EVALUATION OF INTERMODALITY IMPROVEMENT IN INCREASING THE ATTRACTIVENESS OF BRT SYSTEM IN JAKARTA, INDONESIA

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ABSTRACT

This paper is aimed for formulating measures to manage barriers towards improvement of intermodality from and to Bus Rapid Transit (BRT) system, TransJakarta Busway, in Greater Jakarta, Indonesia. It departs from the hypothesis that low level of intermodality may jeopardize the effectiveness of BRT. It firstly assesses current status of intermodality consisting of three expected components (hardware, software, and finware) and explores barriers within public transport provision and operations in Greater Jakarta in relation with the effort to improve intermodality to and from TransJakarta Busway. Further, it investigates whether the improvement of interchange quality through multimodal integration, in addition to travel time, time delay and travel cost could impact to-work-commuters' mode choice through a stated-preference survey. Finally, a set of alternatives for improving BRT attractiveness is approximately evaluated using cost-and-benefit analysis.

Keywords: bus rapid transit, intermodality, transfer, stated-preference, cost-benefit analysis

INTRODUCTION

Since January 2004, Jakarta's government took one breakthrough by introducing Bus Rapid Transit (BRT) System, TransJakarta Busway. To date, Jakarta have been establishing 10 (ten) corridors. The latest development phase consisting of three corridors (corridor VIII – IX) has just finished in the beginning of 2009 and partially active. Jakarta is targeting to have fifteen corridors of busway by 2010.

Figure 1 – Seven Corridors of TransJakarta Busway Network Map

This study focused on seven corridors of TransJakarta Busway shown in Figure 1. The seven-corridor-network is 97.35 km long and covers almost all high density corridors within Jakarta area. It has 125 shelters, consisting of 7 (seven) main terminals, 6 (six) integrated transfer points, and intermediate shelters. Most corridors are now served by 12 m standard buses with capacity of 85 passengers. By August 2008, each corridor attracted 13,000 – 28,000 passengers per day, except corridor 1 70,000 passengers per day. The characteristics in detail are listed in Table 1.

Table 1 – Characteristics of Corridor I – VII

CORR.	ROUTE	LENGTH (KM)	NO. OF SHELTERS	BUS TYPE	RE-QUIRED FLEET
I	Blok M - Kota	12.90	20	12 m standard diesel	91
II	Pulo Gadung - Harmoni	14.00	23	12 m standard CNG	83
III	Kali Deres - Harmoni	19.00	14	12 m standard CNG	121
IV	Pulo Gadung - Dukuh Atas	11.85	17	12 m standard CNG	48
V	Kampung Melayu Ancol	13.50	17	18 m articulated CNG	30
VI	Ragunan - Kuningan	13.30	20	12 m standard CNG	53
VII	Kp. Rambutan – Kp. Melayu	12.80	14	12 m standard CNG	85
	Total	**97.35**	**125**		**511**

Source: TransJakarta Management Body (BLU TransJakarta), by August 2008

Since the beginning, Jakarta intended to establish a trunk-and-feeder BRT network. From network point of view, trunk-and-feeder system is expected to reduce number of operating vehicles on the road and increase the number of trunk lines passengers. While from user point of view, by using a trunk-and-feeder system, passengers who come from outside walking distance of a shelter have to take feeder modes, commonly served by smaller vehicle, to reach the nearest BRT platform along higher density corridors. Accordingly, they must take one or more transfers between modes which require crossing an elevated bridge to access BRT platform on the median of the road. Jakarta's Local Transportation Authority (JLTA) (2006) confirmed that the complexity while transferring, followed by longer time and difficulty to access BRT station are the main reasons for being reluctant from using TransJakarta Busway. Passengers' survey also revealed that long queue at stations, long waiting time and unclear departure/arrival time makes the system less attractive.

Furthermore, a trunk-and-feeder network development is typically coupled with "closed" system business structure which requires bus sector reform to provide a functioning feeder system. It has proven to be the critical success factor for Bogota's Transmillenio system which gets its 60% of passengers from feeder buses (Hook, 2005). Unfortunately, such bold measure has not been taken for Jakarta's case. As a result, the system encounters difficulties in realizing its goals either reducing the number of bus vehicles operating and competing on the road or absorbing larger share of passengers shifting from other modes. In fact, the system reduces road capacity by taking two lanes for its services. Consequently, in spite of contributing to efforts in tackling traffic congestion, it may worsen the condition even further.

There are two weakness points of intermodal trips involving public transports which are: (i) the availability of access and egress mode (Krygsman et al., 2004); and (ii) the higher penalty of having to interchange (Hein and Scott, 2000; Wardman et al., 2001; Zhao, 2006). These two weaknesses are supposed to be relieved through multimodal integration. A quality indicator of the level of integration allowing at least two different modes to be used in an integrated manner in a 'door-to-door' transport chain at an interchange is defined by European Commission (EC) as 'intermodality'. More intermodality means more integration and complementary between modes, which provides scope for a more efficient use of the transport system. Specifically, by ensuring the availability of feeder services integrated with BRT services, Jakarta can significantly reduce the number of competing bus services from its road and provide efficient access mode for passengers from wider catchment area to reach BRT platform. While through improving the convenience to make transfer, the system can expect significant reduction of time and cost associated with it both actually and perceptively. Perception should be emphasized here especially to meet the higher penalty usually given by private mode users.

Accordingly, this paper is aimed for formulating measures to manage barriers towards improvement of intermodality from and to TransJakarta Busway. This issue is analyzed by taking consideration of two sides perspectives: supply side or public transport service providers and demand side or public transportation (both current and potential) users. The rest of this paper is organized into five sections. The second section explains the methodology carried out for achieving three major objectives of this study, followed by the results of each objective in three consecutive sections. Section 3 assesses current status of intermodality based on on-spot observation, interview, and secondary data and explores barriers within public transport provision and operations in Greater Jakarta in relation with the effort to improve intermodality to and from TransJakarta Busway. It begins with the development of a framework to evaluate the current intermodality level by setting the aspects of intermodality that should be emphasized for increasing the attractiveness of TransJakarta Busway. Section 4 attempts to investigate whether the improvement of interchange quality through multimodal integration or intermodality, in addition to travel time, time delay and travel cost could impact to-work-commuters' mode choice. In Section 5, a set of alternatives for improving BRT attractiveness is approximately evaluated using cost-and-benefit analysis method. The set of alternatives are developed by considering provider barriers found in the second section while user benefit is estimated based on the utility model. Finally, some conclusions and further works are drawn.

METHODOLOGY

Method for Assessing Intermodality Status of TransJakarta Busway and Barriers from Provider Perspectives

Intermodality is defined based on users' hypothetical barriers while having to interchange, including lower level of security, inconvenience of changing vehicle, time inflexibility, and unaffordable extra cost. The inconvenience of changing vehicle is assumed to be caused by physical effort required to interchange and the possible necessity to make intermediate stop(s), while time inflexibility would be risked by long transfer time, long waiting time, and unexpected delay. These barriers are expected to be removed through improving the design of: (i) *hardware*: interchange physical design including access and waiting amenity; (ii) *software*: logical integration of information system including intermodal route information, timetable, and real-time display; and (iii) *finware*: combined ticketing and common fare system including fare structure, collection process, and media.

