1. Managing Barriers towards Intermodality Improvement based on Provider and User Perspectives to Promote Commute Mode Shift to Bus Rapid Transit System

Case Study: Greater Jakarta, Indonesia

インターモダリティ改善による BRT システムの利用促進に関する研究：ジャカルタ大都市圏通勤交通における課題と対策

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Abstract: This study is aimed for formulating measures to manage barriers towards improvement of intermodality from and to Bus Rapid Transit system, TransJakarta Busway, in Greater Jakarta, Indonesia. Intermodality is defined as the quality indicator of the level of integration allowing at least two different modes to be used in an integrated manner. This issue is discussed from two perspectives: supply side or public transport service providers and demand side or public transport (both current and potential) users. *First,* 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. *Second,* based on the evaluation framework, the current status of TransJakarta's Busway is investigated through an on-spot observation, interviews, and secondary data collection. *Third,* it further explores the barriers encountered by providers to improve the current status to the expected level of intermodality. *Fourth,* by developing a multinomial logit model based on a web-based survey involving stated-preference experiment, this study analyzes the importance of intermodality improvement in influencing commute mode choice from users' perspectives. *Fifth,* by using the results of the third and fourth step, a set of alternatives for improving BRT attractiveness is approximately evaluated using cost-and-benefit analysis method.

1. Introduction

This study attempts to contribute in formulating measures to tackle worsening congestions in Jakarta. One way to solve the issue is by providing a convenient public transportation alternative which can significantly generates mode shift from private modes. Among all options of public transport modes including subway plans that have been under planning for decades, in January 2004, Jakarta chose Bus Rapid Transit (BRT), TransJakarta Busway, considering the financial constraints and the increasingly urging traffic problems.

From the beginning, Jakarta intended to implement closed trunk-and-feeder system following the steps of Bogota's system. 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. Furthermore, if the nearest BRT platform is an intermediate shelter which is located on the median of a road, then the passengers should transfer through an elevated crossing bridge. Some studies confirm that the complexity while transferring in an intermodal trips involving BRT in Jakarta impose major attention from users (LTA, 2006A; Hidalgo et al. 2007).

Furthermore, a trunk-and-feeder network development is typically coupled with "closed" system business structure which requires bus sector reform both in terms of network configuration and its organizational arrangement. It is critical to provide a functioning feeder system which has become 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. Hypothetically, some significant barriers must have been existed that limit Jakarta system from taking as essential measure as providing an effective feeder system.

As a result, the system cannot achieve 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.

2. Research Goal, Questions, and Objectives

The study is aimed for formulating measures to manage barriers towards improvement of intermodality in Greater Jakarta, Indonesia. This issue is analyzed by taking consideration of two sides perspectives: supply side or public transport service providers (government and operators) and demand side or public transport (both current and potential) users.

To achieve the main goal, six major research steps are being set up:

1. Formulating the framework of intermodality evaluation through literature review related to theoretical strategies and empirical evidences on how to improve TransJakarta Busway system attractiveness through intermodality improvement;
2. Develop the expected level of intermodality to be achieved by TransJakarta Busway;
3. Identify current status of TransJakarta Busway intermodality through field observation;
4. Explore barriers encountered by providers (government and operators) in improving TransJakarta Busway's intermodality;
5. Investigate the importance of intermodality improvement in influencing commuters mode choice;
6. Evaluate the proposed measures through cost-and-benefit analysis and also explore the impact on public transportation system institutional arrangement in Jakarta

3. Summary of Methodology and Results

3.1. Expected Level and Evaluation Framework of Intermodality

To identify important aspects of intermodality to increase BRT attractiveness, a literature review related to theoretical strategies and empirical evidences was conducted. The framework departs from two weakness points of intermodal trips which are: (i) the availability of access and egress mode; and (ii) the higher penalty of having to interchange. 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 actual and perceptive. Perception should be emphasized here especially to meet the higher penalty usually given by private mode users. 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 is defined as intermodality. More intermodality means more integration and complementary between modes.

As for the first weakness point, the availability of access and egress mode, the relation between types of network configuration, specifically trunk-and-feeder network and organizational frameworks were discussed. Further, two best practices namely Seoul and Curitiba were reviewed. Both best practices applied trunk-and-feeder BRT system with unified "free-transfer" fare system with electronic system. What is more essential is that the reform of organizational arrangement for delivering services greatly contributes to the tremendous achievements in Seoul and Curitiba. To be specific, both cities established an intermodal agency to integrate transit modes operations at tactical level to control the service provisions by private operators. The existence of intermodal agency enables the system to enhance the level of integration, not only fare but also other components. The possibility to apply such scheme is to be evaluated referring to existing institutional arrangement of public transportation system provision and management in Greater Jakarta.

