth, better environmental protection. One notable objective was to increase the proportion of rail-based public transport journeys from 33 percent in 1997 to 40–50 percent in 2016, (Transport Department, 1999). In accordance with this objective, the second Railway Development Strategy was issued in May 2000, laying out a planning framework to support the expansion of Hong Kong's railway network through 2016 (Transport Bureau, 2000). Furthermore, public transport interchanges became a required component of new railway stations, in order to facilitate feeder services provided by other public transport modes.

Bus services continued to improve in parallel with the expansion of the railway network. This was partially attributable to the government's strategy of maintaining a competitive public transport market, but also to political pressure in support of maintaining modal choices. Plans to consolidate bus services in conjunction with the commissioning of new railway lines were strongly opposed by politicians and stakeholders.

In the end, once a public transport service is offered, it is extremely difficult to cancel or consolidate that service. In addition, franchised bus operators were without incentive to give up their profitable routes. For example, when planning for new railway lines such as the West Rail, the transport authority had undertaken a comprehensive study of rationalizing the franchised bus services with the goal of avoiding direct bus competition and strengthening feeder bus services to the railways. However, the plan was largely unimplemented. Moreover, many public transport interchanges built adjacent to railway stations failed to facilitate inter-modal transfers, possibly due to conflicts of interest: franchised bus companies, as competitors, were reluctant to play the role of feeder services for the railways. The policy of service rationalization and consolidation proved unwelcome, and indeed met with resistance at every step; eventually, it was implemented to a very limited degree. It turned out that the patronage for the new multi-billion-dollar rail transit link, West Rail, was much lower than expected, and in fact below the level required for a viable return on investment. In 2004, the first year after opening of the West Rail, KCR's profit before tax dropped 75 percent to below HK$500 million after cross-subsidizations from other profitable routes and commercial activities were taken into account. The significant financial burden of financially non-viable infrastructure investment is thus obvious in the presence of overwhelming increases in the supply of PTS.

3.5 The resultant public transit services supply

As a result of the transport policies discussed above, rail-based mass transit services had been developing rapidly since MTR began operating in the early 1980s. Due to the policy of line protection for rail services, the rapid expansion of the railway network in the period between 1984 and 1994, which was characterized by a nine percent average annual growth in rail car-km (Table 2), produced a similar increase in rail-based passenger journeys over the same period. However, given the prevailing policy of giving priority to rail and using other modes as feeders or supplements to areas not covered by rail, franchised bus vehicle-km only increased by an average of 1.7 percent per annum over the same ten years, with an average of 1.4 percent of franchised bus passengers switching to rail services each year.

The railway network in Hong Kong continued to expand through the 1990s and into the new century. By the end of 2004, the total extent of the rail network had increased to 200 km—twice the size of the network in 1990. The level of service had also increased, to 255 million rail car-km in 2004 or 90 percent higher than in 1990. However, over the same period, rail patronage only increased by 15 percent. Franchised bus services, on the other hand, caught up quickly in the 1990s; their gains were partially attributable to the relaxation of relevant regulations, but also to the fact that the development of various new towns throughout the 1980s and 1990s facilitated

Table 2: Rail and bus services and patronage.

	Year			Average annual growth rate	
	1984	1994	2004	1984–1994	1994–2004
Rail car-km (million)	66	156	255	9.0%	5.0%
Rail-based passenger trips (million)	491	1,143	1,315	8.8%	1.4%
Franchised bus veh-km (million)[a]	279	313	513	1.7%	5.0%
Franchised bus passenger trips (million)	1,435	1,246	1,494	-1.4%	1.8%
Population (million)	5.4	6.1	6.9	1.2%	1.2%
Rail passenger trips per rail car-km	7.4	7.3	5.2	-0.2%	-3.5%
Franchised bus passenger trips per bus veh-km	5.1	4.0	2.9	-2.5%	-3.1%
Rail car-km per capita	12.2	25.5	37.0	7.7%	3.8%
Rail trips per capita	90.4	186.8	190.7	7.5%	0.2%
Franchised bus veh-km per capita	51.4	51.2	74.4	0.0%	3.8%
Franchised bus passenger trips per capita	264.2	203.6	216.6	-2.6%	0.6%
Combined rail & franchised bus passenger trips per capita	354.6	390.4	407.3	1.0%	0.4%

[a] The available bus vehicle-km figures between 1987 and 2004 are used for the trend analysis

Source: Census and Statistics Department, 2005; Transport Department, 2005.

the rapid expansion of franchised bus services. The government's policy was that all new towns should rely solely on bus services until, after ten or twenty years, their populations would have grown large enough to support rail links. Overall, rail car-km and bus vehicle-km each increased by an average of five percent per year from 1994 to 2004. In fact, during this period, PTS in Hong Kong built up a reputation for offering efficient, affordable, and high-quality service.