The logical thinking of deriving key measures for removing commuters' barriers from using BRT is shown in Figure 2. By referring to the three aspects shown in the figure, this study further evaluated the current status of each key measure within TransJakarta's system through field observations on March, 2007 to all 6 (six) main terminals and 5 (five) integrated transfer within the seven corridor network. Brief observations at several intermediate shelters were also done. The evaluation focused on qualitative description of current condition compared to the expected condition benchmarked by worldwide BRT system.

Basically, there are many types of interchange points or shelters in current TransJakarta's system, such as (i) end shelters or main terminals; (ii) intermediate shelters; and (iii) integrated transfer point as presented in Figure 3. The evaluation focuses on end shelters and integrated transfer points where multimodal interchange occurs. End shelters are located at main bus terminals in Jakarta, about twice bigger in size compared to intermediate shelters. While, integrated transfer points are classified into two types: (i) Central Busway such as Harmoni Central Busway which is a larger BRT shelter of 5 m x 78 m in size with capacity of 500 people allowing passengers transferring among corridor I, II, and III; and (ii) Sky Walk Paid Area (SWPA) type which is an extended overpasses (about 1 m wide and 200-400 m long) connecting one BRT corridor's shelter to another's shelter located at an intersection. Currently, there are 3 SWPAs available: (i) Dukuh Atas (corridor I, IV, VI); (ii) Matraman Pramuka (corridor IV, V, VII); and (iii) Senen (corridor II, V, VII).

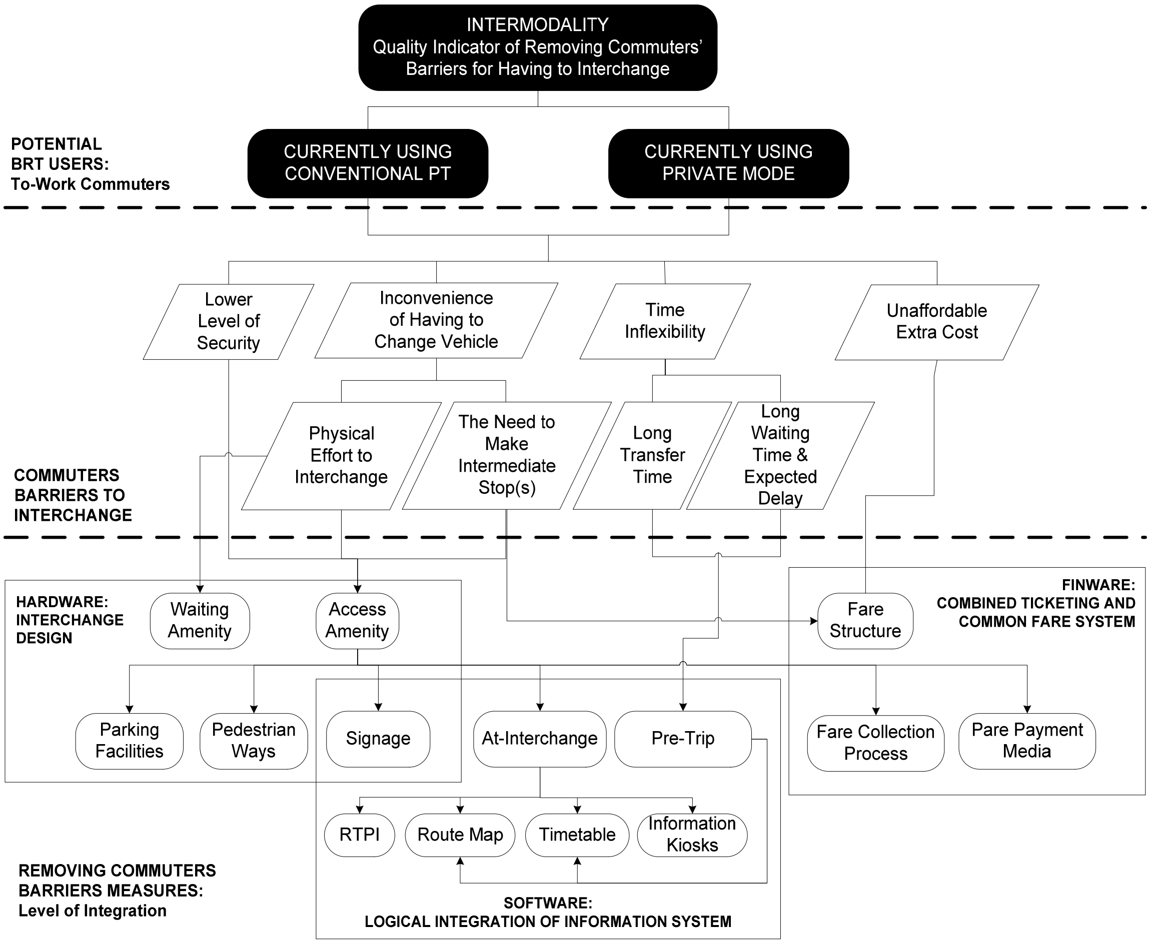

Figure 2 – Intermodality Evaluation Framework

Complementarily, to explore further about each element of intermodality, particularly the reasoning behind the chosen design and other insufficiencies, interviews with Jakarta's Local Transpotation Authority (JLTA), BLU TransJakarta (TransJakarta Managing Body), and two NGOs working closely with the government in this projects, Pelangi Foundation and INSTRAN were carried out in parallel with supporting secondary data collection. Based on the interview and secondary data results, the barriers from provider perspectives are analyzed by classifying them into four categories: legal and institutional, financial, political and cultural, and practical and technological borrowed from the terminologies defined by May *et al*. (2003).

