Mega infrastructure and implication to regional tourism: case study of Macau and Hong Kong

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Abstract

With a rapid growth of gaming market, the number of tourists to Macau increased at exponential rate in recent years. To ensure a desirable environment, many mega infrastructure projects have been proposed and constructed. Internally, the Macau Light Rail (LRT) system is now under construction to facilitate local transportation. Externally, Hong Kong-Zhuhai-Macau Bridge (HZMB) is constructed to link Macau with Pearl River Delta (PRD) region. In a broader sense, above infrastructure development affected not only Macau, but also Hong Kong.

Some key questions are to be answered – How can destinations cope with rapid tourism growth, especially by considering future infrastructure? To understand people’s response to future mega infrastructures, a large-scale stated preference (SP) survey has been conducted in 2010 by Macau government. The survey aimed to address several important issues; for example, how would travel behavior change after the opening of mega infrastructures (e.g., LRT, HZMB)? Initial findings indicate that; in terms of external transportation, most visitors (54%) would still choose ferry; even when HZMB is available. In terms of internal transportation, LRT attracts more “walking” people (50%) than public bus or casino shuttle riders.

Similar to above study, there is another survey done by University of Hong Kong with specific focus on HZMB. In that survey, 300 respondents show their expectation on time saving from HZMB (vs. existing Ferry) is around 1~1.5 hour; correspondingly, the predicted money to save is roughly from
The 300 respondents were also asked their preference in reducing total travelling time or money (if can only choose one) under different time/money saving scenarios. Such question is designed to test the price sensitivity versus time sensitivity. A trend can be observed from survey results – with more time/money to be saved (as % to total trip), people more likely to choose time-saving, instead of money-saving.

**Keywords:**

Mega Infrastructure, Pearl River Delta, LRT, HZMB, Stated Preference, Implication
1 Introduction

With a rapid growth since the liberalization of gaming market in 2002, the number of tourists to Macau increased at exponential rate in recent years. In 2012, the visitors to Macau reached more than 28 million/year, brought about 38 billion USD gross gaming revenue. In 2015, the visitors to Macau even achieve a peak of 30.7 million/year. As a city with 30.5 km² and local population of 652,500 (2016), massive number of visitors means high density as well as challenge on the capacity of accommodation.

To ensure a desirable living and tourism environment, mega infrastructure projects have been proposed by Macau government. Internally, in order to balance and re-distribute the population density, big development projects were proposed in Taipa; including the Cotai Strip Project and Government Public/Economic Housing Program. Taking advantage of the new reclamation in Taipa, such projects contain development from the scratch, including the zoning plan and road network system. Besides, the Macau Light Rail Transit (LRT) project was constructed to facilitate the local transportation and to replace the casino shuttles to certain extent. In addition to three existing bridges, the 4th linkage between Macau and Taipa was planned for better internal connection. Externally, various transportation mega projects were proposed (or already under construction) to strengthen the linkage between Macau and the outside world, including: Hong Kong-Zhuhai-Macau Bridge (HZMB), Regional Rail System, and undersea tunnel to Hengqin Island, etc.

In a broader sense, above infrastructure development affected not only Macau, but also Hong Kong. Several key questions are to be answered in this paper, including – How can destinations (like Hong Kong and Macau) cope with rapid tourism growth, especially by taking into consideration of future infrastructure? Are all mega-infrastructure developments driven by mobility and/or tourism?

Thus, this paper aims for a strategic analysis and for addressing issues in two aspects. First, this study intends to provide a deep understanding of regional transportation blueprint, related government policies, and current status of major infrastructure building in Pearl River Delta (PRD) region. Second, this study attempts to understand the influence of the planned new projects, especially on their impacts in the regional transportation scale, based on travel behavior survey.

