The Study on Promoting Hybrid Canal-Rail Connectivity in Bangkok and its Vicinity

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Abstract

The role of water-based transport has diminished gradually over the last few decades while the dominant role of traditional land-based transportation system could not be sustaining solution for Bangkokians. In the same time, mass transit system has been proposed for alternative solutions, while the current network of waterway are in the circumstance of inadequate accessibility, poor inter-modal linkages as well as unsafety. This research intends to present an idea of hybrid land based and waterway connectivity on the basis of binary logistic regression model. The introduction of some measures to improve the transportation system along these canals in Bangkok could be recommended.The result of study also exhibits how the reincarnation of this mode of transport can leave the urban transportation planners with substantial alternatives to enhance the existing mobility condition when road based congestion and safety issues still remain unsolved. Finally, this study also provides insight to incorporate water transport within the mainstream of transportation planning and progress towards a sustainable integrated transportation system which eventually recalled the appealing of "Venice of East" towards hybrid canal-rail connectivity in Bangkok as a postmodern transportation.

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1. Introduction

1.1 Background of transportation system in Bangkok

The Chao Phraya River is well-known for its role as the initial point of development of Bangkok's urban morphology. The excavation of moats mirroring the curve of Chao Phraya River formed Rattanakosin Island, the present metropolis's royal core. As Thailand's main centres were canal-based settlements, most of the commoners lived on floating houses on the river or around its tributary canals. The presence of the river and canal system is a significant physical feature within historic Bangkok. Thus, socio-economic and cultural aspects of the people are linked with rivers and streams (Askew, 1996, pp. 183-210; Mateo-Babiano, 2012). Since the 20th Century, the role of water transportation has diminished due to the widespread development of inland transport network (Iamtrakul, Thongplu & Kritayanukul, 2013, pp. 34-45). The replacement of water transport has been filled with road based system. However, during the past decade, traffic conditions in Bangkok have worsened significantly due to the rapid increase in private vehicles. Not surprisingly, Bangkokians spend an average of two hours commuting from home to work and back (National Statistical Office [NSO], 2004). As a result of severe traffic congestion, commuters are inevitably exposed to high levels of vehicle-related air pollutants. Thus, a complete network of mass transit systems along with promoting the use of public water transportation is necessary to alleviate traffic congestion towards the more sustainable well-being of society in Bangkok.

Regarding water transportation, the geographical locations of the waterway networks provide possible accessibility through their tributaries. Local commuters can avail of alternative means of travel by utilizing the boat services. Three different types of boat operations provide services which include express boat, ferry boat and long-tailed boat. These boats are different in sizes and purposes. Express boats cater to the needs of those who commute along the Chao Phraya River. Ferry boats serve passengers who wish to cross the river. The long-tailed boats offer their services to passengers who commute into the canals, locally known as "*khlongs*" (Tanaboriboon, 1995).

1.2 Boat services in Bangkok

Boats in the canals of Bangkok offer two types of services: regular services which cater to the public commuters with specified route and a fixed fare rate set by operators, and the irregular services which serve as for-hired or chartered boat like water taxi service. In the past, while Bangkok commuters still relied on the service of long-tailed boats, several routes were in operation to cater the needs of public especially those who live along the canals. However, with the recent development of road-based transport, several areas which were used to solely depend on water transport became more accessible by land transport modes. Gradually, the need for long-tailed boat services began to decline and subsequently some long-tailed boat routes began to cease their operation due to unpopular demand and recession in revenue collected through their operation. Besides, some routes were no longer suitable for navigation purpose due to the installation of flood protection facilities. At present, there are a total of 14 routes where long-tailed boats still offer their services to the interior canals connecting with the Chao Phraya River. In addition, current long-tailed boat routes along the canals in Bangkok are also providing their services which are along Khlong Saen Saeb, Khlong Phrakanong, Khlong Phasi Chareon and Khlong Lad Phrao.

According to the boat commuter statistics collected by the Marine Department (MD) under the Ministry of Transportation, the number of boat commuters had decreased from 82 million persons in year 2011 to 76 million persons in year 2012. Currently, the numbers of passengers step down to 71 million people in 2014 (Marine Department [MD], 2014). In addition, in regards to the frequency of use, boat commuters used ferry boats most, followed by Khlong Saen Saeb boat service, and finally by Khlong Phrakanong boat. The Office of Transport and Traffic Policy and Planning (OTP) had forecasted the numbers of commuters who commute by water transportation in the canal system in Bangkok Metropolitan Area, and expected that the number of commuters will increase from 298,000 trips/day in year 2011 to 487,000 trips/day in year 2032. However, in fact, according to data about the amount of commuters who used these two routes of canal network (Saen Saeb canal and Phrakanong canal), it was clearly seen that the number of commuters is still lower than forecast.

1.3 Mass transit development in Bangkok

There are three main system of mass transit development in Bangkok, the first one is the Bangkok Transit System Corporation (BTSC) metro rail "skytrain" system began official operations in December 1999 but was initiated in 1994 (Bangkok Mass Transit System [BTS], 2015). It comprises a 23.5 kilometers electrified train system of 23 elevated stations. The BTS operates two intersecting routes aligned north-south and east-west which are elevated over two of the most highly congested roadway

corridors in the city, Silom and Sukhumvit Roads (International Business Publications [IBP], 2013). The second one is Metropolitan Rapid Transit (MRT), MRT system is operated by Bangkok Metro Public Company Limited (BMCL). First planned in the mid 1970's, it is the first underground metro system to provide train service over a route of approximately 20 kilometers (Union Internationale des Transports Publics [UITP], 2013). The current system operates with 18 stations and a maximum of 19 trains that run with 5 minutes of headway during peak hours and 10 minutes for regular service (MRTA, 2015). The latest system is Airport Rail Link is an express and commuter rail which provides a service from Suvarnabhumi Airport, via Makkasan, to Phaya Thai station in central Bangkok. The Airport Rail Link opened for service since August 23rd, 2010 with the total length of service of about 28.6 kilometers. Service consists of two express services (a 15-minute non-stop service between the Makkasan city air terminal and the airport, and 18-minute non-stop service between Phaya Thai and the airport) and the city line with eight stations (SRT, 2015).