The impacts of evolving transport policies in the 1980s and 1990s on the supply of PTS and on their patronage can be clearly seen through an examination of PTS utilization rates. As shown in Table 2, from 1984 to 1994, rail passenger trips per rail car-km remained at a level of 7.3 or 7.4, whereas per capita rail passenger trips and rail car-km increased at an approximately equal rate of 7.5 percent per annum. These figures imply that the policy of giving priority to rail succeeded in attracting enough demand to keep pace with rail service expansions. In the same period, bus passenger trips per bus vehicle-km and bus passenger trips per capita declined at the rate of 2.5 percent and 2.6 percent per annum respectively, further affirming the success of the line protection policy for rail services.

In the subsequent decade of 1994–2004, the trend took on a different shape when the effects of policy of service proliferation and competition prevailed. Rail passenger trips per rail car-km suffered an annual decline of 3.5 percent over the 10-year period. Bus passenger trips per bus vehicle-km continued to decline, but at a much faster annual rate of 3.1 percent compared with the preceding 10-year period. In contrast to the 3.8 percent annual increase in rail car-km per capita and the similar increase in franchised bus vehicle-km per capita over the period, combined rail and bus passenger trips per capita only increased by 0.4 percent. It is evident that the overall demand for PTS had already been saturated irrespective of further expansions in PTS. In other words, the indiscriminate improvements of services, both rail and bus, were introduced at the expense of the utilization rates of PTS as well as the financial viability of public transport infrastructure investments.

3.6 Implications

As seen above, the evolution of transport policies in Hong Kong over the past two decades was instrumental in shaping the provision of PTS. In hindsight, some policies were more successful than others. Examining the implications of these policy changes over time may shed light on the question of how to define policies that improve public transport accessibility.

First of all, while privatization is fundamental for pursuing financially viable PTS, it is not a panacea. Managing the provision of competitive services is critical. It is widely believed that privatization and the resultant competition will bring about enhancements in efficiency and service quality (McGuiness et al, 1994; Meyer and Menzies, 2000). Hong Kong offers a good example of quality PTS being provided by commercial corporations. Nevertheless, despite Hong Kong's high population density and low proportion of private car journeys, the policy of service proliferation and competition introduced in the 1990s proved to be ineffective in managing the provision of PTS, as it created wasteful duplicative services, put commercial investments on public transport infrastructure at financial risk, and incurred congestion and emission externalities to society. In the end, the government reverted to the policy of service rationalization and consolidation in the 2000s in order to rectify this problem of service oversupply. In this regard, it is important to focus not only on price regulation, but more importantly on managing service quality and service expansion so that both operators and users benefit.

Clearly defining the hierarchy of PTS is important for avoiding wasteful competition and ensuring the efficiency of the system. Indiscriminate massive service improvements might be good news to travelers—if only these services were financially sustainable. The experience of Hong Kong reveals that without a long-term policy on role differentiation, PTS will eventually enter into a dilemma: on the one hand, huge capital investments are made or committed for mass railway transit projects; on the other hand, excessive supply and competition between modes put at risk the financial viability of the very services these investments were intended to create. Transport policy should therefore aim to maintain an integrated public transport system with well-coordinated services by different modes, with their priorities clearly defined. The policy of transit service coordination and protection introduced in the 1980s in Hong Kong is a good example. The policy ensures that the demand for mass railway transit systems will not be diluted by other modes, and hence the huge investments required to implement such projects can be paid back within a reasonable return period. The effectiveness of service competition must be evaluated in light of its overall benefit to society. Indeed, inefficiency does not necessarily indicate a lack of competition, but rather may be the outcome of wasteful competition in which transport operators underutilize their resources (Cowie and Asenova, 1999).

In planning for rail infrastructure, the time scale of transport policy needs to be commensurate with the project's payback period. Railway infrastructure, which incorporates exclusive rights-of-way and often requires tunneling, is expensive and requires a long payback period of up to twenty years or more. A consistent transport policy should, therefore, match the same time scale in view of both the existing and planned expansions of the rail services. In the case of Hong Kong, a flip-flopping transport policy—first offering line protection to rail service, then encouraging modal competition by relaxing the regulations on competing bus services—jeopardized the viability of the investments on the railway projects. It is, therefore, important to put in place a set of consistent transport policies in association with project stakeholders in order to shape an appropriate operating environment and safeguard a viable market share for the rail services.