The level of integration itself 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 concrete implementations of each component are described through worldwide practices.

3.2 The Current Status of TransJakarta's Intermodality

Based on the evaluation framework developed, this study further tries to analyze the impact of low degree of intermodality on TransJakarta Busway's attractiveness. Therefore, first, we evaluated the current status of TransJakarta's intermodality 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.

Complementarily, to explore further about each element of intermodality derived from the evaluation framework described previously, particularly the reasoning of a design and certain insufficiencies, interviews with Jakarta's Local Transpotation Authority (LTA), 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 observation, it is identified that hardware components (the access and waiting amenity) leave many rooms to improve. Firstly, the design of overpass especially SWPA is not protected from windy rain. It may be better to protect left and right sides of the overpasses with transparent safe materials. Another major problem is the long climbing and walking along the ramps and overpasses. For people with physical constraints, it may not be convenient. Thus, an elevator should still be necessary.

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 lined up approaching the platform. This is because the shelters are mostly small and narrow and the integrated points are too few. In terms of waiting amenity, TransJakarta provides minimalist designed seating furniture and limited air conditioner. While public phone, restroom, and kiosks are only available at main terminals but not inside the BRT shelter, except in Harmoni Central Busway where restroom is available but not functioning well.

Another component of hardware is the availability of parking facilities. Currently, parking facilities for taxi and paratransit are provided informally right besides the edge of BRT ramps. The government is planning to build some park-and-ride facilities at some main terminal areas and other strategic locations. Among seven locations, two of them have been initiated by private sectors. The government is still trying to determine the exact proper location due to land availability and considering about the financing and subsidy to create attractive fare system.

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.

The lack of feeder system is actually the result of two faces of bus industry in Greater Jakarta with different management system between BRT and conventional buses. While BRT's operations are handed out to private sectors who are being paid based on cost per vehicle-km, the daily operational of bus system is handed out to bus crews on daily bases under sublet revenue sharing system between bus owners 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 except large buses, 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.

In overall, 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 shown by lower ridership than expected.

3.3 The Barriers for Improving Intermodality from Provider's Perspective

Borrowing the terminologies defined by May *et al*. (2003), 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 bus-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.

3.4 The Importance of Intermodality Improvement from User Perspective

The next step is to contribute further understanding about the importance of the expected level of intermodality improvement designed in the second step from potential users' perspective. Therefore, web-based stated-preference experiment was carried out. Besides its affordability and practicality, this study chose to use web-based survey involving stated-preference survey because: (i) the survey intended to utilize respondent input regarding their current trip information to automatically calculate the new alternative attributes. This is considered as one way to enhance the realism of stated-preference choices. Thus, the survey requires some degree of complexity that is best handled by computer; and (ii) the survey targeted non-riders of BRT along seven corridors. Here, large employers can provide a good base for convenience sampling assuming that employees have easy access to internet.

There are two results yielded in this step: (i) the trip complexity changes and (ii) the importance of intermodality on commute mode choice. In terms of trip complexity changes, it is found that bus especially medium and small buses remain important as access and egress mode. Therefore, it is quite relevant if in the future, such role is maintained but improved. For improving it, route reconfiguration through establishing a trunk-and-feeder network alone is insufficient, unless if it is supported by other integration measures to increase interconnectivity from origins to BRT network, reduce feeder performance gap compared to BRT, and make transferring more convenient. Therefore, the whole bus reform is undoubtedly necessary.

Table 1 Stated-Preference Attributes and Levels

ATTRIBUTES	BUSWAY OPTION (P&R AND F&R)
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

From the 78 samples collected through this study, the average length trip using BRT is about 12.3 km. Under the scenarios given, the commuters are actually able to save in-BRT-vehicle-time ranging from 8 to 22 minutes. But due to considerable time required to access, egress, and transfer, the total travel time is compromised. Compared to current trips average travel time which falls at 72 minutes, feeder-and-busway option can only reduce 3 minutes by applying the best scenario. The scenarios could provide 16 to 47 minutes time reduction for current BRT users. While, private mode and other public transport users hardly enjoy any travel time reduction. Though such result is reasonable, but further study is required to minimize the technical error caused by low accuracy of the data when estimating each travel time based on the inputs given by respondents. At least, the result confirms that to promise a significant travel time reduction is quite challenging.