1.4 The canal-rail connectivity

There are potential of merging the aforementioned canal transit system and the expanding rail transit system due to the geographically characteristic. However, the condition of connectivity must be provided as a network of water buses serving the waterfront and other waterways to the rail network which would in part capitalize on the latent potential of canal network. The major advantage of both canal transit system and rail transit system is being free of traffic congestion, thus allowing for predictable and fixed commuting time this research intends to search for the tool which is enabling for analyzing and measuring urban connectivity using multi-modal transport. In fact, out of the over 1,161 waterways and canals in Bangkok Metropolitan Region, there are routes with navigable potentials that could interconnect with the expanding rail transit system at multiple junctions, creating urban hubs and densifying the urban connectivity network. This study aims to demonstrate the potential of hybrid canal-rail connectivity by focusing on users' behavior and attitude on shifting their mode when canal-rail connectivity is available. Furthermore, the canal-rail connectivity would involve intermodal behavior of travelling that requires transfer stations with pleasant walkways linking boat piers and rail stations. In this respect, with an extensive waterway network, Bangkok should utilize this potential of the usage of canals and canal-based transit and tried to find ways to revive it. As well as more specific investigation on the development of canal-rail intermodal stations and nearby communities under the concept of transit-oriented development (TOD) should be studied and bring about an appropriate recommendation to apply with the specific development context.

2. Literature Review

2.1 Concept of Transit-Oriented Development (TOD)

Transit-Oriented Development (TOD) is a form of urban development centred on the provision of access to high-quality public transportation and dense, walkable neighborhoods. TOD is typically defined as more compact development within easy walking or biking distance of a transit station, typically a half mile (The Center for Transit-Oriented Development [CTOD], 2010). This proximity to transit would allow people to make daily commutes by using transit, walking and biking, rather than driving. The high density neighborhoods should support a mix of uses and activities including mixed-income housing, work places, child care, stores, and restaurants, etc. With the advantage of this type of development, people are able to reduce their travel expenditure. In particular, car usage and possibly even car ownership could be reduced as well (The Center for Transit-Oriented Development [CTOD], 2010). TOD promotes the possibility that people with a wide range of incomes will be able to live and work in places with interconnected transportation networks that offer a variety transportation options. To bring about significant changes in behavior, however, people need alternative modes of transport that are convenient, punctual, seamlessly connected, and safe. Development should cluster around transit facilities and create a network of places and nodes at a community scale or even regional scale (The Center for Transit-Oriented Development [CTOD], 2010). TOD can help mitigate various important challenges that currently face cities today are reduce congestion and increase mobility options, increase livability, increase economic activity, improve environmental quality and health, maximize efficiency of transportation and real estate investments, generate sustainable transit ridership and fare box revenues and support diverse neighborhoods.

2.2 Community development around the canal-rail transfer stations and along the canal transit routes

The concept of Transit-Oriented Development (TOD) mentioned in topic 2.1 is to clarify the overall definition and the core of TOD. This is the process of linking development with transit routes and defined as a paradigm for creating attractive and sustainable

communities, or compact neighborhoods (Bernick & Cervero, 1996). It aims to reduce the problems of travel, especially traffic congestion, fuel consumption, and wasting money and time on travel. The success of TOD will be enhanced through significant changes in traveling behavior. The highly interconnected transit networks that are convenient, timely, seamlessly connected, and safe can motivate passengers to choose a better mode of transport. Moreover, the development of land surrounding transit stations can reduce the need to travel through mixed-use development, high-density living and a close proximity to frequent passenger transport (Hamton, 2010). In regional scale, TOD is a mechanism to encourage 'Compact City' that leads to urban sustainability. The compact city means a relatively high-density, mixed-use city, and an intensified city based on an efficient public transport system and dimensions that encourage walking and cycling (Burton, 2000, p. 1970).

2.2.1 Building density and intensity

Building to a higher density is one of the primary characteristics of transit-oriented development as compared to conventional development. The advantages of this idea are to reduce auto-dependency, making efficient use of TOD sites, supporting pedestrian-friendly, and creating lively environment. Density allows sufficient customers within walking or bicycling distance of the transit stop. Jeffrey Zupan and Boris Pushkarev's works in 1977 also supported the notion that auto use declines and transit use rises as a function of both residential density and the presence of dense agglomerations of nonresidential floor space around the transit stop. Therefore, building density influences walking distance and the demand of auto use (William, 1999, pp. 167-178). However, how to measure density is still a contentious issue in the urban development literature. In terms of TOD, ordinances are more likely to establish minimums in order to ensure density adequate to support transit system (Dittmar & Ohland, 2004). However, to ensure the livability of TOD districts, many localities balance requirements for higher density with detailed requirements for open space. These appear to indicate that densities could be increased substantially before they would reach an undesirable level.

2.2.2 Mixed use development

The reduction of auto use via high-density development in TOD will be feasible with the introduction of a mixed-use environment (Hamton, 2010). Providing a mix of uses within neighborhoods helps make communities (a) more convenient because several errands can be completed in one trip, (b) more affordable because a car is not needed for every trip, (c) more dynamic and livable because of enlivened sidewalks and public spaces, and (d) more incentives in economic because of job-producing commercial development. Rather, TOD offers a wider range of housing, mobility, and shopping choices than conventional suburban development (Bernick & Cervero, 1996). Hence, a rich mix of choices is the defining feature of the best neighborhoods that can offer many activities within walking distance.

2.2.3 Active and walkable streets

The terms "walkable" and "walkability" have been given new meaning as a result of efforts to address the multiple problems caused by designing communities primarily for motorized travel (Steiner & Butler, 2007). It promotes the health, safety, and welfare of residents. The walking distance or walkability from transit station is a criterion to define the territory of a TOD. Generally, TOD is located within a 10-minute walk, or approximately 0.5 miles from a light rail, heavy rail, or commuter rail station. To take advantage of transit proximity and planning, design elements encourage walkability and create pedestrian-friendly, that connect to surrounding communities. Active, walkable streets are a function of many urban elements working together, namely land use, sidewalks, building placement and orientation, entrances, fenestration, block size, placement and supply of parking, and street standards (Dittmar & Ohland, 2004). These are elements to encourage people to connect several places around transit stations in TOD by walking or by cycling.

