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Special Conventional Transport Model for a New BRT Line Passenger Demand Prediction (The General Modeling Method)

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Abstract. Indonesia is a developing country with limited government budget. Hence, the BRT is one of the most appropriate first mass transit to be developed in Indonesian big cities. Therefore, the New BRT Line Passenger Demand Prediction Method need to be developed. The research were conducted in Makassar City, having 3 BRT corridors in operation. The BRT survey indicated that the BRT Users are the previous Public Transport User (76%) and Motorcycle User (24%). Therefore, a Special Conventional Transport Modelling is considered the most appropriate to make a New BRT Line Passenger Demand Prediction. This modeling method incorporates Special Steps Sequence, Limited Modelling Area, Restricted Trip Generation, Modal Split Coefficient Matrix and Trip Assignment Matrix Technic. The modelling primary and secondary data collection indicate that this Special Conventional Transport Modelling is the most appropriate, regarding its Potential Users variety. This can be considered as a proof that this Special Conventional Transport Modelling is the most appropriate for this purpose.

1. Introduction

Indonesian big cities need implementation of mass transit. Urban Public Transport must be part of Public Service Obligations. As a developing country, Indonesian government budget is considerably limited. Therefore, the easiest and the cheapest mode to be developed is the BRT [1-3]. Implementation of the BRT has been done in several metropolitan cities. A lot of New BRT Lines are still to be implemented in other big cities [1-3]. However, the Ministry of Transports Guidance for Bus Line Planning, Design and Operation is still too simplified in passenger demand prediction aspect. A method to calculate the BRT Ridership in developed countries, such as in Los Angeles County, is not appropriate at all for Indonesia [4,5]. Direct modelling method based on Public Transport Users Onboard Interview Survey (OIS) is quite used several times for New BRT Passenger demand modelling, but this method is already several times critized as not well enough considering various potential demand [1,2]. Therefore, a more appropriate Demand Prediction Method, better adapted to the real potential demand, need to be developed.

It can be imagined easily that Modelling Method design should be developed in two level : the general modelling method and the each steps modelling method. The general method, in principal, covers the determination of the modelling type and the steps sequence. The general method must be defined first and it must be adapted to the case condition. The each step modelling calculation can only be defined afterward.

Several principals aspects have to be defined concerning the general modeling method. First, the Modeling Area extension depend on the BRT Infleuence Area [1,2]. Second, the variety of potential BRT User must be considered [1,2]. Third, modeling type should be choosen among the three basic modelling type, i.e the direct model, the conventional model and the unconventional model [6-11]. Fourth, if the conventional model is used, the four steps sequence must be defined. In general, there are four types of Steps sequences : Sequence Type 1 : (TG+MS) - TD - TA, Sequence Type 2 : TG - MS - TD - TA, Sequence Type 3 : TG - (TD+MS) - TA, and Sequence Type 4 : TG - TD - MS - TA. TG is the trip generation step, MS is the modal split step, TD is the trip distribution step, while TA is the trip assignment step [6].

Only after the general modeling method will have been determined and its appropriateness will have been proofed, that each modeling steps can be carefully designed.

Regarding the characteristics of the Potential Users and the various Modelling Type, a Special Demand Modelling method for a New BRT Line Passenger Prediction Demand need to be developed. This paper discuss only the development of the General Modelling Method, together with a proof that the method is the most appropriate one.

2. Research Method

Papers Scope of Discusions. The entire Demand Modelling Method is long enough to be written in a paper. This paper discuss only the general aspect of the General Modelling Method development together with a proof that the method is the appropriate one for a New BRT Line Passenger Demand Prediction. Other more in detail discusions, on each of the four steps modelling, will be written in the other following papers.

Research Objective. The research objective is to develop a Special Demand Model for a New BRT Line and is to proof that the method can be used and the most approriate one to cover the variety of the entire potential BRT user.

Research Method. The research was done by following these steps : research objective statement, research steps design, BRT users trip characteristics, demand modelling method development, method evaluation and conclusions.

Research Location. The research was done in Makassar City having 3 BRT in operation, i.e Mamminasata BRT Corridor 2, Corridor 3 and Corridor 4. Corridor 2 and Corridor 3, operated inside the Makassar City, were taken as references for BRT Passenger Trip Characteristics. Coridor 1 to be opened is taken as Passenger Prediction Case. The map of Makassar City is presented in Figure 1 below.