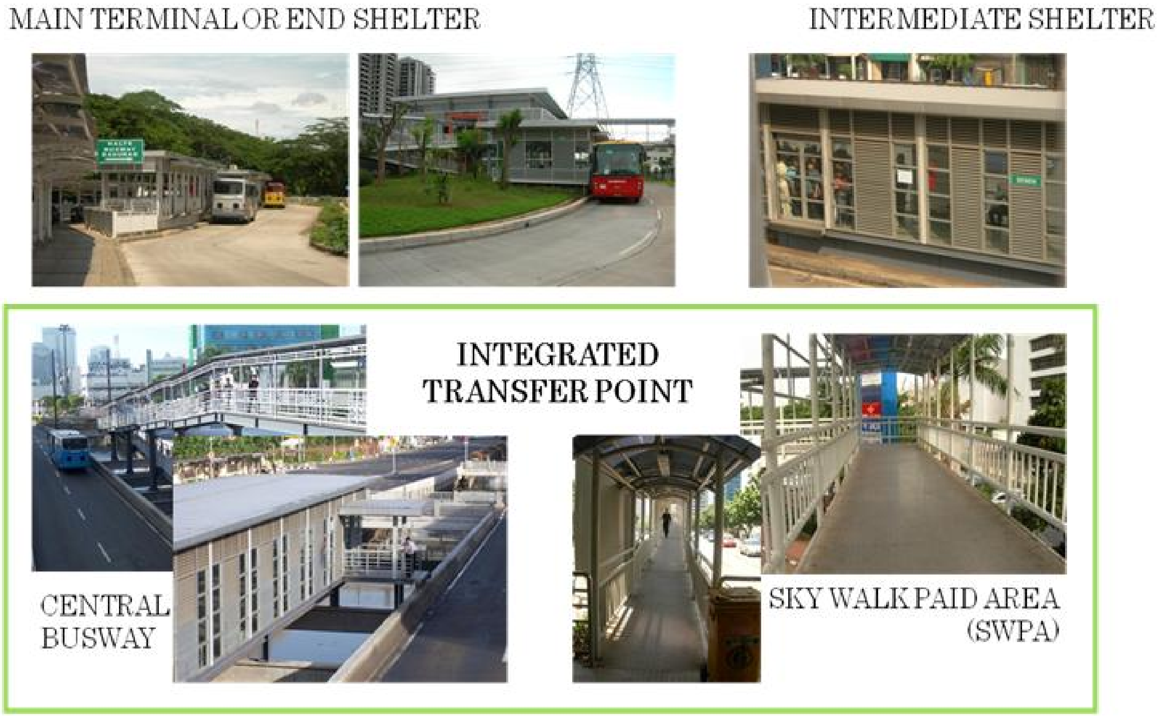

Figure 3 – Types of TransJakarta Busway Interchange Points or Shelters

Method for Assessing the Importance of Intermodality from User Perspectives

There are at least three important dimensions in commuter travel decisions that have been consistently found: (i) travel time reliability; (ii) travel cost affordability, and (iii) more recently, the stop making or trip chaining (Hensher and Reyes, 2000; Bhat and Sardesai, 2006; and Ye et al, 2007). Additionally, this study recognizes that the resistance of car-commuters to shift to public transport is higher as they tend to value interchanging much higher than the absolute time and cost required. Nevertheless, it is hypothesized that such values may be able to be changed by offering specific combinations of: (i) provision of park-and-ride facility; (ii) improvement of feeder quality; and (iii) improvement of interchange facilities (hardware, software, and finware). The potential users' behaviour towards it was investigated through a web-based stated-preference (SP) survey.

Web-based survey to conduct a preference survey has been increasingly utilized. Despite some remaining insufficiencies such as respondent bias due to low penetration, complexity of survey that is best handled by a computer-based instrument and affordability are the main reasons for choosing this mean of survey (Spitz et al, 2006). Specifically for SP survey, the unbiasedness of SP data collection is strongly dependent on the ability of individual respondents to comprehend the hypothetical choice scenarios presented to them as intended. One measure is by enhancing choice presentation through providing visual aids, map, and other spatial and non-spatial information (Yamada and Thill, 2003). Another measure concurrent with a move towards the use of efficient designs of choice set is through utilizing web-survey's interactivity for pivoting current respondent's experience, embodied in a reference alternative captured earlier in the survey, to derive the attributes levels of SP experiment (Rose et al, 2008).

Therefore, we developed a user-interactive set of questions involving SP choices with reference-alternative which require automated branching and input pivoting. This makes it possible to include visual aids to assist respondent, randomize questions, and furnish data on the response process of respondents. It furthermore may be more practical in terms of data collection, processing, and expectedly easier for respondents to answer.

The survey was designed for the internet using a combination of HTML code, javascript, active server pages (ASP). In addition to prompting/branching users and carrying out server-side validation, ASP was also used to automatically generate and present the attribute levels for the SP experimental design based on pivoting off the current estimated travel time and travel cost by commuters. Furthermore, javascript was used for client-side validation to ensure that respondents answered the required questions.

The survey was focusing on the Greater Jakarta area's commuters working at companies located along the seven corridors of TransJakarta Busway. These potential respondents were grouped into four possible current modes: (i) drive alone (by car, motorcycle, or bicycle); (ii) shared-ride (by using private modes and by using company's vehicle); (iii) public transport; and (iv) combination of private and public modes (by park-and-ride/P&R or kiss-and-ride/K&R).

Since this method was considered new for respondents in Greater Jakarta and the content may be too complicated, thus, we carried out preliminary survey on March – April 2008. Besides for evaluating the survey administration method applied, it was also aimed for evaluating the content of questionnaires, both regarding general commuting trips, testing some hypotheses related to factors influencing commute mode choice and the stated preference experimental design. The final survey was conducted on September – November, 2009.

During preliminary survey, once the instrument was ready, invitation letters introducing the pilot surveys were gradually dispatched to HRD or General Affair managers of selected companies along two corridors of BRT through fax and phone. Each company was asked to permit and invite at least 10 employees to participate in this survey. This way, the respondents have already been screened to meet the requirement needed for reducing respondent bias. While screening questions were also asked in the first of the questionnaire to ensure the home and work locations. Follow-up reconfirmation and reminder faxes and calls were carried out.

The preliminary survey distribution process provided us at least two technical insights for the final survey: (i) the survey administration which highly relied on the flexibility of each company's policy in allowing their employees to participate in the survey was quite burdensome; (ii) the applied method was not adequate the cover all targeted points since the low access possibility to non-office commercial areas which dominated some parts of the corridors and also to governmental offices was low due to bureaucratic obstacle.