3. Methodology

This research has been conducted the questionnaire survey in order to understand how commuters response to the choice of canal-rail connectivity to recommend for appropriate planning and design for proximity area of hybrid canal-rail connectivity in Bangkok. The process of method of analysis as explained as follows;

3.1 Data collection

The questionnaire is aimed to investigate travel behavior of commuters and their opinions on linking Bangkok's canals network to Mass Rapid Transit lines. The data obtained explained commuters' behaviors and factors affecting a shift in transit mode, along with recommendations in policies and mathematical modeling. Population and sampling is one of the most important sequences in conducting questionnaire survey. It identifies a subset of subject that represents the entire population

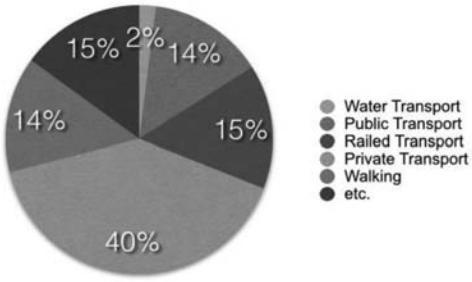


Figure 1. The percentage of BMR's existing travel patterns. (World Bank Report, 2007)

Table 1. Total allocated questionnaires in each administrative province. (Ministry of Interior, 2013)

Administrative Province	Population	Population in Percentage	The average percentage of existing travel patterns in BMR						Total allocated questionnaires
			walkin-g	Private Transport	Railed Transport	Public Transport	Water Transport	Etc.	
			8	25	25	8	25	9	
Bangkok Metropolitan Administration	5,686,252	53.95	55	160	160	55	160	60	650
Nakhonpathom	882,184	18.18		60		20		20	100
Nonthaburi	1,156,271	23.83		50		15	50	15	130
Pathumthani	1,053,158	21.70		70		25		25	120
Samutprakan	1,241,610	25.59		38	38	12	38	14	140
Samutsakhon	519,457	10.70		36		12		12	60
TOTAL			55	414	198	139	248	146	1,200

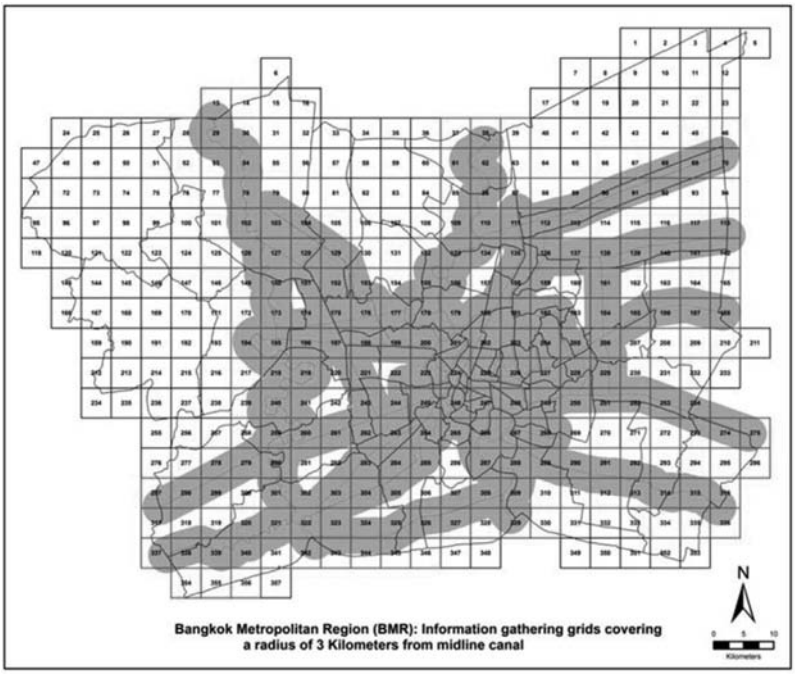


Figure 2. The distribution of data collection.

because answers given from sampling will be generalized in order to represent characteristics of the entire population. For this study, population taken from areas within 3 kilometers from canal routes in Bangkok Metropolitan Region was figured for processing a sampling. As a result, there are 1,111 samples derived from calculating through Yamane's formula (Israel, 1992, p. 4). Thus, 1,200 samples were set as the sample size across BMR area. Investigating existing travel patterns of BMR population for setting proportions of respondents in varied patterns in each site. Regarding results shown on Figure 1, it is found that private cars share the highest percentage of all modes while water transportation has the lowest percentage comparing to other modes.

3.2 Distribution of data

A total of 1,200 questionnaires were allocated by using two criteria, which are the average percentage of modified BMR's existing travel patterns and population in each administrative province (Table 1).

The proportion of purposive sampling was designed by focusing on the major modal usage of hybrid canal-rail network (50 percent), followed by private transport (25 percent), public transport and walk (8 percent each). In conclusion, 650 questionnaires were allocated to Bangkok Metropolitan Administration and 140, 130, 120, 100, and 60 questionnaires were administered in Samutprakan, Nonthaburi, Pathumthani, Nakhonpathom, and Samutsakhon respectively. The last step is distributing questionnaires in grid scale. The BMR were equally divided with a 25 sq.km. grid (Figure 2). This was followed by picking grids covering an acceptable radius distance of 3 kilometers from canal. As a result, grey coloured areas represent the most suitable areas for distributing questionnaire survey.

3.3 Data analysis

There are two analyses in this section which can be explained below:

• Data analysis (descriptive statistics) – in this study, the descriptive statistic is applied to explain the characteristics of samples in regards to mode choice, socio-economic perspectives, attitude towards development of Hybrid Canal-Rail mode (HCR) and some expectation to choose HCR for travel in the future. There are 1,200 samples collected in Bangkok Metropolitan Region (BMR) during November – December 2014.

• Samples were collected randomly in each 3x3 kilometers grid ranges. The sampling method in this research is random sampling in each grid, therefore, the sampling method covers all types of passengers and is well normalized. There are four categories in this analysis. The first category is the quality of service vehicle (i.e., safety of service vehicle and condition of service boat). The second category is the condition of hybrid canal-rail (HCR) station (i.e., effectiveness of space usage in hybrid canal-rail station and provision of facilities in HCR station). The third category is the condition of surrounding (i.e., attraction points nearby HCR station, and development project of surrounding area). And the fourth category is travel behavior (i.e., the number of trip chain, expected travel time in HCR mode and expected travel cost in HCR mode). These four categories are considered as independent variables.