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1 The territory of Macau contains Macau peninsula and the Taipa island.
2 It is a project with a goal of developing a Las Vegas type of “Strip” containing more than 20 casinos/resorts.
2 Literature review

2.1 Planning Study on the Coordinated Development of the Great Pearl River Delta Township

As a joint effort between Department of Housing and Urban-Rural Development of Guangdong Province, Development Bureau of Hong Kong SAR, and Secretariat for Transport and Public Works of Macau SAR, the “Planning Study on the Coordinated Development of the Great Pearl River Delta (PRD) Township” was released in 2009. Having the function as a high level planning guidance, the planning study defined Hong Kong as International Metropolis, and International Finance, Trading, Shipping, Logistic Center; and Macau as Global Tourism and Leisure Center. Other major cities in the PRD region were also defined based on specific function and development potential.

In terms of overall land development concept, “Master Spatial Layout Coordination” was emphasized in the planning study. The PRD was defined as a region with 50 million people, 9 major cities, and 3 metropolitan circles (Fig. 1). In addition, other spatial planning ideas; such as: “one area three regions, three axes and four layers” were also addressed in this planning study.

![Fig. 1 Planned Township Development of Pearl River Delta (Source: Planning Study on the Coordinated Development of the Great Pearl River Delta Township, 2009)](image)

In terms of transportation, the concept of cooperated development was mentioned in the PRD planning study. “1-hour Traffic Circle” is defined as the urban/metropolitan area, which can be internally accessible within an hour by using different travel means (Fig. 2). Furthermore, five major transportation systems of PRD were specifically highlighted, including:
1. Multi-airport System: open (low-altitude) air for 5 regional airports, shared resources/labor, helicopter system, etc.

2. Integrated Port System: coordinate function of ports through negotiation between operators, improve cargo transfer efficiency, etc.

3. Regional Railway System: Strengthen Macau-HK Route, Multi-modal coordination with port and airport

4. Regional Expressway System: Further connect Guangdong with Hong Kong, Macau, and other provinces

5. Waterway Passenger System: Make full use of waterway transportation, especially during peak season (Chinese New Year, Golden week, etc.)

**Fig. 2.** Concept of 1-hour Traffic Circle (Source: Planning Study on the Coordinated Development of the Great Pearl River Delta Township, 2009)

2.2 Cross-boundary travel survey

In addition to the aforementioned PRD Township Planning Study, Hong Kong Planning Department has been conducting the Cross-boundary Travel Survey since 1999 to collect statistical information about the characteristics of cross-boundary trips and trip makers on a regular basis. A Cross-boundary Travel Survey was conducted during October 28 to November 10, 2011. The publication entitled “Northbound Southbound 2011” presents the findings of the Cross-boundary Travel Survey 2011, with statistical tables contain detailed statistics of the 2011 and the past Cross-boundary Travel Surveys.
Generally speaking, with strong tie between Hong Kong, Mainland China and Macau, tremendous growth in cross-boundary travel was observed over the years. The average daily number of 616,500 cross-boundary passenger trips in 2011 as recorded in the two-week survey period, was about 1.7 times that of 357,400 in 2001 (Fig. 3). Similarly, according to the administrative records, there were also rapid increases in the average daily cross-boundary vehicle trips, from 31,000 per day in 2001 to 42,800 per day in 2011 (Fig. 4).

Fig. 3. Average Daily Cross-Boundary Passenger Trips (Source: Cross-boundary Travel Survey, 2011)

Fig. 4. Average Daily Cross-Boundary Vehicle Trips (Source: Cross-boundary Travel Survey, 2011)

The trip between Hong Kong and Macau is one focus in the Cross-boundary Travel Survey. During the two-week survey period in 2011, there were an average daily of 54,100 passenger trips between Hong Kong and Macau.

3 The definition of cross-boundary trip was one-way movement between Hong Kong, China and Macau in either direction.
Hong Kong and Macau made through China Ferry Terminal, Hong Kong-Macau Ferry Terminal and Tuen Mun Ferry Terminal in both directions, representing an increase of 16.0% over the 46,600 trips per day recorded in 2009.