Finally, the provision of PTS needs to be appropriately staged with new development. Urban development and PTS provision for a new area should be jointly planned so as to ensure that PTS established in the early stages of urbanization will remain effective means of transport as the community grows and matures. When it began developing the new towns, the government of Hong Kong adopted a "trigger point" policy under which the construction of high-capacity, capital-intensive railway infrastructure would be triggered only when a new town has grown to a particular size; this policy was guided by the principle that an area must have grown to a level that would generate sufficient demand to sustain the rail service financially. The experience of Hong Kong proved that this policy did not work. By the time rail service is introduced, a new town will have been developed more or less to its full extent. The addition of new rail service to the existing bus routes that have served the community in the interim will inevitably result in excessive capacity for the area, leaving the new rail service in financial difficulty due to much lower than anticipated patronage. On the other hand, experience from the implementation of the policy of service rationalization and consolidation in the 2000's in Hong Kong shows that removing or consolidating existing bus routes is difficult, if not impossible, as residents are already accustomed to them. It is beyond doubt that a substantial population size is essential for the viability of a rail link. Therefore, it is advisable to build the rail link in phases, in coordination with the development stages of the new town; in other words, the railway should be extended gradually as the new town expands. Bus services can play a supplementary role as feeders from the very beginning. The objective is to maintain a well-coordinated PTS network serving the new town through all stages of its development.

4 Land-use policy and urban density

4.1 The policy on land development

Tremendous economic growth in the past few decades has established Hong Kong as a major financial center. But Hong Kong is a small place, with a total land area of 1,104 square kilometers—slightly smaller than Los Angeles. Furthermore, because of the hilly landscape and the large number of outlying islands, only a relatively small portion of land is usable for development. In response to these constraints, Hong Kong has been expanding its usable land by reclamation, but despite this effort, it has become more densely populated due to population growth over time, mainly by immigration. Counting only the built-up metropolitan areas, the urban density in Hong Kong is around 36,700 persons per km^2 (Bertaud, 2002), almost six times that of London or five times that of Tokyo. Such a high population density requires an efficient transportation system to support mobility and economic development. On the other hand, this high density also provides the essential ingredient for the development of mass transit types of PTS. Indeed, developing efficient PTS has been a key policy objective of the Hong Kong government.

Land scarcity and population expansion require the government to use land resources effectively. Land-development strategies, in turn, have catalyzed sustained high-density development over the years. The limited supply has caused rapid increases in the prices of land and property, with the average price index of private domestic premises recording a four-fold increase in the past quarter of century (Census and Statistics Department, 2005). As a result, the average income from land sales has contributed over three-quarters of all funds for capital works in Hong Kong. The tax and rental income on land and property, as well as due to land and property transactions, has also accounted for an average of about 20 percent of the total inland revenue of Hong Kong (Treasury Department, 2005), and enabled the territory to maintain low tax rates. The resultant prosperous real estate market has thus formed one of the most important pillars for the economic growth of Hong Kong.

Further development of the existing central business districts around Victoria Harbor through land reclamation and replacement of low-rise buildings with modern skyscrapers has generated tremendous converging traffic demand from residential areas and new towns to these central districts, while the construction of high-density residential estates around railway stations has created a large pool of potential passengers to support the operation of rail transit services and recover investments in railways. Conversely, rail service provides a convenient and accessible mode of travel for nearby residents. Synergistically, the improved accessibility brought about by the rail service helps boost the value of properties built on top of railway stations. In the end, the high urban density resulting from Hong Kong's land development strategies, especially along the railway corridors, provides ideal conditions for the development of integrated rail and property projects.

4.2 The relation between urban density and PTS quality

It is beyond doubt that high population density is positively correlated with high PTS usage. The key question is: How high does urban density need to be in order to ensure the financial viability of PTS? A prescriptive answer to this question provides an important benchmark for planning the provision of PTS. To find this answer, we apply an analytical approach that examines the relationship between urban density and the financial viability of rail services to the case of the Tseung Kwan O (TKO) new town in Hong Kong. TKO is the latest new town developed in Hong Kong, with a total development area of 10.05 km^2 and a population of 350,000.

In formulating the model for the case study, only two travel modes are considered, rail and direct bus services, as justified by the fact that only about 10 percent of the daily trips in Hong Kong are made by private cars. Rail service is complemented by feeder bus services to take passengers from more distant locations to the rail stations. Individual commuters choose one of the two modes according to their travel costs. Users of the bus service walk to their nearest bus stop to access the bus service; users of the rail service take a feeder bus or walk to their nearest rail station. A more detailed description of the bus and feeder bus networks can be found in Wang and Lo (2007). To cope with the competition between the two modes, the rail operator adjusts its service quality so as to optimize its financial performance. Nevertheless, given a low urban density, it can be the case that no matter how the rail operator optimizes its service, it simply cannot be financially viable due to low demand. In other words, there exists a threshold urban density below which rail transit services are unlikely to be financially viable. In this study, we determine what this threshold density may be.