• The dependent variable is the intention of respondents to ride on the HCR (either boat to rail, rail to boat or from other modes to HCR). This is coded as "choose" or "not choose". This study applied binomial logistic regression model to predict which factors motivated respondents' decision to use HCR mode.

3.4 Binary logistic regression model

Independent variables (development factors, expected travel time, expected travel cost, and the number of trip chain) have been collected in Linkert scale while the dependent variable (decision to use HCR) could be answered in terms of "use" (represented by 1) and "not use" (represented by 0) (Rodrigues, 2007). Therefore, the general regression equation could not be applied in this circumstance due to statistical problem. Independent variable is ratio scale and dependent variable is categorical value. Thus, this research applied logistic regression model to predict which variables affected whether decision of passengers will choose canal-rail transit for future transportation or not. (Christensen, 1997).

4. Result of analysis

4.1 Existing transit demands and intermodal transfers

4.1.1 Characteristic of respondents

Most of the respondents are female (56.10 percent), and 43.90 percent are male. The majority of respondents are between 21 to 25 years old (28.60 percent). The group of respondents whose age falls in the range of 26 to 30 years old (24.30 percent) represent the young emerging "worker group". Most of the respondents obtained Bachelor degree or Diplom degree (67.30 percent), followed by respondents who are in junior high school, high school, or vocational school (21.70 percent). The private sector is the largest occupational category; accounting for 27.70 percent of total employment. The second largest occupational category appears to be university students (24.50 percent), followed by sole practitioners/businesses owners (16.90 percent). For income level, 36.60 percent of respondents earned between 10,001 – 20,000 THB/month. Concurrently, 27.60 percent of the respondents earned between 20,001 – 30,000 THB/month. However, for the lower-income group, 21.50 percent of total respondents reportedly earned less than 10,000 THB/month.

The first group of respondents is living in a small-size (less than 3 persons) household unit (47.60 percent); while the second group of respondents are living in a medium-size (4-5 persons) household unit (30.80 percent). In regards to housing types, most of the respondents are living in single detached houses (66.80 percent), followed by dormitory (12.80 percent), and condominium (7.80 percent) type respectively. There are about 52.50 percent of the total respondents who are living in their current residence for more than 5 years. The second group of respondents have been living in their current residence for 3 – 5 years (16.00 percent). Only 13.30 percent of the respondents lived in their current residence for less than 2 years. In terms of private vehicle ownership, 37.50 percent of total respondents is reportedly owned private cars; followed by motorcycle owners (10.70 percent) and bicycle owners (5.20 percent). Surprisingly, there are 39.50 percent of respondents who do not own any vehicles.

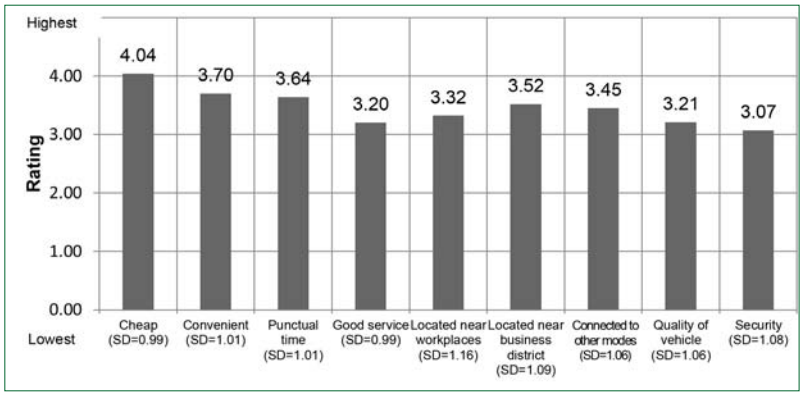


Figure 3. The supportive reason on selection of water transportation in Bangkok.

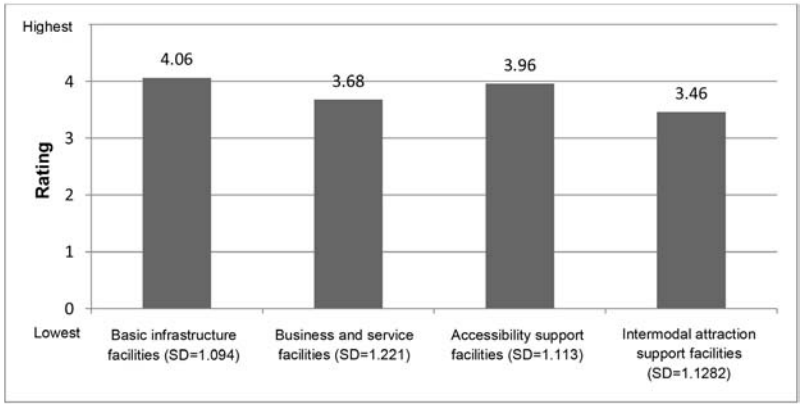


Figure 4. Supporting facilities at intermodal station.

4.1.2 Experience and preference for water transportation

Most of the respondents have some experiences in using water transportation in BMR (58.00 percent). They traveled by ferries (38.70 percent), express boats (29.90 percent), or canal boats (21.00 percent). The main purpose of using water transportation is for recreation which includes exploratory shopping along the waterways (45.70 percent). The proximity of their residences and the water piers plays a large role influence on water transit usage (29.90 percent); this is followed by the proximity of their workplace and the piers (15.80 percent). Respondents who avoid water transportation reported that their houses are located too far from the piers (63.80 percent); or the piers are not well-lit and too difficult to access in terms of boarding and safety (35.80 percent).

Most of the respondents (42.10 percent) rarely preferred water transit; they are using it less than once a month. This is followed by a group of respondents who uses the service once or twice per month (23.30 percent). Finally, there are currently 17 percent of the respondents who regularly use water transportation for their daily commute. Most of the respondents (33.10 percent) prefer to travel by water transportation during peak hours (08:01 – 11:00). Others (22.40 percent) prefer travelling in the early morning time (05:00 – 08:00). Finally, 69.30 percent of the respondents prefer to use water transportation anytime whenever it is available. When considering users' attitude on water transportation, there are five levels of rating to determine the respondents' choice. Travel fares play an important role on commuter's decision (4.04), follow by accessibility to pier (3.70), and travel time (3.64) (Figure 3).

4.1.3 Intermodal station facilities

The service facilities at intermodal stations can be classified into 4 categories: 1. Basic infrastructure facilities; 2. Business service relates facilities; 3. Accessibility facilities; 4. Intermodal facilities (Figure 4).