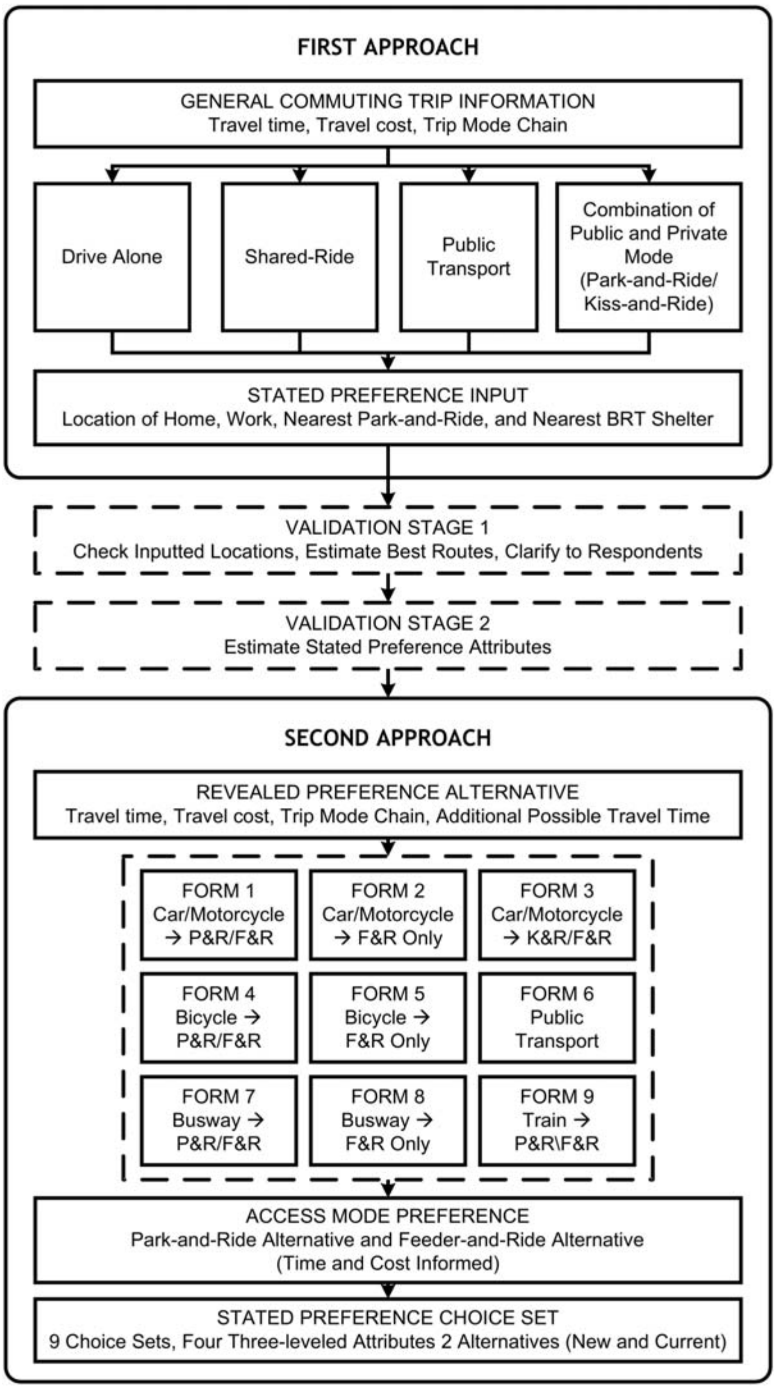

Figure 5 – Web Survey Process

Therefore, in the final survey, besides expanding the area research from two to the whole seven corridors, we also requested personal contacts to distribute the questionnaire bottom-up way and also distributed through some mailing lists. The latter method was kept complementary while the former method was continued. Furthermore, despite prompting the whole questions to respondents at once, it was decided to divide the questionnaires into two approaches. The first approach was aimed for collecting general commuting trips information, stated preference inputs, and e-mail address for further contact. While the second approach mainly contained the SP choice sets to be sent to the respondents once the first approach data has been validated. Such attempt was made to reduce task complexity imposed to respondents at one time. Afterwards, it was also useful to provide a time span for necessary validation or confirmation on SP input data.

The final survey was administrated through a web site hosted by the University of Tokyo. After receiving password, each respondent was asked to log in to the second approach and subsequently branched into one of nine SP forms according to their current mode. The overall process is summarized in the following Figure 5.

To be able to present more realistic choice sets, in the first approach, we embedded a google-powered map API as demonstrated in Figure 6 presented with some landmarks to assist respondents in locating their home location, work location, nearest P&R location, and nearest BRT terminal. We also provided TransJakarta Network Map as shown in Figure 1.

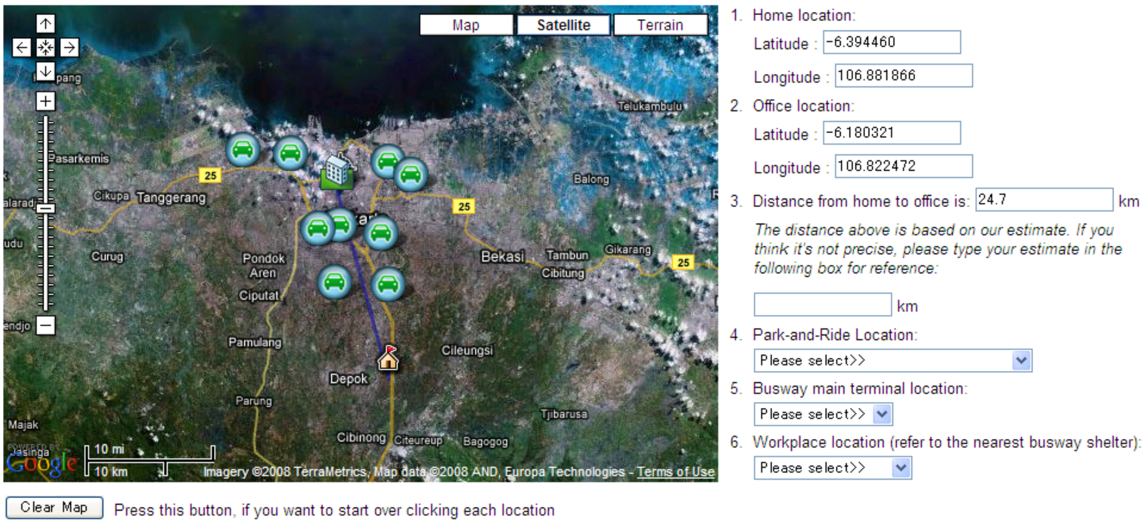

Figure 6 - Screenshot of BRT Route Information Collection

The system was applying a program to capture longitude and latitude and linked it to a script for calculating distance between two points. We also linked it with databases containing (i) longitude and latitude of each P&R facility and BRT shelter; and (ii) travel time and number of transfer matrices between BRT shelters. Such approach was expected to increase the accuracy of estimating door-to-door travel time. Thus, the system automatically generated access distance, BRT-in-vehicle-time, number of transfer, and egress distance.

Afterwards, these inputs were validated to check the key locations and the accessibility to BRT network along possible routes from home to office. Current commuting trip information was also validated. If there was unclear information, we contacted each respondent through e-mail for confirmation. Instead of pivoting the reference alternative by percentage, for example -5%, 0 or + 5% of current mode travel time, as most SP experiment with reference alternative did, it attempts to provide an alternative as realistic as possible. Therefore, once the data is confirmed, next step is to determine two possible routes for each respondent and estimated door-to-door travel time under proposed scenarios.

The first route choice involves private mode as the access mode to the nearest P&R facility. The mode was determined based on private mode ownership and distance. Those whose home located up to 7 km from the nearest P&R were suggested to use bicycle running 20 km/hour. The rest depended on private mode ownership, either car (40 km/hour) or motorcycle (50 km/hour). The second route, on the other hand, involves bus feeder, train, or walking or feeder-and-ride (F&R). Current trip information was also consulted to check the appropriateness of route and travel time estimated.

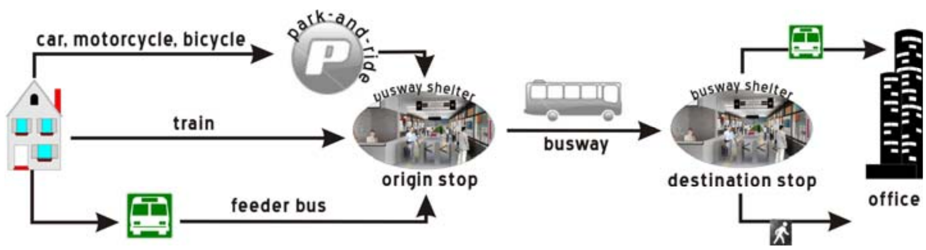

Figure 7 – Hypothetical Trip Chains

The new BRT alternative was described in four three-levelled attributes. Since the complete factorial for the design is a 3^4 or 81 treatment combinations or each combination of factor levels, it would be difficult (if not impossible) to ask each respondent in a sample to evaluate and respond to all combinations. Thus, we developed fractional factorial design to reduce the number of options. As a result, we presented 9 (nine) choice sets to respondents, each with four attributes as listed in Table 2.

The first attribute was door-to-door travel time constructed upon three elements: (i) BRT speed; (ii) transfer time per transfer; and (iii) P&R location for P&R option or feeder speed for F&R option. The levels were determined based on field survey, secondary data, and preliminary survey's result. First level was basically referring to the current condition. The second attribute was time delay under extraordinary circumstances such as traffic or transit problem. In spite of the commonality in using ratio of additional time and total travel time for representing time unreliability, it was decided to set up three levels of possible additional time which is shorter than the current average BRT waiting time found through our preliminary survey showing 20 – 40 minutes interval.