The model involves the following five components.

(i) Estimating rail service patronage

The logit demand split model is applied to capture travelers' choices between the two modes in accordance with their travel costs. For travelers originating at location (x, y) in the study region, the percentage of passenger demand choosing the rail service can be expressed as:

$$P_r(x,y) = \frac{e^{\beta C_r(x,y)}}{e^{\beta C_r(x,y)} + e^{\beta C_b(x,y)}}, \tag{1}$$

where $C_r(x, y)$ and $C_b(x, y)$, respectively, represent the travel cost of the rail and direct bus service, and β denotes the scaling parameter associated with the logit model.

The travel cost includes both fare and travel time, with the latter being converted into monetary terms via the value of time. Walking is considered as the access mode to the rail stations or bus stops, with the walking distance simply taken as the straight-line distance between the origin location and the intended station or stop. Travel time includes access time, waiting time at stations (taken as half of the headway), and in-vehicle time. For rail users, the travel cost is expressed in equation (2). Travelers choose the station and the nearest feeder bus with the minimum travel cost.

$$C_r = \frac{l_w}{V_w} \times VoT_{\text{walk}} + \frac{l_f}{V_f} \times VoT_i + 0.5 \times H_r \times VoT_{\text{wait}} + F_r \tag{2}$$

In equation (2), the first term describes the walking access time cost, with l_w, V_w, and VoT_{walk} representing the walking distance (including interchange between feeder bus and railway station), average walking speed, and value of walking time, respectively. The second and third terms represent the feeder bus access time cost and in-train travel time cost, respectively, where VoT_i characterizes the value of time while inside the train or vehicle. The fourth term represents waiting time cost in stations and the last term denotes the fare.

For bus users, access time includes only walking time. Travel time on the highway is determined by the BPR function, which takes into account the delay due to traffic congestion. Total travel cost, where f describes the traffic flow on the highway, can then be expressed as:

$$C_b = \frac{l_w}{V_w} \times VoT_{\text{walk}} + \frac{l_b}{V_b}\left(1 + \alpha\left(\frac{f}{c}\right)^{\beta}\right) \times VoT_i + 0.5 \times H_b \times VoT_{\text{wait}} + F_b \tag{3}$$

As the study region is mainly residential with few commercial stores or enterprises, it is reasonable to assume that the majority of rail passengers are local residents on work trips to the city centers. Let ρ be the average total trip generation rate for public transit trips, which includes both the bus and rail service passengers; Ω the study region; and $d(x,y)$ the population density at point (x,y), then the patronage for the rail service can be estimated as:

$$D_r = \iint_{\Omega} \rho \cdot d(x,y) \cdot P_r(x,y) dx dy . \tag{4}$$

Solving equations (1)–(4) yields the patronage for rail service at a fixed level of rail service quality. Note that this system of equations involves a fixed-point relationship between modal split, traffic volume, and travel time: the modal split determines the traffic volume on the highway, which in turn determines the travel time by bus under congested conditions, and ultimately feeds back to the modal split again.