Based on collected data, most respondents expressed the highest level of need for basic service facilities (4.06). This is followed by accessibility facility (3.96) and business service facilities (3.68). Under the basic facilities category, respondents expressed the need for public toilet improvement (3.87), common ticketing system (3.40), and navigation system (3.34), respectively. With regards to business and service related facilities, the respondents expressed the need for Automate Teller Machines (ATM) in moderate-to-high level (3.96); followed by the convenient shop (3.46), and food shop (3.25). Under the accessibility facilities category, respondents strongly preferred pedestrian access to stations (4.07), followed by the improvements of connectivity to another public transit systems such as BTS, MRT or others modes (3.82). Finally, provision

of parking space (3.81) is also preferred. The real estate development around intermodal stations are strong drivers of future ridership demands (3.76). Having hospital or medical services facilities (3.24) and office building (3.06) near the hybrid transit station is also preferred. In the development of intermodal station, most of the respondents are paying attention to safety improvements (4.51), accessibility and convenience of the intermodal station (4.13), and improvements of ticketing system (3.90), respectively.

4.1.4 Current mode of transportation usage

There are three categories of transportation modes which are considered in this study; (1) private vehicles (i.e., private cars, motorcycles, and bicycles); (2) paratransit (i.e., taxi and van); and (3) public transit (i.e., buses, BTS, MRT, BRT, ARL and boats); and (4) others (i.e., walking) (Figure 5). Most of the respondents still preferred private cars (35.51 percent). When considering public transit, buses are the preferred mode for the respondents (16.58 percent), followed by canal boats service (13.87 percent); while vans were adopted as an alternative mode of paratransit (5.67 percent). According to data collected on travel behaviors, most of the respondents prefer less connections between their origins to their destinations (50.50 percent), while 49.50 percent of total respondents need to use at least two modes of transit. The current travel cost of respondents is approximately 51.38 THB/trip (origin to destination) (Figure 6). When considering the duration of travel time, it shows that respondents could reach their destination within 38.67 minutes/trip (Figure 7).

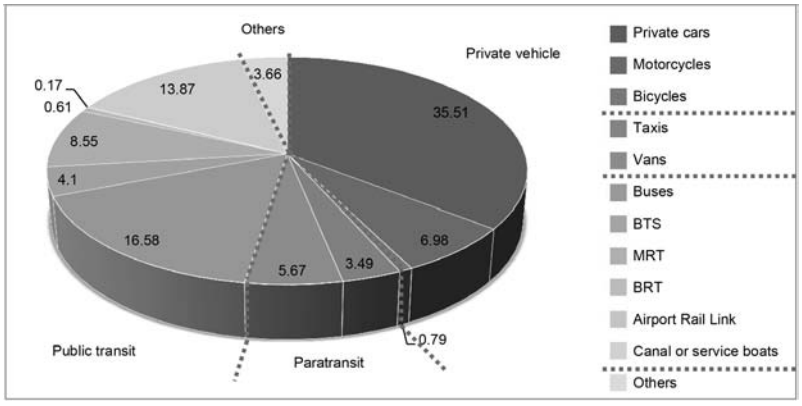
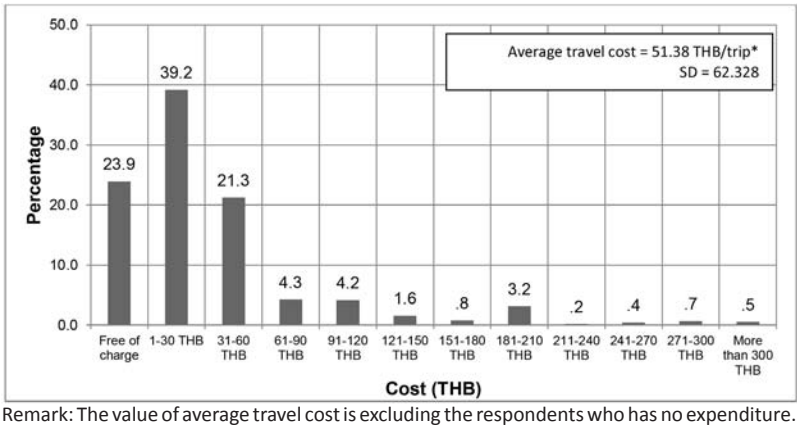


Figure 5. Mode of transit usage: shading listed from dark (high usage) to light (low usage).



Remark: The value of average travel cost is excluding the respondents who has no expenditure.

Figure 6. Travel cost (THB) per trip vs. percentage of respondents.

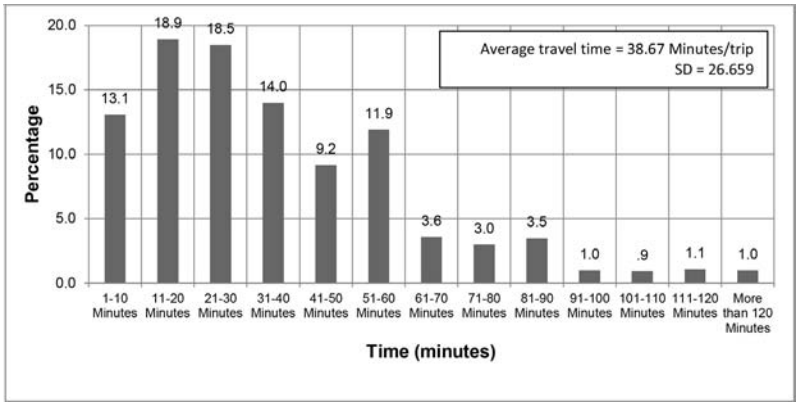


Figure 7. Travel time (Min) vs. percentage of respondents.

Table 2. Future demand of canal-rail transit.

		Quantity	Percentage
As your preference, if possible. Will you decide to use boat for your travel trip?	**Yes**	**831**	**69.30**
	No	369	30.80
	Total	1,200	100.00
If the canal-rail transit is established, will you use this transit mode?	**Yes**	**701**	**58.40**
	No	499	41.60
	Total	1,200	100.00

Table 3. The effect of park and ride infrastructure on the commuters' demand.