Fig. 5 presents “average daily passenger trips between Hong Kong and Macau – by direction, and by usual place of residence”. Four different groups of passengers on the basis of their usual places of residence (e.g., Hong Kong, Macau, China, and Other) were distinguished for analytical purposes. Several interesting patterns can be observed. The majority of trips between Hong Kong and Macau were made by people living in Hong Kong. They took up 61.6% of all trips in 2011. In terms of number increase, trips made by people living in Hong Kong actually rose by 15.6%, from an average daily of 28,800 in 2009 to 33,300 in 2011.

Another group with rapid growth of cross-boundary travel is people living in the Mainland. The number of passenger trips between Hong Kong and Macau made by people living in the Mainland increased by 21.6% from an average daily of 5,700 in 2009 to 6,900 in 2011. It is noted that departure trips to Macau significantly outnumbered arrival trips, suggesting that it was common for people living in the Mainland to travel from Hong Kong to Macau and then returned to the Mainland direct from Macau rather than through Hong Kong.

![Average Daily Passenger Trips between Hong Kong and Macau](image)

**Fig. 5.** Average Daily Passenger Trips between Hong Kong and Macau by Direction by Usual Place of Residence (Source: Cross-boundary Travel Survey, 2011)

Trip purpose was also recorded in the Cross-boundary Survey. For example, a large proportion of
People Living in Hong Kong visited Macau for leisure. Of the average of 33,300 trips they made per day in 2011, 73.9% were for leisure, 13.7% for visiting relatives and friends and 8.6% for business. Compared with the 2009 Survey, the average daily of leisure trips increased by 17.2% from 21,000 to 24,600 in 2011.

2.3 Long-range transportation master plan of Macau (2010-2020)

With an initiative of Macau Department of Transportation (DSAT) and involvement from international transportation consultants and experts, the “Long-range Transportation Master Plan of Macau (2010-2020)” was completed in 2010. Taking into consideration of mega infrastructure development in the future, this transportation master plan described not only future projects, but also how those mega developments affect travel pattern, living environment, even the economy of Macau.

Using “Long-range Transportation Master Plan of Macau (2010-2020)” as a policy whitepaper, Macau government is gradually implementing its short-term, mid-term and long-term goals, including: restructuring public transport in 2012 to enhance commuting, opening light rail in 2015 \(^4\) to comprehensively prioritize public transport, and interconnecting regional transport in 2020 to realize the vision of green transportation, etc. Several of the key infrastructures were described in the following.

3 Status of infrastructure projects in pearl river delta

3.1 Macau light rail transit (LRT)

Adopting a holistic concept of public transport networks, Macau government consider the Light Rail (LRT, Fig. 6) as the backbone; supported by buses and taxis (for the first and last mile), to create a better commuting environment for residents and tourists. Macau LRT is designed to be 21 km long with 21 stations, with headway of 3~6 minutes, average speed of 33km/hr, and maximum capacity of 8,000 people/hr/direction.

\(^4\) The Macau LRT was under significant delay. Only the Taipa section is currently under construction and expected to open no early than 2019.
Construction of the Light Rail Transit (LRT) system began in 2011 – starting from the LRT Taipa section; then LRT Macau (peninsula) section. The construction of the “heart” of LRT system (i.e., the depot) commenced on November 23, 2011. This represents an important milestone for light rail project. The whole LRT project was expected to be completed in May, 2015, as originally planned.

However, due to various reasons (e.g., shortage of labour, design and procedure flaws) the whole LRT construction was under significant delay. So far, only the LRT Taipa section is under construction. The LRT Macau section is now paused (i.e., all the primary design is completed, but not entering the construction) due to labour issues and protest of local residents.