(ii) Determining the population density

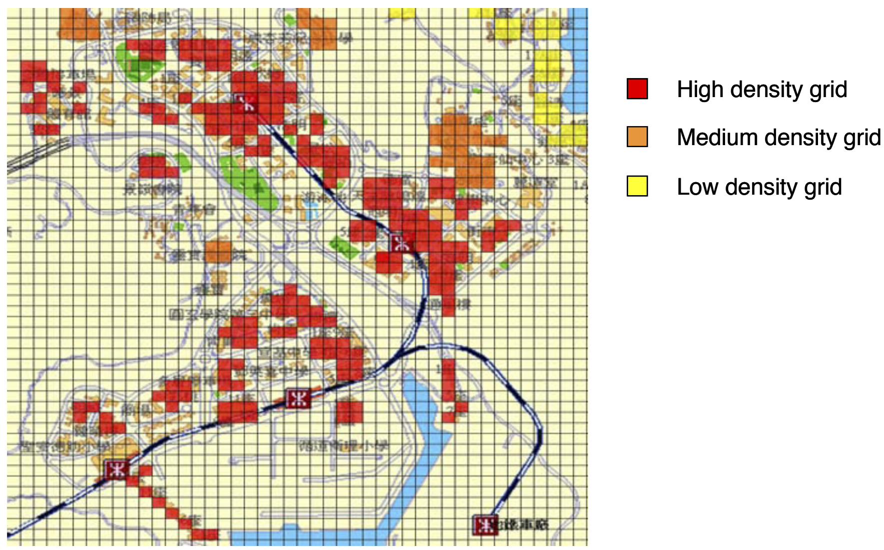
An effective method of determining population density distribution for the entire study area starts with imposing a 65 by 65 meter grid over TKO new town, as shown in Figure 2. To simplify problem, population densities are classified into four categories: high, medium, low, and zero. Each grid square is classified manually into one of these four density categories, depending on the actual situation and characteristics of the residential estates lying within it. Data from the 2001 population census in Hong Kong (which divided TKO into 13 zones and provided the population size precisely for each zone) is then used to calibrate the exact density (in population per km^2) for these four population density categories. With the population known from the census and the number of grid squares classified as high, medium or low density in each zone, we obtain the result that a "low" population density corresponds to 5,210 persons/km^2; density ratios between the high, medium and low categories are 68:22:1. Note that high density goes up to 354,380 per km^2. This number may seem high, but it is due to the fact that new private estates are typically 50-story buildings and the grid size used for this population density calculation is small, at 0.065 km x 0.065 km. In any case, the population density of each grid square in the study area is determined such that the population counts, zone by zone as well as the overall total, are consistent with the census data.

(iii) Determining total rail service cost

The total cost of transit service includes both fixed, amortized construction costs and operating costs that mainly depend on headway H_r. A similar total cost function is found in Black (1995). Revenue is expressed as a negative term to offset the construction and operating costs. Overall, the total cost function is expressed as:

$$TC = \varkappa + \gamma_p C l K / H_r + \gamma_e t_{rt} / H_r - F_r \cdot D_r . \tag{5}$$

Figure 2: TKO layout with grids of different population densities.



The first term in (5) represents the depreciation of construction cost of the railway including its stations. The second term represents operating costs, wherein γ_p, C, l, K denote the average rail service operating cost per passenger space-km, train capacity, rail line length and service time, respectively. The third term estimates equipment costs, where γ_e describes the average daily cost for owning one vehicle and t_{rt} is the train travel time for one round trip on the line. The last term represents total fare revenue (expressed as a negative cost term).

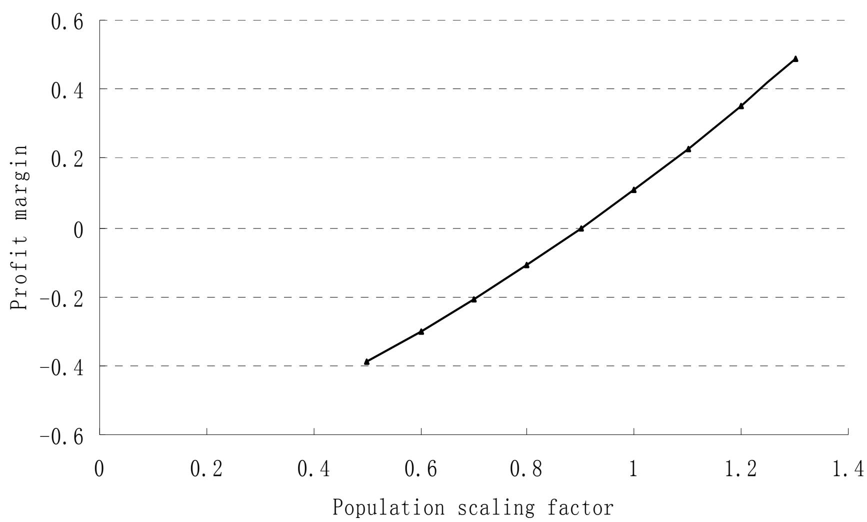
(iv) Optimizing rail service quality

The rail operator optimizes the rail service quality, in terms of headway considered in this study, so as to minimize the total cost expressed in (5), subject to the demand split model (1)–(3) for the study region defined by (4). Essentially, by adjusting the headway, the total cost of operation will be changed. The modal split and hence the patronage for the rail service will also be affected, which in turn impact the revenue term in (5). This procedure involves optimizing the objective function (5) subject to the choice equilibrium constraints expressed in (1)–(4). This mathematical program can be solved by an iteration method. In the interest of space, we leave out the details of the solution procedure, which can be found in Wang and Lo (2007).