Variables	Percentage
If a park and ride service available, will you use the existing water transportation and rail system?	
Not use	33.40
Park and ride	64.80
Park and not ride	1.80
Parking fare	
Daily subscription	65.30
Store hour	34.70
Water transportation fare type	
Flat rate fare	49.60
Fare based on the distance	50.40

Table 4. Attitudes and expectations of respondents towards the establishment of canal-rail intermodal project.

Variables	Percentage
Do you agree with the establishment of Hybrid Canal-Rail network stations?	
Agreed	94.5
Disagree	5.5
Expectation towards the establishment of Hybrid Canal-Rail network station	
Route construction improvement	61.7
Service improvement	38.3

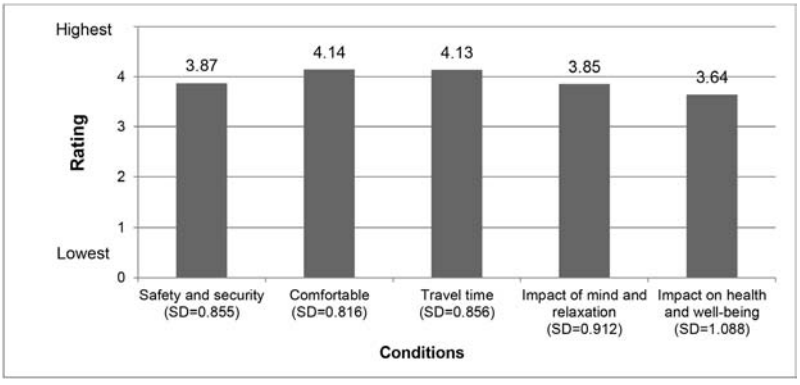


Figure 8. Respondents' attitude towards the quality of existing travel trips.

4.1.5 Future demand of canal-rail connectivity

In regards to the preference for canal-rail connectivity, 69.30 percent of the respondents preferred to use canal transportation if linkages to other modes of transit are available. In particular, most of the respondents (58.40 percent) intended to use the hybrid mode of canal-rail transit when the new connectivity is available (Table 2).

There are 3 considerations for the respondents' decision to use canal-rail transit: (1) the provision of park and ride; (2) parking fare structure; and (3) water transportation fare (Table 2).

The respondents who are using private vehicles are willing to use the canal-rails transit when there are park-and-ride facilities (64.80 percent). In terms of the parking fare structure, 65.30 percent of commuters prefer to pay the parking fee on a daily basis. Moreover, 50.40 percent of respondents prefer to pay their travel fares on the basis of actual distance (Table 3). On the expectation of developing canal-rail transit linkages, 94.50 percent of total respondents expected to see new improvements in the near future. In particular, 61.70 percent among all respondents, are expected to see new construction related to hybrid connectivity project (Table 4).

With regards to the attitudes of the quality of the existing trips, comfort is the most important variable in using canal-rail transit; it is a major concerns of most respondents (4.14) (Figure 8). This is followed by the expectation of saving travel time (4.13), and safety (3.87), respectively.

4.2 Determining Factors of Transit Demand: Towards the Future Development of City-Wide Canal-Rail Connectivity

There are 3 types of transportation modes which are regrouped in this study. The categories of analysis consisted of (1) private vehicle; private car, motorcycle, and bicycle. (2) paratransit; taxi and van. And (3) public transit; bus, BTS, MRT, ARL, BRT and boat service. This section describes the commuters' demand in relation to the percentage of improvements in various canal-rail transit infrastructures.

1) Canal-rail service vehicle improvements

There are 10 factors that are related to the improvement of canal-rail service vehicles as depicted in Figure 9. In order to encourage commuters to switch from private transit to canal-rail transit, the deciding factors are: travel time reduction (66.80 percent), reasonable travel cost (65.80 percent), and safety conditions (65.75 percent). In regards to paratransit commuters, the deciding factors are: reasonable travel time (68.35 percent), convenience and comforts (67.67 percent), and the general condition of vehicles (67.94 percent). Finally, for commuters who are using public transit, the deciding factors are: convenience and comforts (69.41 percent), reasonable travel cost (68.27 percent), and travel time (67.09 percent).

2) Intermodal station improvement

There are 15 factors that are related to the improvement of canal-rail service vehicles (Figure 10).

To motivate commuters to switch mode from private cars to hybrid transit, the deciding factors are: convenience and comforts of the intermodal station (66.67 percent), safety (66.43 percent), and the provision of drop-off area (65.99 percent). In regards to paratransit commuters, the deciding factors are: the provision of drop-off area (78.86 percent), the convenience of connectivity to other modes (78.29 percent), and parking lots (75.71 percent). For commuters who are using public transit, the deciding factors are: drop-off space (70.80 percent), the effectiveness of space usage (70.60 percent), and the provision of basic services (69.14 percent).

3) Improvement of surrounding area

There are 8 factors that relate to the improvement of canal-rail service vehicles (Figure 11). The deciding factors are: the attraction places around intermodal station (67.67 percent), accessibility (66.46 percent), and comforts (65.91 percent).

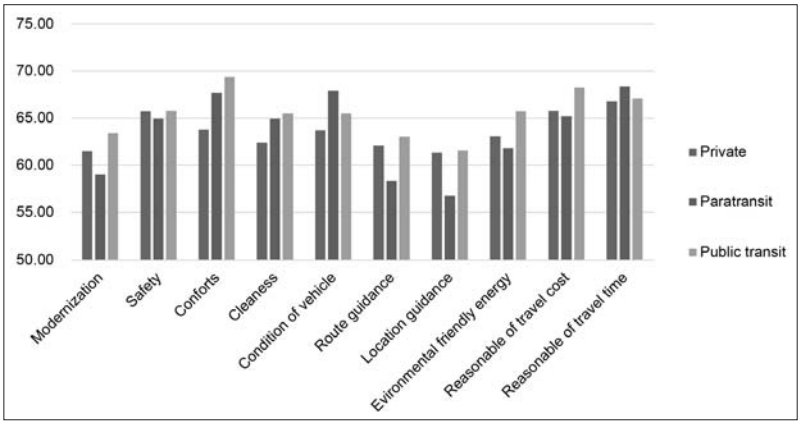


Figure 9. Factors of service vehicle that have influence on demand shifting.