Figure 1 Mamminasata BRT Network

3. Development of Demand Modelling Method

3.1. Modelling Objective

The main Modelling Objective is to predict hourly passanger demand in morning peak hour calculated by segment and by direction for the New BRT Line. Therefore, these passenger demand must be calculated based on Bus Stops based BRT Passenger Origin Destination Matrix (OD Matrix). So, several principal questions have to be answered on this research.

- Who are the potential BRT Users ?
- How large is the modeling area extension ?
- What modelling type must be used ?
- What modelling step sequence should be used ?
- How the each steps calculations should be designed ?
- How is the method to calculate the embarking and disembarking passenger volume ?

3.2. Modelling Method Considerations

In defining the Modelling Method, among the three principals Modelling Type, these following considerations must be taken into account :

- cover the whole potential demand – identify the potential users
- logical – choose among modeling main types.
- easiness of data collection – previous modes are public transport and motorcycle.
- easiness of calculation – direct method and conventional model is easy to calculate.
- accuracy assurance – several sample size guidance for conventional model.

3.3. Mamminasata BRT User Trip Characteristics

A small research to reveal the BRT User Trip Characteristics during morning peak hour was done in Makassar. The survey was taken on Mamminasata BRT Corridor 2 and Corridor 3. The research gives the following main characteristics. The morning peak hour BRT are used practically only by working trip at 50% and schooling trip at 50%. Thus, morning peak hour BRT utilisation can be considered as stable in number and even in user. The existing BRT Users consists of 76% previous public transport users and of 24% previous motorcycle users. The existing acess mode before embarking consists of 51% motorcycle, 19% public transport, 18% becak, and 9% walking. The acess distance to the embarking BRT Stops consists of 48% trip having distances between 1.0 – 2.0 km, 36% trip having distances between 0.0 – 1.0 km and 16% trip having distances between 2.0 – 3.0 km. The existing egress mode after disembarking consists of 71% walking, 18% becak and 11% public transport. The egress distance after disembarking consists of 71% trip having distances between 0.0 – 0.5 km, 21% trip having distances between 0.5 – 1.0 km and 8% trip having distances between 1.0 – 1.5 km. Becak is an Indonesian non-motorized tricycle taxi. These all compositions are the general BRT Users Trip Characteristics Composition for the two corridors all together. Each composition for each corridor are slightly different each other [2].

Thus it can be concluded that the Mamminasata BRT potential users are the public transport users and the motorcycle users in the Influence Area. The Trip Origin Influence Area cover a strip of 2 km to the left and to the right of the BRT Line. While the Trip Destination Influence Area cover a strip of 1 km to the left and to the right of the BRT Line.

3.4 Development of Demand Modelling Method

The most important considerations are the potential passenger demand and the influence area mentioned above.

The modelling method basically will be choosen among the three basic modeling type : direct model, conventional model and unconventional model [1,2,6].

Unconventional Model. The Unconventional Model is definitely can not be used for this prediction calculation. The BRT is not yet in operation, so the existing passenger flows to be observed and counted, to produce the OD Matrix, are not yet exist.

Direct Model. The Direct Model theoritically can be used for this modelling. The potential public transport user are collected and identified on-board the Public Transport, which are in-line with and which are across the New BRT Line. The potential motorcycle user are collected and identified also on the streets which are in-line with or which are across the New BRT Line. But this method has major difficulty, doing Road Side Interview Survey (RSIS) for motorcycle is very laborious and not easy at all, besides it needs an important funding. More than that the adequate sample size is also difficult to be achieved. Thus, the Direct Model is decided not to be used.

Conventional Model. The remaining one has to be used is the Conventional Model. For this Conventional Model, two types of data collection must be choosen : a home based data collection or a mixture of office-based & school-based data collection.

- A Mixture of Office & School Based. The influence area for origin and destination are known. But this method is still difficult, due to the office and school population data.
- Home Based. This one is very classical one, incorporating the Household Interview Survey (HIS) data. This method can be done.

Decision. From the reflexion above, the Conventional Model based on HIS is the most appropriate one. This method is simple and yet accuracy can be managed. This lead us to several new techniques which has to be defined : the Modelling Steps Sequence, the BRT Demand Modelling Area, the BRT Trip Generation technique, the BRT Trip Distribution technique, the BRT Modal Split technique, and also the BRT Trip Assignment technique.