(v) Results of the sensitivity analysis

A sensitivity analysis reveals how the total cost of rail service varies with urban density. The sensitivity analysis applies a uniform scaling factor to the current density of each grid square in the study area. It is assumed that the rail service capacity is sufficient to accommodate the projected demand. In each case, the headway is optimized so as to achieve the minimum total cost. For each density level as indicated by the scaling factor, we calculate the profit margin, defined as the ratio of profit to total cost (including both depreciation and operation costs). Figure 3 shows the resultant profit margin as the population scaling factor is varied from 0.5 to 1.3.

Figure 3: Profit margins at different density levels.



The results show that rail service could be barely financially viable (i.e. with zero profit) when population density drops to 90 percent of the current level of 35,000 per km². More specifically, by placing high population density along the rail line and with a favorable urban population density distribution pattern for the rail service, the fare revenue is just enough to cover the costs of the railway. It appears that the urban profit margin density of around 31,500 per km² (= 35,000×90%) is the threshold urban density for barely maintaining the financial viability of rail service in the specific case of TKO in Hong Kong. However, any private rail company would seek a higher viable return. MTR earns an average of five percent return on its net fixed assets over the past five years due to its additional property development profit, which translates into a profit margin of roughly 40 percent (as defined above). Without this property development profit, as shown in Figure 3, MTR would have required an even higher urban density to achieve an equivalent financial return—approximately 42,000 per km² (= 35000×120%). Here we caution that this estimate of the required population density is subject to the assumptions of the analytical model and to the specific characteristics of this case study. Nevertheless, even though this result is an approximation, it provides a sense of the magnitude of the problem. This required overall urban density of 42,000 per km² is not found anywhere in the world; it raises questions of practicality as well as desirability from the perspective of urban development.

The population density of TKO, at 35,000 per km², is among the highest in the world and about the same as the average density of Hong Kong, counting only the usable land (Tang and Lo, 2008a). Certainly, Hong Kong is at the extreme end of the urban density spectrum; the success of financially viable private rail services in Hong Kong may be attributable to this high urban density, but density is only one contributing factor. As discussed in Section 3 (and elaborated further in Section 5), even at such a high population density, rail transit services must rely on accompanying transport policies to manage the supply and competition from other modes of PTS, as well as on additional support in the form of indirect subsidies to make a reasonable return on investment.

4.3 Implications

The urban density of development is a key factor in ensuring the financial viability of a rail transit link. Generally, higher urban densities allow for better rail services, in terms of coverage and service quality, (i.e., shorter headways and closer station spacing), which are essential for initiating a positive cycle of attracting more patronage (Wang and Lo, 2007). The case study of TKO new town in Hong Kong further reveals a threshold urban density of around 31,500 per km² for the financial viability of a rail service, which is an important benchmark to note. This threshold density is consistent with the population density of Hong Kong for built-up areas.

5 Financial viability of transit services

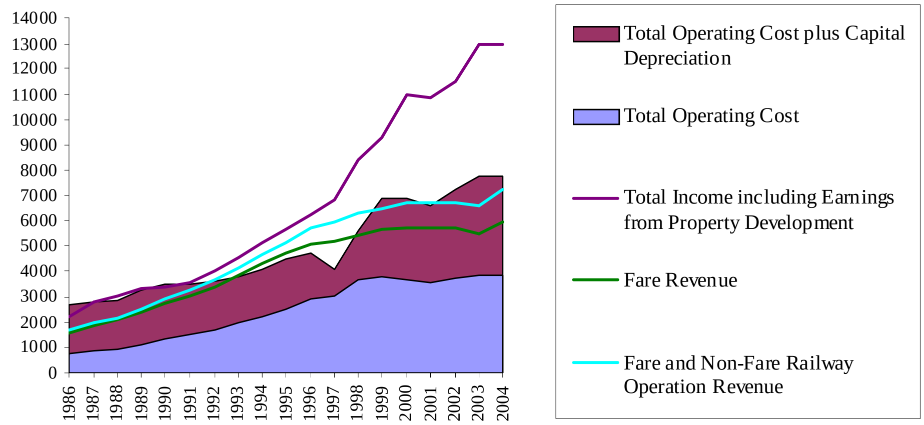
For the purpose of providing financially sustainable accessibility via public transport, it is not possible for operators to endure long-term financial losses. Profitable operation is an ideal situation, although it has proven difficult to achieve in many countries around the world. The success of Hong Kong in providing financially viable PTS, therefore, serves as an important reference. This section analyzes the account books of KMB and MTR, with an eye to determining how these transit operators maintain their profitability while providing quality services over the years.