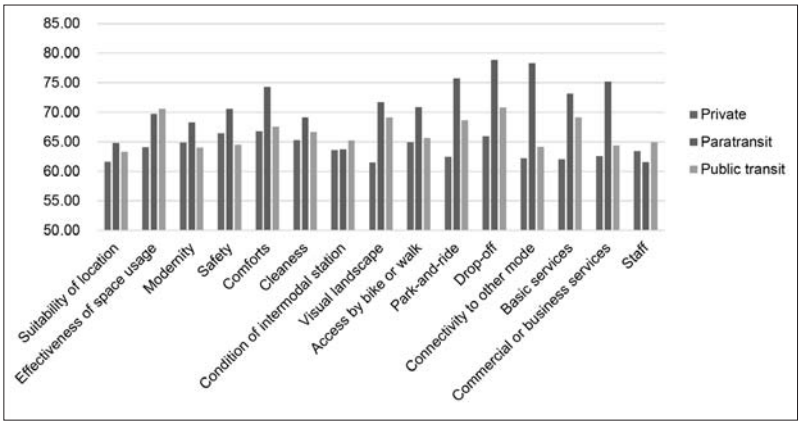


Figure 10. Factors of intermodal stations that have influence on demand shifting.

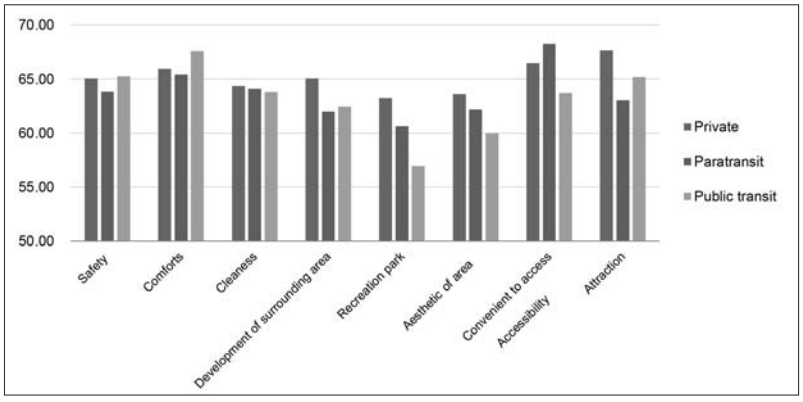


Figure 11. Factors of surrounding areas that have influence on demand shifting.

Table 5. Classification of forecasting canal-rail network.

	Observed		Predicted		
			If the canal-rail transit is established, will you use canal-rail transit mode?		Percentage Correct
			Not use	Use	
Base model	If the canal-rail transit is established, will you use canal-rail transit mode?	Not use	0	499	0.0
		Use	0	701	100.0
	Overall Percentage				58.4
Predicted model	If the canal-rail transit is established, will you use canal-rail transit mode?	Not use	188	311	37.7
		Use	128	573	81.7
	Overall Percentage				63.4

Table 6. Result of binary logistic regression model.

Variables*	B	S.E.	Sig.	Exp(B)	95percent C.I. for EXP(B)	
					Lower	Upper
Number of trip chain	0.325	0.076	0.000	1.384	1.192	1.606
Travel time	-0.010	0.002	0.000	0.990	0.986	0.995
Modernity of canal-rail service vehicles	0.010	0.004	0.020	1.010	1.002	1.019
Safety of canal-rail service vehicles	-0.019	0.005	0.000	0.981	0.973	0.990
Park-and-Ride in the intermodals station	-0.009	0.004	0.025	0.991	0.983	0.999
Commercial attraction	0.083	0.049	0.092	1.087	0.987	1.198
Constant	2.393	0.358	0.000	10.941		

* Using Backward Likelihood Ratio method

Remarks: B refers to Coefficient value of variable
S.E refers to Standard Error
Sig. refers to Significance level of variable
Exp(B) refers to the Exponential of (B) value and the probability of occurrence of dependent variable based on each independent variable
C.I refers to the Confidence of Interval

In regards to paratransit commuters, the deciding factors are: accessibility (68.25 percent), comforts (65.41 percent), and cleanness or the area (64.08 percent). For commuters who are using public transit, the deciding factors are: comforts (67.58 percent), safety (65.25 percent), and the cleanness (63.80 percent).

4.3 Mode Shift toward Canal-Rail Transit

This research applied binary logistic and it is assumed that travelers' preferences of an alternative mode (hybrid canal-rails) should capture the highest utility value among other alternatives (Kapteyn; 1985). The comparative result between based model and predicted model was derived by binary logistic regression model which are shown below (Table 5). The result could predict the increase of passengers' decision to use canal-rails transit from 58.40 percent to 63.40 percent. Therefore, there are 311 passengers who would not shift to canal-rails transit.

According to the result from binary logistic regression model, there are two kind of factors which are influenced the respondents' decision: positive factors and negative factors (Table 6). Both of two factors are described as follows:

1) Positive factors

The most important factor that positively influenced on the decision of commuters to using canal-rails transit is the number of trip chains, which positively influenced respondents by a factor of 1.384.

The second most important factor is the improvement of the canal-rails station (commercial improvement). This factor positively influenced on the decision of respondents by a factor of 1.087. Moreover, modernizing the canal-rail service vehicle will positively influence on the decision of commuters by a factor of 1.010.

2) Negative factors

These "negative factors" included travel time, safety condition and provision of park-and-ride at intermodal station; all of there factor resulted to negative or little effect on the decision of respondents in switching transit mode. In other words, making improvements on these factors will not change commuters' decision to switch mode. The result demonstrates some discrepancies between what the respondents intuitively thought to be important factors in switching modes and what actually gives them the highest utility. One should note that there are very rare cases of accidents occurring in water or rail transportation. In addition, the current canal boats are economical and runs on schedule. Adding more improvements to these factors would inevitably result in additional costs to the fare structure such as park and ride infrastructure, etc. Thus, when the improvements are focused on the aspects of safety, travel time, and accessibility, the result runs contrary to the respondents' intuition.

5. Conclusion and Recommendation

Based on the result of analysis in previous section, there are 3 out of 6 factors which have positive influences on the can-rail transit demand. Thus, to encourage commuters to change their travel behaviors, all parties should focus on different levels of transportation policy along with a strategy to capture the diversity of commuters' lifestyles.

• First, the priority of transportation should focus on the modernization of canal-rail service. This is due to the fact that the conditions of canal service vehicles still leave much to be desired. The service providers such as boat companies could improve the quality of service vehicles to attract more commuters.