3.5. Conventional Model with Special Steps Sequence

Even if it is a conventional model, this is not an ordinary conventional model. The ordinary conventional model step sequence type 1 follows this four steps sequence : TG/MS – TD – TA, while the ordinary conventional model step sequence type 4 follows this four steps sequence : TG – TD – MS – TA [6]. Different from those two, this special model must incorporate the public transport and motocycle trips modal split in the TG step and the BRT modal split after the trip distribution is done. Regarding this neccesity, the step sequence must be a mixture of type 1 and type 4. Thus, this is a conventional model with new steps sequence : $(TG+MS)^{MA}$ (only for the modelling area) – TD^{MA} (only for the modelling area) – MS^{1BRT} (special MS for BRT choice in a matrix form) – TA^{1BRT} (special TA for New BRT Line). The modal split step must be done twice. The Model Step Sequence diagram is presented in Figure 2 below.

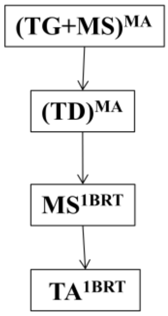

Figure 2 Modeling Special Step Sequence

3.6. Special Demand Modelling Area

The demand modelling area must cover the BRT Line influence area. The influence area for embarking passenger cover a strip of 2 km to the right and to the left along the BRT Line. While the influence area for the disembarking passenger cover a strip of 1 km to the right and to the left along the BRT Line [2]. By using this influence area principal, the traffic zone is designated as Kelurahan. Therefore the demand modelling area cover each Kelurahan in the influence area. It must be kept in mind that the production influence area can be different from the attraction influence area and not all of the whole area of each Kelurahan are included in the influence area.

3.7. Special Trip Generation Model for the the Modelling Area

The first step that must be done very carefully is the trip generation step. The trip generation step should be calculated based on the zonal regression trip production and proportional trip attraction [1,6]. The two must be done for the modelling area only, which is very limited. The trip generation data used are only those in-which the trip destination is inside the attraction modelling area and the trip origin is inside the production area. Data collection is executed based on HIS method.

The trip production model must be developed very carefully, this must incorporate the trip toward the attraction modelling area against the entire related zonal data. Therefore, the general form of the trip production formula can be presented as follows.

$$TP_i = a_0 + a_1\, Pop_i + a_2\, Mod^1_i + ... + a_{n+1}\, Mod^k_i \qquad (1)$$

where :

- TP_i : trip production toward attraction modelling zone of production part of zone i
- a_n : coefficient
- Pop_i : the entire population of zone i
- Mod^k_i : the entire population of Mode type k of zone i

Due to the number of page limitation, the detail of the Trip Generation – Modal Split Modelling can not be presented in this paper and will be presented on the following paper.

3.8. Special Trip Distribution Model for the Modelling Area

Ordinary gravity model should be used for this special trip distribution model [1,6]. The Origin-Destination Matrix (OD Matrix) cover the entire Modelling Area. Special attention must be taken since the Production Zones and the Attraction Zones can be different.

Due to the number of page limitation, the detail of the Trip Distribution Modelling technique can not be presented in this paper and will be presented on the following paper.

3.9. Special Modal Split Model toward a New BRT Line

Another technique has to be well thought is the Modal Split Model toward the New BRT Line. It has been decided that this Special MS Model will be used after the Trip Distribution step to get the BRT OD Matrix out of the Motorcycle OD Matrix and Public Transport OD Matrix. Hence, the Modal Split toward the New BRT must be presented in a Modal Split Matrix form, which must be developed based on a Mathematical MS Model, which is in-turn developed based on the Trip Maker Stated Preference of the BRT Model Choice. The mathematical model is a regression of Modal Choice Coefficient data against Travelling Distance. An appropriate regression model must be used for this case, since the dependent variable is a catagorical data [1,2,12,13].