The financial statements in the annual reports of MTR and KMB show the overall financial performance of the entire company or group. To ensure meaningful data analysis, we have made comparable adjustments to each company's financial data and disaggregated the data to the respective core businesses. For example, assets and expenditures, including recurrent expenses, capital depreciation, financial costs and corporate overheads, have been allocated to each company's transport and non-transport related businesses in the same proportion as their respective shares of fare revenue in income. In particular, the financial viability analysis of MTR considers three aspects: (1) income derived purely from the core business of providing PTS, (2) income from (1) plus income from other commercial activities that complement railway operations, and (3) income from (2) plus income from property development and management. The results of painstakingly working through the account books of MTR for the past 20 years and segregating the financial data according to these three aspects are presented in Figure 4.

MTR has been operating under prudent commercial principles and enjoying fare autonomy since its establishment in accordance with the MTR Ordinance. The company has not set fares at a level that would allow it to earn a large profit, however. Instead, since MTR started operation in 1979, the average fare increase of MTR has been about 5.6 percent per annum, in line with the average growth of Consumer Price Index for the same period. On average, the fare revenue of MTR accounts for about 70 percent of its total income. The high proportion of non-fare revenue reflects the strategy and financial needs of MTR for business development in addition to railway operations, which enhances its financial performance while paying for capital investments. On the other hand, the fares of KMB used to be dictated by the Profit Control Scheme (PCS) defined by the government, which capped the annual "permissible" return at 16 percent of the company's average net fixed assets. The PCS was abolished when KMB renewed its franchise in 1997, following the same new arrangement as other franchised bus companies. The fare revenues of franchised bus services typically constitute the majority of the companies' total income. In the case of KMB, the fare revenue makes up over 90 percent of its income. These differences in the fare regulations governing rail and bus services grant the rail operator more flexibility in the competitive market; the rationale for this difference is that rail operators have to pay for the capital costs of infrastructure development, as well as for maintenance costs associated with the rail operations, whereas bus services make use of roadway infrastructure that is provided for free (with the exception of the few tolled tunnels in Hong Kong) by the government.

Fare revenue has enabled KMB to earn a viable 14 percent return on net fixed assets over the past five years. On the contrary, MTR would not have been able to survive financially had it relied on fare revenue alone. Figure 4 shows that ever since the railway opened for service in 1979, it has not been able to earn enough fare revenue to pay for high capital depreciation and financing costs, which, on average, have been similar in

Figure 4: The cost and turnover of MTR over the past two decades.



magnitude to operating costs over the past twenty years. The exception was the few years prior to the completion of the Airport Railway in 1998 when patronage crested and the investment to build the urban lines had been paid off. Thus,the profitability of MTR has relied heavily on non-fare recurrent revenue from commercial activities in stations, such as kiosks and advertising, as well as railway consultancy services (i.e. the difference between the light blue and green lines in Figure 4). Such revenue has doubled over the past ten years. Nevertheless, despite increases in revenue, MTR still suffered from operating loss (after accounting for capital depreciation) in the years subsequent to the opening of the Airport Railway. This is obviously not commercially viable. The financially viability of MTR has been largely dependent on earnings from property development on top of train stations, including profits from property sales and recurrent revenue from rental and management of associated shopping arcades (i.e. the difference between the top brown and light blue lines in Figure 4). This significant source of income can be regarded as an indirect subsidy from the government, in terms of the scarce land resources, by granting MTR the right to develop properties on top of train stations, in return for the capital investment on railway infrastructure development. Without the income from property development, MTR would be unable to earn a viable return and would have to seek alternative support from the government for its continuous service improvement and network expansion. In other words, government subsidies, in one form or another, are crucial to the financial viability of a mass transit railway—even one with high levels of patronage and good operating efficiency like MTR.

The high capital depreciation and financing burden borne by MTR is largely the result of the prevailing transport policy that rail companies receive no direct government funding support and are fully responsible for capital investments in infrastructure, and also reflects the well-known huge capital costs associated with railway development. Tang and Lo (2008b) estimated that the marginal cost of one passenger space-km for the TKO Line built in 2002 was more than HK$3.5. In contrast, the roadway infrastructure for bus operations is built and maintained by the Hong Kong government as public works. As such, expansion of the bus fleet is the main, if not the sole, capital investment required for KMB to expand its route network. Over the five years prior to 2002, Tang and Lo (2008b) estimated that the average marginal cost of an additional passenger space-km for KMB was only HK$0.16. As discussed above, the right to develop property above railway stations and depots can be regarded as an indirect government subsidy to compensate MTR for its capital investment in railway development. Based on our account book analysis, the property development profit and the recurrent income derived from managing and renting out the associated shopping malls have enabled the company to earn an average five percent rate of return on net fixed assets over the past five years.