• Second, commuters with a higher number of trip chains will likely to shift themselves to the hybrid canal-rail transit for their convenience. This factor shows the importance of connectivity factor. Today, in order to generate higher trip chain number, most passengers will have to go through many inconveniences in transferring from one vehicle to anothers. Most of these vehicles are operating in the informal sector such as motorcycle taxis or mini buses. Therefore, transportation service providers -- such as BMTA, BTS, MRT, BRT, boat service providers and BMA -- should collaborate as one interdisciplinary entity and make the connectivity at various mode of transportation more convenient.

• Third, the improvement of commercial attractions could increase the number of commuters. This alternative policy option should be implemented in accordance to concept of TOD. Therefore, BMA should establish the specific development plan around the proposed development of intermodal station, and should encourage private organizations, business enterprises, shop owners, real estate developers to participate in the development plan. Also, providing some basic infrastructure services such as Auto Telling Machine (ATM), banks, medical care center, or the one-stop service center, could drive future demand for canal-rail transit. This strategy leveraged on the advantage of trip chain, where one can do several activities at different stops in one trip.

• When the consideration has been made to offset the negative variables, it is demonstrated that over-investing in travel time, provision of park-and-ride, and safety may actually decrease the amount of commuters. This runs counter intuitively to many respondents' desires. However, when all factors are considered, the net utility for the system is reduced. Again, this may be due to the fact that the safety infrastructure for both the Metro and canal boats are already at acceptable level, when compared to other service aspects, given service with their low accident rates. Making more investment in these areas will not produce additional shifts towards the hybrid system.

• In regards to travel time, the current boat and rail transit are already running on scheduled service. Thus, making the boat or the Metro faster is not a logical investment. However, the concept of creating a hybrid linkage of different "guaranteed transit schedules" has yet to be explored. Therefore, BMA and transportation planners should implement some new service concepts such as "guaranteed travel time", "guaranteed business schedule" among intermodal transit systems. All of those policy options could improve the quality of connectivity and performance of the hybrid canal and rail network.

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References

Askew, M. (1996). The rise of moradok and the decline of the yarn: Heritage and cultural construction in urban Thailand. *Sojourn: Journal of Social Issues in Southeast Asia, 1*(1), 183 – 210.

Bangkok Metropolitan Administration, Office of Traffic and Transport. (2013). *New decades of Bangkok's Canals: A handbook of water transit for modern Bangkok*. Bangkok: Office of Traffic and Transport, Bangkok Metropolitan Administration.

Bangkok Mass Transit System [BTS]. (2015). *BTS skytrain system - structure of routes and stations*. Retrieved April 20, 2015, from http://www.bts.co.th/corporate/th/02-structure02-1-1.aspx.

Bernick, M. S. & Cervero, R. B. (1996). *Transit villages in the 21st century*. New York: McGraw-Hill.

Burton, E. (2000). The compact city: Just or just compact? A preliminary analysis. *Urban Studies, 37*(11), 1969 – 2001.

Christensen, R. (1997). *Log-linear models and logistic regression (2nd ed.)*. New York: Springer.

Dittmar, H. & Ohland, G. (2004). *The new transit town: Best practices in transit-oriented development*. Washington, DC: Island Press.

Hamton, F. (2010). *From urban sprawl to compact city: Analysis of urban growth management*. Saarbrücken: VDM Verlag Dr. Müller.

Iamtrakul, P., Thongplu, W. & Kritayanukul, P. (2013). Transformation of water transportation in Bangkok. *Journal of Society for Transportation and Traffic Studies, 4*(4), 34 – 45.

International Business Publications [IBP]. (2013). *Thailand Transportation Policy and Regulations Handbook*. Washington, DC.: Author.

Israel, G. D. (1992). *Determining sample size*. Gainesville, Florida, U.S.: University of Florida.

Kapteyn, A. (1985). Utility and economics, De Economist. *De Economist, 133*(1), 1 – 20.

Mateo-Babiano, I. B. (2012). Public life in Bangkok's urban spaces. *Habitat International, 36*, 452 – 461.

Marine Department [MD], Ministry of Transport and Communication. (2014a). *The amount of boat commuters at Khlong Pha Kanong Pier in 2014* (*Statistic yearbook*). Bangkok, Thailand.

Mass Rapid Transit Authority of Thailand (MRTA). (2015). *M.R.T. Chaloem Ratchamongkhon Line*. Retrieved April 20, 2015 from http://www.bangkokmetro.co.th.

Ministry of Interior, Department of Provincial Administration, Official Stations Registration System. (2013). R*egisted Population Data in year 2013; Department of Provincial Administration*, Ministry of Interior.

National Statistical Office [NSO]. (2004). *Use time survey 2004*. Bangkok, Thailand: Author.

Rodrigues, G. (2007). *Logit models for binary data (Lecture notes)*. Retrieved from http://data.princeton.edu/wws509/notes.

State Railway of Thailand [SRT]. (2015). *Airport rail link* (Bangkok). Retrieved April 20, 2015 from http://www.srtet.co.th/ internet/en/index.html.

Steiner, F. R. & Butler, K. (2007). *Planning and urban design standards*. Chicago, Illinois: John Wiley & Sons.

Tanaboriboon, Y. (1995). Bangkok water transport: An overlooked alternatives. In R. Bruttomesso (Ed.)*, Cities on water and transport* (pp. 43-52). Venedig: Città d'Acqua.

The Center for Transit-Oriented Development [CTOD]. (2010). *What is Transit-Oriented Development? TOD tools for metropolitan planning organization*. Berkeley, California: Author.

The Rockfeller Foundation. (2015). *Hybrid canal-rail connectivity linking Bangkok's canals networks to mass rapid transit lines, by Thammasat University*. Bangkok, Thailand: Author.

Union Internationale des Transports Publics [UITP]. (2014). *Bangkok urban rail at a glance*. Retrieved March 25, 2015 from http://www.asiapacific.uitp.org/sites/default/files/images/0603_Fact%20Sheet_Bangkok%20Urban%20Rail_May%202014.pdf.

William, K. (1999). Urban intensification policies in England: Problems and contradiction. *Land Use Policy, 16*(3), 167 – 178.

World Bank. (2007). *Strategic Urban Transport Policy Direction for Bangkok*, Washington, DC.