Table 2 - Stated Preference Experimental Design: Attributes and Levels

Attributes	Busway Option (Park-and-Ride or Feeder-and-Ride)
Door-to-door travel time	Level 1: BRT speed 18 km/h; Feeder speed 10 km/h; P&R location 5 min walk; Transfer time 10 min Level 2: BRT speed 24 km/h; Feeder speed 15 km/h; P&R location 3 min walk; Transfer time 7 min Level 3: BRT speed 27 km/h; Feeder speed 20 km/h; P&R location 1 min walk; Transfer time 5 min
Time Delay	*Possible additional time due to extraordinary circumstances, e.g. traffic conditions, transit problems, etc* → Level 1: 15 mins; Level 2: 10 mins; Level 3: 5 mins
Total travel cost	*Single fare for parking, feeder, and busway* → Level 1: Rp 7000; Level 2: Rp 8000; and Level 3: Rp 9000
Interchange Facility Improvement	Level 1 : POOR → elevator, toilet, waiting seats, queue space Level 2: GOOD → plus schedule and route information Level 3: EXCELLENT → plus multimodal ticketing system

The next two attributes - total travel cost and interchange facility improvement - were actually two main measures proposed for improving the degree of intermodality. The third attribute was the introduction of single fare for access mode and BRT. The fourth was the improvement of three elements of interchange facility: (i) “hardware” element to reduce physical effort and convenience while transferring from one corridor to another and while waiting for the next bus to come; (ii) “software” element to alleviate the uncertainty of multimodal trips through providing schedule and route information; (iii) “finware” element to provide a unified multimodal ticketing system. Similar to travel time, the first element here is placed as the base level, while the rests were added respectively.

Before entering the SP choice, each respondent was being informed about his/her current mode attributes as reported in the first approach and further asked to choose one preferable access mode, either private mode or feeder. As consideration, we advised the time and cost required for each access mode. By choosing one, the respondent was prompted to either P&R choice set or F&R choice set. The respondent was asked to choose whether they would use the new alternative or keep on using the current mode.

To gain better understanding about these elements, in the questionnaire, some pictures were also included in the SP choice sets as shown in Figure 8. In this experiment, it was preferable not to show them at once altogether with the choice set because it can cause distractions, either or by providing links because it requires extra effort and may be troublesome for low speed internet connection. Therefore, it was chosen to take the advantage of javascript’s *onmouseover* and *onmouseout* event handler. Each figure would be presented onto the screen if the users placed their computer cursor on each of the interchange facility attribute’s explanation listed on the first column as demonstrated in Figure 9. The graphic would disappear directly if the cursor moves away.

Figure 8 – Interchange Facility Improvement Graphics

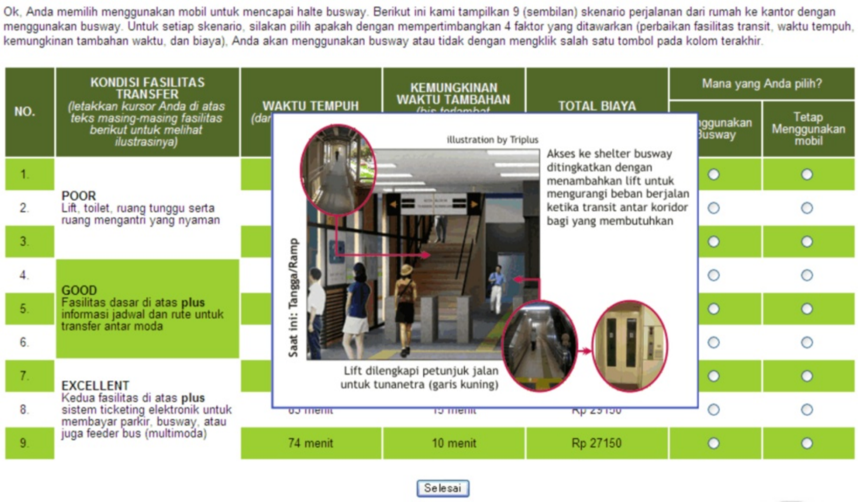

Figure 9 – Screenshots of Stated Preference Choice Set (in Indonesian)

Method for Evaluating the Proposed Measures: Policy Options

Derived from the SP choices, the development of policy options were attempted to mainly compare the impacts between improving travel time through increasing BRT speed and improving the convenience to interchange which is highlighted in this study. They also determined by considering limitations encountered by providers. As a result, nine policy options are formulated as listed in Table 3. Policy 1A to 1C shows improvement of BRT speed from 18 km/hour in the base situation to 24 km/hour. Policy 2A to 2C further shows improvement of speed up to 27 km/hour. Different from policy 1 and 2, policy 3A to 3C emphasize on interchange improvement into excellent level while BRT speed remains at 18 km/hour. The difference between policy A, B, and C is the level of BRT fare ranging from Rp

7,000 to Rp 9,000. All options are accompanied by capacity enhancement by employing CNG articulated bus and 1 minute headway.

Table 3 – Policy Options

Policy Options	Fare (Rp)	BRT Speed (km/hour)	Time Delay (mins)	Transfer Time (mins)	Interchange Points
Base	3500	18	15	10	No Improvement
Policy 1A	7000	24	10	10	
Policy 1B	8000	24	10	10	
Policy 1C	9000	24	10	10	
Policy 2A	7000	27	5	10	
Policy 2B	8000	27	5	10	
Policy 2C	9000	27	5	10	
Policy 3A	7000	18	15	5	Excellent Level
Policy 3B	8000	18	15	5	
Policy 3C	9000	18	15	5	

Note: Feeder service is operating at 15 km/hour, connecting all zones to nearest main terminals/BRT shelters

Besides maintaining one minute headway, in terms of speed improvement cost, two main issues are attempted to be tackled here. First, reducing transfers by providing direct services and thus, requires passing lanes at each station. Providing passing lanes may require road widening to maintain sufficient lane for mixed traffic which is not included in this cost estimate. Second, managing bottlenecks at eight points by employing green light phase extension for BRT and advancing control centre including software and GPS system. Additionally, it may also require some underpasses for busway particularly for busiest intersections. It is also assumed that feeder service operates at the same speed level, 15 km/hour and it is available connecting all zones to nearest BRT main terminal/shelter.

ASSESSMENT OF INTERMODALITY STATUS AND BARRIERS FROM PROVIDER PERSPECTIVES

Availability of Access/Egress Mode and Integration with Other Trunk Lines

As mentioned above, the availability of access/egress mode to/from TransJakarta Busway is challenged by the lack of feeder system which is actually the result of two faces of bus industry in Greater Jakarta with different management system between BRT and conventional buses (large, medium and small buses). While BRT's operations are handed out to private operators who are being paid based on cost per vehicle-km by the government, the daily operational of conventional bus system is handed out to bus crews on daily bases under sublet revenue sharing system between bus owners/operator companies and bus crews which relies highly to patronage rate. Moreover, the fact that BRT's fare is much cheaper than conventional bus due to subsidy makes BRT has no choice than being places as a competitor by conventional bus operators especially those whose routes are overlapping with BRT. Enforcing control over conventional buses is also not an easy task since there is lack of regulation and that particularly medium and small buses which outnumbered large buses are mostly owned by small operators or even individuals.

Regarding the prospect of multimodal integration with other trunk lines in Greater Jakarta, the new railway law enacted in 2007 provides larger opportunity since it is explicitly promote multimodal integration including with BRT. It also opens a greater possibility for private sectors to enter railway market. Additionally, it also puts ground for regulator and operator separation. Some of the realizations of this law are: (i) the spin-off of a division under Indonesia Railway Company (PT KAI) in charge of Greater Jakarta's commuter train service; (ii) the development of airport link through joint venture; and (iii) the most recent one is the preparation phase of subway system implementation. Since the new law and the new mechanism of BRT are working in parallel with the old face of bus industry, the institutional arrangement of public transportation system in Greater Jakarta becomes more complicated with no integration at all.