5.1 Implications

Reviewing the financial performance of the two leading PTS operators in Hong Kong revealed that their profitability relies to a large extent on favorable transport policies and administrative measures. For KMB, the Profit Control Scheme, the exemption from fuel tax and other duties that apply to all other types of vehicles (Tang and Lo, 2008b), and more importantly, the relatively small amount of direct competition from other bus operators (in contrast to the case of Citybus and NWFB on Hong Kong Island) have secured the company's fruitful financial performance on franchised bus operations over the years. For MTR, which operates under a policy requiring the railway operator to recover infrastructure costs, fare revenue has not been sufficient to cover operating costs plus capital depreciation, even given the very high urban density of Hong Kong. It is indirect subsidies from the government in the form of an exclusive right to develop property on top of railway stations, plus fare autonomy that enables MTR to earn a high credit rating in the finance market, that have helped ensure the financial viability of its operations in Hong Kong's highly competitive PTS market. These subsidies can perhaps be justified by the external benefits that the railway contributes to the macroeconomy and to the environment.

The experience of Hong Kong also sheds light on a business model that goes beyond the core business of transportation and successfully extends and integrates railway operations with different sorts of commercial opportunities, such as real-estate property development and retail shop rentals at stations, etc. These commercial opportunities turn out to be of critical importance for the financial viability of rail operations in

Hong Kong. This business model thus offers an innovative way for providing and financing rail services. This integration creates synergy between property development and rail patronage. The rail service improves the accessibility of the adjacent real-estate properties and hence increases their values, while at the same time the real-estate properties generate traffic for the rail service and hence increase its fare revenue. Higher fare revenue can in turn support better service quality, leading to still higher levels of patronage. This synergy may offer a way to break the vicious cycle of declining PTS and pave the way for improving the accessibility on public transport via financially viable PTS.

6 Concluding remarks

Public transit services improve accessibility for all. The planning and design of these services involve important financial and welfare considerations. Over-supply of these services is not only wasteful in terms of resource allocation but adds to road congestion. Conversely, under-supply, although it requires less capital investment, causes long waiting times, over-crowded services, suppressed economic activities, and worsened problems associated with private car transport. Obviously, neither is desirable. The situation is particularly intriguing if the PTS are to be provided by the private sector, whose primary objective is not to ensure an efficient utilization of the transport infrastructure but to maximize profit. This study, drawing upon the case of Hong Kong, examined the management of accessibility via public transport through three perspectives.

First, we traced and characterized the transport policies in Hong Kong over the past two decades and related them to the resultant transit services supply. The outcome showed that the transport policies played an active role in managing the supply, despite that the services were all privately operated. Leaving the services supply purely to the private sector did not seem to be able to achieve the balance. Instead, defining the service hierarchy and priority, facilitating modal coordination, maintaining a set of consistent transport policy commensurate with the infrastructure payback period, etc. are imperative for avoiding wasteful competition, hence ensuring efficiency of the public transit system and financial viability of the services.

Second, we analyzed, through a case study focused on the new town TKO in Hong Kong, the relationship between urban density and the financial viability of mass transit rail carriers. The results confirmed that urban density is instrumental in ensuring sufficient patronage and hence fare revenue to financially sustain the rail operation. Our rough estimate was that a minimum population density of 31,500 per km^2 was essential to achieve breakeven operations, which is consistent with the overall population density in Hong Kong. For private operations to make a reasonable return to investment, this result showed that an even higher density would be required—on the order of over 42,000 per km^2, which is not found anywhere in the world. Therefore, although urban density is an important planning variable, high density alone cannot ensure the financial viability of rail operations.

Third, to look deeper into how the private operations in Hong Kong have maintained their financial viability, we studied the account books of two major operators, MTR (rail) and KMB (bus). KMB's operations are supported by free access to the roadway infrastructure without paying for construction and maintenance costs, by subsidies on gasoline and licensing fees, etc., put in place by the government. For MTR, profits derived from the government-granted right to develop property on top of stations accounts for a substantial portion of its profits. In either case, indirect subsidies, in one form or another, appear to be inevitable, especially for rail operations.

The experience of Hong Kong indicates that a "win-win" situation can exist between operators and users, wherein operators make a reasonable return on investment while providing services and users have access to affordable, high-quality transit services. Each of the three aspects discussed above contributes to the success of this win-win situation; however, this outcome is not an automatic result of privatization, but requires the continual effort of the government in land use planning, in defining a transport policy framework to monitor and regulate competition, and in providing an enticing environment to ensure the services' financial viability. In the end, the experience of Hong Kong sheds light on a business model that can draw upon the strength of the private sector in providing transit services, which may pave the way for improving the accessibility on public transport via financially viable services.

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