As for the importance of intermodality, through the Multinomial Logit model result developed from 297 observations, it is justified that door-to-door travel time in which out-vehicle time (a function of number of transfer and three-level of transfer time) and in-vehicle time (access, BRT, and egress) were incorporated is the most influencing factor on commute mode choice, followed by time delay for BRT service. The best model further indicates that the tendency of choosing current mode over the new alternative may change if all three components of proposed interchange facilities improvement are introduced. While the proposed single fare for parking, feeder, and BRT seems to have lower effect although the average travel cost that the new alternative offered was cheaper.

Table 2 Model Estimate Result

VARIABLES	Best Model	
	Coeff.	**t-ratio**
Attributes		
Total travel time (min)	-0.022	-5.057
Time delay of new BRT alternative (min)	-0.078	-3.850
Total travel cost (home to work)	-0.000027	-2.556

VARIABLES	Best Model	
	Coeff.	t-ratio
Excellent interchange dummy	0.778	2.624
Good interchange dummy	0.241	0.806
Statistics Summary		
No. of observation	297	
Log likelihood with constant only	-192.813	
Log likelihood at convergence	-173.104	
Adjusted Rho-squared	0.102	

It is found that total travel time is valued Rp 794/min or Rp 47,640/hour, almost four times higher than the average current travel cost. While interchange improvement including multimodal ticketing system is valued 36 minutes reduction of total travel time equal to Rp 28,307. It reflects that these two attributes are considered highly influencing towards the decision to shift to BRT.

Conclusively, the main barrier to take intermodal trips involving public transports from user perspective is the compromised door-to-door travel time in which no. 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.

3.4 Evaluation of the Proposed Measures

As the *fifth* and also the final step, it is aimed for evaluating three possible alternatives to be implemented in order to improve TransJakarta's Busway attractiveness.

It begins with developing policy options to be evaluated. The policy options are 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 and determined by considering limitations encountered by providers. For the analysis, three main integrated transfer points are selected. Afterwards, the demand for each interchange is forecasted by using the utility model estimated based on SP data and JICA-SITRAMP O-D Matrix Data (2020). Utilizing the estimated demand, cost-and-benefit ratio is analyzed. Additionally, institutional arrangement required for realizing those alternatives is discussed.

The measures to improve speed and also alleviate overcrowding passengers at interchanges are: (i) maintaining one minute headway; (ii) providing direct services by connecting two corridors into one line; and (iii) managing intersections and bottlenecks. While for improving the convenience to interchange, by considering current conditions of three selected interchanges, the emphasis is placed on: (i) improving access to platform by providing at least one elevator; (ii) providing extended bridge to the nearest station/bus terminal; (iii) providing restroom within the shelter area; (iv) providing timetable, intermodal route information, and real-time display; and (v) applying integrated electronic ticketing system with smartcard technology.

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.

The result of benefit-and-cost analysis confirms three measures essential to be implemented to improve the attractiveness of TransJakarta Busway:

(i) capacity enhancement; (ii) feeder provision; and (iii) interchange convenience improvement. These measures have several impacts on institutional arrangement since they are difficult to be achieved under the existing arrangement.

It is recommended to divide the authorities into strategic, tactical, and operational level in order to establish a more efficient decision making process. In line with the ongoing progress of railway sector enhancement, an intermodal transport authority in order to realize software and finware integration is emphasized, as well as strengthening BLU TransJakarta. Both elements are working together at tactical level.

One problem that may occur is fleet provision as evidently shown by the current system. Public financing is likely to be the last solution expected. It is recommended to establish horizontal separation between fleet provision and its maintenance-operation. The operators can rent the fleets from fleet company. It can further be applied for feeder system by furbishing the existing conventional buses.

In terms of feeders, it is proposed to accelerate network reconfiguration for increasing interconnectivity to BRT network and to minimize number of transfers. However, learning from best practices and current problems faced by Jakarta's bus industry, Jakarta should also emphasize on favoring a healthy atmosphere among operators in delivering services and promoting cooperation towards integration through introducing controlled competition throughout the whole bus industry.

4. Conclusions

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.

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