Convenience to Transfer: Hardware, Software and Finware

In terms of the convenience to transfer, it is identified that hardware components (the access and waiting amenity) leave many rooms to improve. Firstly, one major problem is the long climbing and walking along the ramps and overpasses. Providing an elevator can be an option. So far, one elevator is available at one intermediate shelter financed by private sector, but the maintenance is poor and therefore, not functioning well.

Secondly, the unreliable service creates a long, ineffective, and dangerous queue where, at some circumstances, passengers trespass the automated door and line up approaching the platform. This is because the shelters are mostly small and narrow and the integrated points are too few. Nonetheless, the main cause of such unreliable service is shortage of bus fleets due to managerial problems. Moreover, as mentioned above, most corridors are served by standard bus instead of articulated-bus resulting in lower capacity.

Since the establishment of TransJakarta Busway, conventional buses, particularly large buses, become the subject of reform. Overlapping routes with BRT corridors are incrementally being eliminated or restructured. The operators of those routes were then invited to join BRT consortium. One consortium mainly operates one to two corridors. Up until now, five large bus companies including the state-owned company and one medium bus company have joined seven consortiums. To make on-street competition free, the system is adopting cost per kilometre-travelled payment between the government and the consortium based on contracts and standards of operation procedure (SOP). Each phase of development implemented different agreement scheme. The whole BRT system is planned by JLTA and managed by BLU TransJakarta, an operating unit under JLTA.

Cost per km payment varies between corridors. It largely depends on negotiation of consortium's responsibilities between BLU TransJakarta and the related consortium.

Generally, all consortiums have to provide fleets, cover operational, maintenance, and overhead cost, except corridor I, the pilot, whose fleets were purchased by the government. As for corridor II – VII, fleets are provided by the consortium and additionally through auctions. Not all fleet requirements have been fulfilled. By August 2008, as listed in Table 1, 329 fleets were available out of 511 total fleets required. In fact, for corridor IV – VII, new operators were also invited through auction to cover fleet shortage and won the tender with lower fee. Consequently, it triggered protest wave from other consortium and caused a deepening unprofessional atmosphere in TransJakarta's service delivery.

Figure 4 – Conditions of Hardware, Software and Finware of TransJakarta Busway

In terms of software, currently, intermodal route maps and timetable are not available, while the signage and BRT route map are simply designed. Establishing route map is not easy because to date there is no accurate existing bus routes data. Furthermore, BRT development along with bus routes restructuring is still on-going. For the case of timetable, TransJakarta is still required to address vehicle sufficiency, intersection delay, and other bottlenecks to be able to provide reliable service.

Lastly, about the finware component, it is not standardized. Some corridors use paper-based ticket while others use smartcard. Some with manual validation while other use automatic turnstiles. However, all shelters provide manned ticket booth which require additional time to queue. Such differences are the result of different ticketing company handling each phase of development. Furthermore, TransJakarta has tried to integrate ticket and fare with bus feeders at the beginning of its implementation but the scheme of being paid after reimbursement was not fully accepted by bus crews and it is immediately no longer effective.

Conclusively, the lack of intermodality particularly in terms of inconvenient transfer due to its unreliable services with low average speed and also the lack of integration with other modes has jeopardize the attractiveness of TransJakarta Busway, as reflected by lower ridership than expected.

The Barriers for Improving Intermodality from Provider's Perspectives

By synthesizing the interview results with some relevant sources as explained previously, the barriers for improving intermodality from the provider's perspective are classified into four categories as follows:

1. *Practical and technology barrier* are found in terms of physical design of the interchanges. Here, land availability is the main barrier including relatively narrow streets on some segments of the corridors enforcing the system designers to "compromise" the required station size and amenity. Further, there are also mixed traffic segments and bottlenecks at some points. It also includes lack of key skills and expertise in designing procurement contracts for private sectors in order to provide detailed engineering and construction-maintenance scheme.

2. *Political and cultural barrier* are encountered in improving service reliability in order to increase capacity, reduce long waiting time and provide effective feeder system. The barriers come from the management of conventional buses which have been developed in a bottom-up way without sufficient regulation. Furthermore, there are some "ethics" to be maintained in order to avoid social unrest. Thus, competitive tendering has not yet been realized for the current system which also becomes the barrier to develop a better public-private-partnership scheme.

3. *Financial barrier* is significant since the source of fund heavily relies on public means where subsidy increases year-by-year. Such inefficiencies are actually the result of weak management. One apparent problem is settling the cost per vehicle-km to be paid to the operators due to lack of accountability between BLU TransJakarta and the operators.

4. *Legal and institutional barriers*: lack of effective legal power to allow good governance practice in tendering services, enforce bus network reconfiguration to realize software and finware integration, establish firm level of service standards among operators, and establish coordination between TransJakarta authority and other public transportation.

ASSESSMENT ON THE IMPORTANCE OF INTERMODALITY FROM USER PERSPECTIVES

Estimation Results

From 78 potentials SP respondents were gathered from the first approach of final survey, 46 respondents replied. The characteristic of SP respondents are shown in Figure 10.

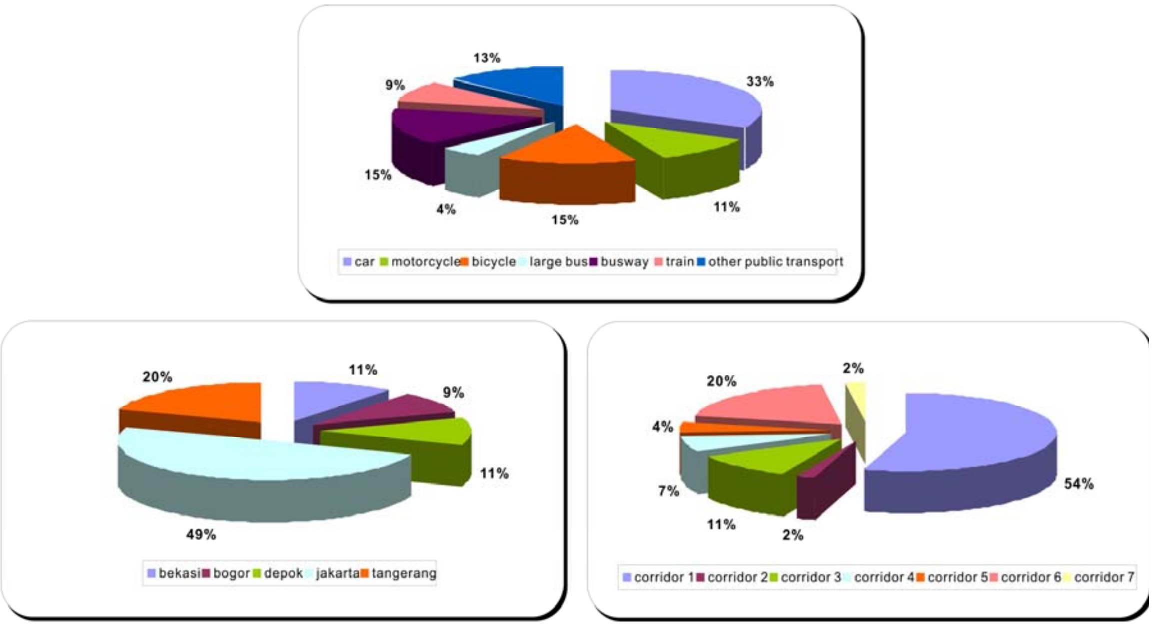

Figure 10 – Proportion of SP Respondents based on Current Mode, Origin, and Destination

To determine the variable effects, we estimated various combinations of multinomial logit (MNL) model based on several data sets. We found that the model performed better when current bicycle user and busway user samples were excluded from the data set. As a result, we estimated two models developed based on 297 observations.