Considering above situation, Macau government would try to ensure the LRT Taipa section open in 2019. For the LRT Macau section, due to its significant delay, there is emerging voice from local politicians urging the stop of construction. Thus, one reasonable short-term scenario is the “half-LRT” serving the Taipa island (where is Cotai Strip located), up to Barra temple in Macau peninsula. With this compromised route, the usage of LRT (for both tourists and local residents) will be affected.
Besides, other issues will further lower tourists’ intention of using LRT, including: insufficient room for luggage inside LRT cars, no direct linkage from all LRT stations to resort properties, etc. Eventually, we may expect more local residents using LRT than tourists – especially casino/resort employees living in Taipa island.

3.2 Regional rail system

Fig. 7 Regional Rail System of PRD (Source: Hong Kong government)

Fig. 7 describes the Regional Rail System of Pearl River Delta. One important section is the High-speed Rail (HSR) extension from Shenzhen to Hong Kong (shown in purple). This project was also delayed due to the boycotted funding mechanism in Hong Kong. Another critical section is the “Guangzhou-Zhuhai Intercity Rail” (Fig. 8). To fulfill the seamless transfer between Taipa and Zhuhai (through Hengqin Border), the “Guangzhou-Zhuhai Intercity Rail” and “Macau LRT Hengqin Extension” (shown in orange, Fig. 6) need to be both finished.

Fig. 8 shows the route map of Guangzhou-Zhuhai Intercity Rail, the route between Zhuhai CBD to Zhuhai airport (circled in GREEN) started from 2012 and expected to be finished by end of 2016. By then, we can expect some very different ways of entering Macau from Mainland China.
3.3 Hong Kong-Zhuhai-Macau bridge (HZMB)

As discussed, the LRT system enhances transport within Macau and connects to railways in mainland China, promoting integration of Macau and the Pearl River Delta region. The Hong Kong-Zhuhai-Macau Bridge is another crucial transport link with mainland China. Total length of HZMB Main Bridge is about 29.6 km, including an under-sea tunnel of 6.7 km; and two artificial islands. The east end of HZMB connects to Hong Kong (near Hong Kong International airport); the west end connects to both Zhuhai and Macau – to form a “Single Y” alignment (Fig. 9).

According to current plan, the HZMB’s landing point will be at the east-north corner of Macau peninsula (i.e., near the “arc”). However, the current environment (i.e., high-rise buildings with high density, narrow and complicated road network) of that location is not perfect to accommodate the HZMB traffic. In terms of construction, the bridge construction on the Zhuhai-Macau artificial island is now progressing satisfactorily. The Hong Kong-Zhuhai-Macau Bridge is expected to be completed for

There will be vehicle control on HZMB. For private vehicle to use the bridge; the dual-license (i.e., Hong Kong-Guangzhou) is needed, and the toll is around 100 ~ 150 RMB/car. Vehicle without dual-license can apply daily quota for day-pass of HZMB use; according to senior government official of Hong Kong. For tourism shuttle bus or limo; there will be quota control on using the bridge as well. However, a lot of the vehicle control policies are still under discussion between Hong Kong, Macau and Chinese government.

Fig. 9 Hong Kong-Zhuhai-Macau Bridge (Source: Hong Kong government)

3.4 Hengqin development

The development of Hengqin island can be considered as another type of infrastructure. On August 14, 2009, the China State Council approved the implementation of the Overall Development Plan of Hengqin, which incorporates Hengqin Island into Zhuhai Special Economic Zone, aimed at developing Hengqin into a demonstration area for exploring new mode of cooperation between Guangdong, Hong Kong and Macao under the policy of “One Country, Two Systems”.

On December 16, 2009, Hengqin New Development Zone was officially established. It is the third national-level New Development Zone, founded after Shanghai Pudong and Tianjin Binhai New Development Zone.