In the first model, the utility of current mode was estimated by seven parameters: the total travel time, time delay, total travel cost from home to work, number of transfer, and three constants. In addition to those parameters, in the new BRT alternative utility, two dummy parameters representing excellent and good level of interchange improvement quality were included.

As presented in table 4, in the first model, total travel time, time delay, total travel cost, and the presence of excellent interchange quality covering hardware, software, and finware elements were found statistically significant. However, although statistically significant, time delay's coefficient was found positive which does not make sense.

Table 4 - Model Estimate Results

VARIABLES	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
	Coefficient	**t-ratio**	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Attributes								
Total travel time (min)	-0.022	-4.290	-0.023	-4.637	-0.022	-4.584	-0.022	-5.057
Time delay for all alternatives	0.008	2.557						
Time delay of new BRT alternative (min)			-0.031	-0.960	-0.080	-3.491	-0.078	-3.850
Total travel cost (home to work)	0.000	-2.699	0.000	-2.747	0.000	-2.565	0.000	-2.556
Excellent interchange dummy	1.035	3.124	1.030	3.129	0.767	2.556	0.778	2.624
Good interchange dummy	0.492	1.469	0.497	1.492	0.230	0.758	0.241	0.806
No. of transfer	0.264	1.327	0.114	0.602	0.023	0.214		
Alternate Specific Constant								
Current Alternative: Car	1.276	2.360	0.927	1.519				
Current Alternative: Motorcycle	0.877	1.479	0.810	1.237				
Current Alternative: Other Public Transport	0.761	2.107	0.940	2.164				
Statistics Summary								
No. of observation					297			
Log likelihood with constant only [*LL(C)]*			-192.813					
Log likelihood at convergence [*LL*(β)]	-167.510		-170.622		-173.081		-173.104	
Adjusted Rho-squared [1-(LL(β)/LL(C))]	0.131		0.115		0.102		0.102	
Willingness to Pay								
Value of total travel time (Rp/min)					804		794	
Value of time delay of new BRT alternative (Rp/min)					2884		2827	
Value of time delay of new BRT alternative (min)					0.28		3.6	
Value of excellent interchange (min)					-34		-36	
Comparison								
Current average cost per minute trip					Rp 195/min			

Note: *No. of transfer was not shown explicitly to the respondent in the choice set, but incorporated in the door-to-door total travel time attribute

Further, time delay between current alternative (consisting car, motorcycle, and other public transportation) and new BRT alternative were specified into two different parameters. Based on some estimates, it was found that the variable became negative in case of new BRT alternative but statistically insignificant, while it remained positive for current alternative but statistically significant.

As shown in Model 2, the same result was obtained when time delay for current modes was removed. The changes of parameters were followed by the change of constants. The first model shows that car users and public transport users other than BRT strongly tend to choose their current mode. On the contrary, the second model cannot explain such tendencies. It indicates that multicollinearity between time delay and constants may have occurred.

Regarding the time delay, it may be explained by the fact that the gap of time delay between current and new BRT alternative was quite wide whereas preference towards current mode remains high as shown in Table 4.

Another reason is that the definition of time delay between current and new alternative may differ. For current mode, the respondent was asked maximum travel time from home to work under an extraordinary circumstance that has been experienced, such as due to very congested traffic or very long waiting time. Then, in the data set, each maximum travel time was subtracted by average travel time to obtain time delay. It was not expected that the interval between the average travel time and maximum travel time would be that wide. Based on that possible reasoning, in model 3, all constants were removed. As a result, all variables except number of transfers were found statistically significant. Finally↵ in model 4, we excluded number of transfers. Compared to model 3, the value of time delay for BRT is found higher in model 4.

Table 5 - Attributes by Mode

SAMPLE BY MODE	**NO. OF OBSERVATION**	**ATTRIBUTES**			
		Average Total Travel Time (min)	**Average Time Delay (min)**	**Average Total Travel Cost (Rp/trip)**	**Average No. of Transfer**
Current Mode	!	!	!	!	!
Car	135	57	61	15,900	0.00
Motorcycle	45	43	91	3,800	0.00
BRT	63	88	77	19,104	2.00
Other Public Transport	108	90	36	7,393	1.25
Bicycle	63	72	39	714	0.00
Mean		71	65	13,808	0.65
New BRT Mode		!	!	!	!
Park-and-Ride	189	72	10	11,552	2.60
Feeder-and-Ride	225	78	10	8,480	2.00
Mean		74	10	10,164	2.30

If we dig into the data by breaking down the current mode into car, motorcycle, BRT, and other public transport, it can be seen that the average current travel time experienced by private modes, particularly car and motorcycle, is shorter than the average travel time offered by the new BRT alternative, although the service is a lot more reliable. As for current public transport users other than BRT, cost and the number of transfer are lower. Sample details by mode are listed in Table 5.

Regarding willingness to pay, we estimated value of time and value of interchange facility improvements, at Rp 794/min or Rp 47,640/hour. Referring to Model 4 result, total travel time is valued four times current travel cost. It is obviously a lot higher than the current research findings indicating Rp 3,531/min (ITDP, 2003) or 1/3 of per hour wage rate for car users and 14% of per hour wage rate (Suryo et al., 2007). Furthermore, time delay reduction value is Rp 2,827/min, while interchange improvement including multimodal ticketing system is valued 36 minutes total travel time reduction or Rp 28,307. It reflects that these two attributes are considered highly influencing towards the decision to shift to BRT.

Limited sample and high appreciation for time-related attributes and less for cost makes the representativeness of the sample becomes questionable and may indicate that the result is likely representing high income level people. However, the sample consists of 45% private car users, 18% motorcycle users, and 36% public transportation users besides BRT. The proportion is not so much different from the current modal share consisting of 40.3% private car users, 13.1% motorcycle users, and 34% public transportation users. For the case of Greater Jakarta, the utility of motorcycle and public transport increases as the income become lower and vice versa for the case of car (JICA and Bappenas, 2004; Yagi and Mohammadian, 2006). Additionally, car becomes more attractive as travel time becomes longer (not necessarily long distance, i.e. highly congested area). Referring to those tendencies, the sample should to some extent also have reflected various elements of people although it cannot be denied that the respondent recruitment method applied in this study focuses on white-collar employees with relatively higher education level and it cannot reach lower educated people with internet illiteracy.

Conclusively, based on user perspective, the main barrier to take intermodal trips involving public transports is the compromised door-to-door travel time in which number of transfer time is incorporated. High speed BRT does not reduce the whole travel time and its complexity. Nevertheless, the result of SP survey shows that this barrier can be relieved through the introduction of integrated ticketing and fare system as well as physical and information system improvement.

EVALUATION ON THE PROPOSED MEASURES

Modal Share, Benefit-Cost Ratio and Load Factor

For the analysis, three main integrated transfer points are selected. The demand for each interchange was forecasted by using the utility model estimated based on SP data and JICA-

SITRAMP O-D Matrix Data (2020). Based on the distance of each OD pair, travel times for car, motorcycle, bus, and BRT were calculated. Average car speed is assumed to be 28.5 km/hour, while its speed along BRT corridors dropped to 15 km/hour. Motorcycle and bus speed are assumed to be flat, 30 km/hour and 20 km/hour respectively. While in terms of cost, referring to the average cost/km by mode collected from the samples, car travel cost is Rp 1,900/km, motorcycle cost is Rp 300/km, and bus cost is Rp 1,200/km.

Afterwards, by applying the utility model developed through stated preference experiment as followed, modal shares of each mode were estimated.

$$U_{car}/U_{bike}/U_{pt} = -0.022TT - 0.000027TC$$
$$U_{brt} = -0.022TT - 0.000027TC - 0.078TD + 0.78int1 + 0.28int2$$

where:
U = utility for each mode alternative
TT = door-to-door travel time (feeder in-vehicle-time, BRT in-vehicle-time, and transfer time)
TC = door-to-door travel cost (access mode cost and BRT cost)
TD = time delay for BRT
Int1 = dummy variable for excellent interchange
Int2 = dummy variable for good interchange

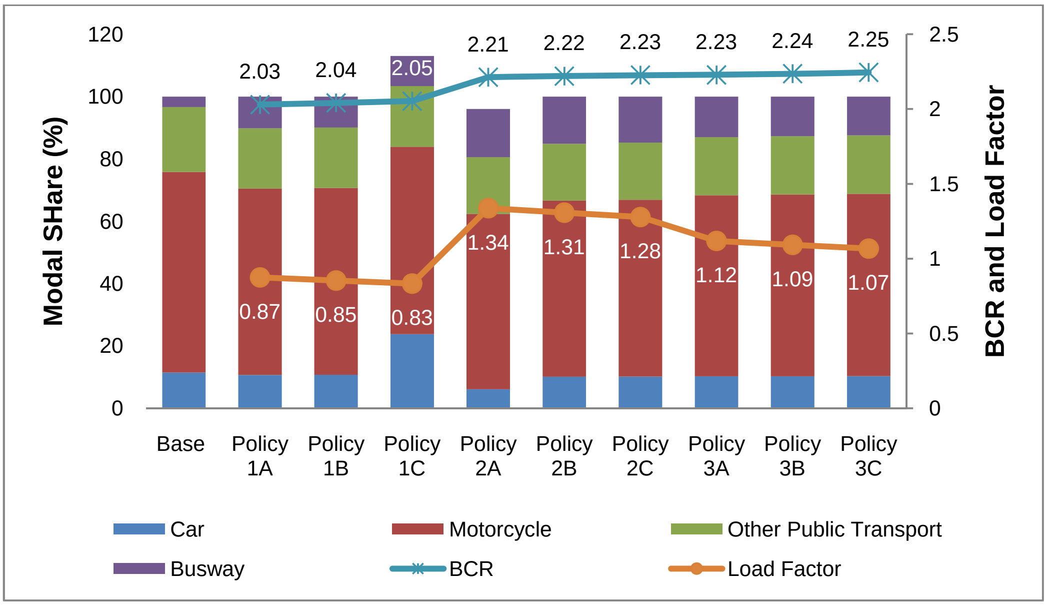

Figure 11 – Modal Share, BCR and Load Factor

Note:
[1]For user benefit calculation, annualization factor is 365, uniform series present worth factor (8%, 15 years)
[2]Speed improvement costs refer to Bogota's system (Wright and Hook, 2007), including intermodality improvement costs, except crossing bridge cost which is based on TransJakarta system (JLTA, 2006).
[3]CNG articulated bus purchase cost is based on the current operating CNG articulated bus for corridor V, the purchase cost is Rp 3.5 billion/unit
[4]All values are presented in million Rp (currency rate: Rp 10,000/US$)

User benefits from travel time savings, time delay reduction, and interchange improvement are estimated for the selected ODs covering around 30 percent of all trips in 2020. User Benefits are calculated as the change in consumer surplus: $0.5(U_1-U_2)(V_1+V_2)$, where U_1,U_2, V_1 and V_2 are the unit travel times and the number of trips (or demand) without and with intervention, respectively. By establishing the value of each improvement in Rp/min, finally, the value of user benefits can be calculated using the formula of $0.5(U_1-U_2)(V_1+V_2)$(unit value of benefit).

In terms of modal share, improvement of BRT speed to 24 km/hour increases the share of BRT by almost 7% from 3.34% in base-scenario. Larger share is resulted from improving BRT speed to 27 km/hour at about 15% compared to interchange improvement at about 13%. Based on the benefit-and-cost ratio, improvement of interchange is slightly higher than improving BRT speed to 27 km/hour but the result shows that all options are economically viable since the ratio is more than 2. However, the load factors show that improvement of interchange offers more reasonable load factor than improving BRT speed to 27 km/hour.

CONCLUSIONS AND FURTHER WORKS

This study has confirmed that “the convenience to transfer” reflected by three components of intermodality – hardware, software, and finware – to and from a trunk-and-feeder BRT system like TransJakarta Busway is an influencing factor on commute mode choice. The result of this study also shows that an increase of BRT average speed cannot automatically guarantee total travel time reduction and become one of main barrier for potential users to take intermodal trip involving BRT. Therefore, understanding the “full-trip” complexity of all potential users of BRT remains fundamental especially for large cities intended to apply a trunk-and-feeder BRT system with segregated lane on median of the road like Jakarta. Here, the interconnectivity of feeder in terms of network configuration and establishing a relatively even quality of feeder compared to trunk service should be emphasized.

Nonetheless, the government should swiftly manage the barriers encountered in accelerating such reform. The process should depart from a detailed plan and sufficient regulation allowing appropriate procurement procedure to be able to negotiate effectively with other stakeholders, particularly the incumbents. In further works, it is necessary to map all the incumbents along with their resources (routes, bus fleet and employees). It is also fundamental to provide a more accurate method to evaluate the policy options offered. First, for developing cities like Jakarta, it is necessary to investigate the impact of level of income differences in evaluating user benefits. Second, it is also essential develop a specific cost per km formula for Jakarta’s case as the basis towards a stronger contractual arrangement

Furthermore, regarding financial barrier, it is recommended to develop a more accurate financial projection by considering government funding resources and exploring the possibility of separating fleet provision and operating-maintenance as proposed in this study since the high cost of fleet provision can cause a problem and may jeopardize the reliability of service or any other innovative financing scheme for other cost elements.

As for improving BRT speed and capacity, this study points out land availability as the barrier for enhancing station capacity including by providing multiple stopping bays at stations. This further leads to limitation of vehicle size. Thus, as another alternative, by referring the comprehensive trunk-and-feeder network configuration, potential route permutation for direct services and bottleneck points, this land availability barrier and to what extent it can be managed should be further studied.

Finally, to improve the representativeness of a web-based survey, the respondent recruitment method should be improved. This study collects respondents through companies' HRD managers as intermediaries who were expected to further invite their employees to participate. The approach was made by inviting people through open mailing list and provided screening questions in the instrument. For further study, to increase the number of samples, potential respondents should not only be contacted through e-mails but also by intercepting respondents in the targeted area (e.g. in front of the offices, malls, high traffic pedestrian areas, etc) and provide them an introduction about the survey with some short screening questions. If the respondent matches the requirement, he/she can be asked to access a web-link for the rest of the survey.

Ideally, by solely rely on web-based survey is insufficient, but combining it with other type of instruments remains necessary if resources are available. In terms of survey complexity, web-based survey may be more compatible with computer-aided interview rather than paper-based survey, if the aim of using web-based survey is to utilize its interactivity or other advantages.

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