The CIQ (Custom, Immigration, Quarantine) process is a key for the Hengqin development. The CIQ management is implemented on the principles of “easing first tier/hierarchy, controlling second...
tier/hierarchy, separating passengers from goods, and managing by classification”. On April 11, 2013, the “Supervision and Administration Measures” for Entry-Exit Inspection and Quarantine in Hengqin was issued. The document clearly defined the CIQ procedures under “first tier” and “second tier”:

“First Tier”: The ports between Hengqin and Macau are defined as “the first tier”. People need to go through a simple CIQ process in the First Tier. The border crossing between Hengqin and Macau can be further simplified in the future, which would justify Hengqin’s integration with Macau.

“Second Tier”: The channels connecting Hengqin and downtown Zhuhai are defined as “the second tier”. Starting from August 1st 2013, the Hengqin new development zone started to implement new measures to facilitate entry into the district for Macau vehicles and tax exemptions for Macau products.

4 Response to mega infrastructure

4.1 Macau DSAT’s trip survey

To understand people’s behavioral response to future mega infrastructures, a large-scale trip survey has been conducted in 2010 by Macau Department of Transportation (DSAT). Total 2,400 valid samples were collected containing local residents (1200) and tourists (1200). The residents were further categorized by trip type (internal vs. external), and the tourists were separated according to their locations of residence. The sample composition of DSAT’s trip survey is shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1 Sample composition of Macau DSAT’s trip survey</th>
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<tbody>
<tr>
<td><strong>Sample Size</strong></td>
</tr>
<tr>
<td>RESIDENT (total 1200)</td>
</tr>
<tr>
<td>Making Internal Trip</td>
</tr>
<tr>
<td>Making External Trip (Cross-Border)</td>
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<tr>
<td>(With Car = 232; Without Car = 68)</td>
</tr>
<tr>
<td>TOURIST (total 1200)</td>
</tr>
<tr>
<td>From HK and Shenzhen</td>
</tr>
<tr>
<td>Others</td>
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The survey aimed to address one important research question – how would people’s travel
behavior change after the opening of all mega infrastructures (e.g., LRT, HZMB)? Taking HZMB as one example, the competition between current ferry services and the bridge is important for future transportation planning in PRD region. In a hypothetical question asking how people will travel after the opening of Hong Kong-Zhuhai-Macau Bridge (HZMB), 54% of tourists and 66% no-car residents remain on ferry, while only 44% of car-owning resident still choose to take ferry after the opening of HZMB (Fig. 10).

![Travel Mode Share after opening of HZMB](source: Macau DSAT’s Trip Survey, 2011)

One thing to be noted, in the survey of 2011, many details of HZMB remained unsure (e.g., toll, speed limit, permission on private vehicle entering Macau); thus, respondents answered “hypothetical questions” purely based on their initial knowledge on future mega infrastructure (no hint was given to respondents during the survey). People’s travel response might change after they fully realize after experiencing the HZMB, and after the perceived utility getting constructed.

4.2 HKU study: expected saving of time and money after the opening of HZMB

University of Hong Kong conducted a series studies about the travel behavior change after the opening of HZMB. By collecting 300 survey responses from 5 majors ferry terminals in Hong Kong, Macau and Zhuhai, it is shown that the average time people spend on a PRD trip (self-reported) is around 3.3 hours, and the total money spend on this trip is around HKD $344. Clearly, the current
ferry journey between Hong Kong and Macau is only part of people’s trip chain, because above time and money spending are both more than a typical “HK-Macau” ferry trip.

In the survey, the 300 respondents also show their expectation on time saving from HZMB (vs. Ferry) is around 1~1.5 hour; correspondingly, the predicted money to save is roughly from HKD $41~100 (Fig. 11). The implication is – for people expecting to save HKD $100 on using HZMB, if the general cost (e.g., toll) of HZMB is more than HKD $69, they would be likely to still choose ferry, considering a typical ferry ticket of HKD $169.

![Expected Time to Save](image1)

![Expected Money to Save](image2)

Fig. 11 Expected Time and Money Saving after HZMB (vs. Ferry)

In this research, the 300 respondents were also asked their preference in reducing total travelling time or money (if can only choose one) under different time/money saving scenarios. Such question is designed to test the price sensitivity versus time sensitivity. As shown in Fig. 12, a trend can be observed – the more time/money saving (as % to total trip), people more likely to choose time, instead of money. For example, the HZMB will be more likely absorb the “HK-Macau Commuters”, instead of people traveling from Mainland China, since the time saving of HZMB would be a larger % for those HK-Macau Commuters.

![People's choice on 30%](image3)

![People's choice on 50%](image4)

![People's choice on 70%](image5)

Fig. 12 People’s choice on 30%, 50%, 70% “time vs. money” saving scenarios
4.3 LRT maximization

In addition to HZMB as infrastructure for external trip, DSAT’s Trip Survey also explored people’s travel pattern change after the LRT (internal trip). Results shows, in terms of internal transportation, the “walk group” is main customer for LRT. That is, LRT will attract more “walking” people (50%) than bus or casino shuttle riders.

As previously discussed, the LRT is introduced as a backbone transportation system in Macau. The existing taxis, public buses, casino shuttles would all become supplement with the LRT. Casino shuttles, especially, were considered as potential issues by local government, although this unique system does/did take critical function in transportation. Regarding to casino shuttle, Macau DSAT’s policy direction is to regulate the service by setting fixed parking locations, increasing the parking turnover, and making Express Line along the less busy corridor. After the completion of LRT, the casino shuttle might be further limited.

In a study about “Optimization of Transportation at Gongbei Border Gate”, a “LRT Maximization” scenario is modeled (Fig. 13). In that scenario, the casino shuttles are generally not allowed to pick up passengers in border gates. Instead, casino shuttle serves as feeder bus for LRT and pick up people from every LRT stations. By doing so, the forecasted market share (in 2020) of casino shuttle at Gongbei Border Gate will be reduced from 10% to 4%; with LRT growing from 18% to 38%.

![Fig. 13. LRT maximization scenario at Gongbei border gate (Macau)](image-url)
5 Conclusions

This paper first presented an overview of planning concepts in PRD region, deep understanding of regional transportation blueprint, and current status of major infrastructure building. To understand the influences of those new builds, this paper analyzed the results of Macau DSAT’s travel behavior survey. As results show, the “competition effect” between new and existing travel mode is not obvious. For example, the ferry will still be a prevailed mode even after the opening to HZMB. The Macau LRT will not affect the bus and casino shuttle, but make the “walking people” as its main customers. Only after the “LRT Maximization” scenario, the LRT would start to pick up the right mode share as a “planned” backbone transportation system. From this study, it is very obvious that – “behavior change always takes time”. The infrastructure development may not even guarantee the behavior change.

Taking Macau as example, its visitors reached a peak of 30.7 million/year in 2015; which is close to the total population of Malaysia. With the current policy of promoting mass market and non-gaming, the annual visitors should be increased in the future – 50 million/year is the number being discussed; which is close to total population of whole PRD region. We all believe that a city cannot have infinite tourism carrying capacity (TCC). However, using the infrastructure development to improve the TCC may have two issues. First, the building of infrastructure can very easily be delayed, and will undermine its original functionality (e.g., improving TCC). Second, even the infrastructure is completed on time, people’s behavior won’t easily change as we planned.

However, people’s travel response can change after realizing more policy detail of those new builds. Thus, the survey and modeling should be refined/calibrated after the finalization of some important detail (e.g., vehicle control on HZMB, Fare of LRT).

One important things to be noted, in discussion of cross-regional transportation in PRD area, the size (land, population) difference among China, Hong Kong, and Macau make it very hard to achieve one universal planning paradigm. The better we understand specific concern (including: policy, current behavior, etc.) of various regions in PRD, the more precisely we can foresee the implication (or impact) of future mega infrastructure.

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