Using the Special Matrix Technique for Transportation Network Analysis convention [17,18], the Modal Split calculation formula can be written as below.

$$f.MS^{PT}(D) \sim \text{special regression of } m.MS^{D.PT} \quad (2)$$
$$f.MS^{MC}(D) \sim \text{special regression of } m.MS^{D.MC} \quad (3)$$
$$m.MS^{BRT.PT} = m.D \times f.MS^{PT}(D) \quad (4)$$
$$m.MS^{BRT.MC} = m.D \times f.MS^{MC}(D) \quad (5)$$
$$m.OD^{BRT.PT} = m.OD^{PT} \times m.MS^{BRT.PT} \quad (6)$$
$$m.OD^{BRT.MC} = m.OD^{MC} \times m.MS^{BRT.MC} \quad (7)$$
$$m.OD^{BRT} = m.OD^{BRT.PT} + m.OD^{BRT.MC} \quad (8)$$

where :

- $m.D$: matrix of interzonal distance
- $m.OD^{PT}$: origin destination matrix of public transport trips
- $m.OD^{MC}$: origin destination matrix of motorcycle trips
- $m.MS^{D.PT}$: matrix of modal split coefficient data, for public transport trips
- $m.MS^{D.MC}$: matrix of modal split coefficient data, for motrocycle trips
- $f.MS^{PT}(D)$: modal split function against distance, for public transport trips
- $f.MS^{MC}(D)$: modal split function against distance, for motorcycle trips
- $m.MS^{BRT.PT}$: matrix of modal split coefficient model, for public transport trips
- $m.MS^{BRT.MC}$: matrix of modal split coefficient model, for ,otorcycle trips
- $m.OD^{BRT.PT}$: origin destination matrix of BRT trips from public transport
- $m.OD^{BRT.MC}$: origin destination matrix of BRT trips from motrocycle
- $m.OD^{BRT}$: origin destination matrix of BRT as a whole

Due to the number of page limitation, the detail of the Modal Split Modelling can not be presented in this paper and will be presented on the following paper.

3.10. Special Trip Assignment for a New BRT Line

Practically, all Trip Assignment discusions are about assigning the Public Transport OD Matrix into several Public Transport lines [14-16]. In this case, the Trip Assignment is not about assigning the trips into several BRT Lines, but merely assigning the trips into a New BRT Line. This means assigning the BRT OD Matrix into Embarking and Disembarking Passenger Volume on each bus stops. This needs several following steps.

Based on the Modal Split Toward the New BRT Line, the Traffic Zone based BRT OD Matrix can be calculated. The next step is getting the Bus Stop based BRT OD Matrix. It can be easily gotten by assigning bus stops to each traffic zone. After this only, the Trip Assignment can be made. Trip Assignment is basically an All-or-Nothing so it will be very easy and special. It can be done directly to get the Embarking and Disembarking for each Bus Stop and for each Direction and afterward to get directly the Number of Passenger for each Segment and for each Direction. The BRT OD Matrix must be devided into two across the diagonal cells to get a BRT OD Matrix for each direction.

Using the Special Matrix Technique for Transportation Network Analysis convention [17,18], the BRT Trip Assignment calculation formula can be written as below.

$$m.OD^{BRT.TZ} = m.OD^{BRT} \quad (9)$$
$$m.OD^{BRT.BS} \sim \text{grouping of } m.OD^{BRT.TZ} \quad (10)$$
$$m.OD^{BRT.BS.d1} = \text{upper half of } m.OD^{BRT.BS} \quad (11)$$
$$m.OD^{BRT.BS.d2} = \text{lower half of } m.OD^{BRT.BS} \quad (12)$$
$$s.E^{d1} = s.R^{OD.BRT.BS.d1} \quad (13)$$
$$s.DE^{d1} = s.C^{OD.BRT.BS.d1} \quad (14)$$
$$s.E^{d2} = s.R^{OD.BRT.BS.d2} \quad (15)$$
$$s.DE^{d2} = s.C^{OD.BRT.BS.d2} \quad (16)$$
$$s.PS^{d1} = P^{d1}{}_{n-1} + E^{d1}{}_{n} - DE^{d1}{}_{n} \quad (17)$$
$$s.PS^{d2} = P^{d2}{}_{n-1} + E^{d2}{}_{n} - DE^{d2}{}_{n} \quad (18)$$

where :

$m.OD^{BRT.TZ}$	:	traffic zone based BRT origin destination matrix
$m.OD^{BRT.BS}$	:	bus stop based BRT origin destination matrix
$m.OD^{BRT.BS.d1}$	:	direction 1 BRT origin destination matrix
$m.OD^{BRT.BS.d2}$	:	direction 2 BRT origin destination matrix
$s.E^{d1}$	:	set of embarking volume, direction 1
$s.DE^{d1}$	:	set of disembarking volume, direction 1
$s.E^{d2}$	:	set of embarking volume, direction 2
$s.DE^{d2}$	:	set of disembarking volume, direction 2
$s.PS^{d1}$	:	set of passenger volume by segment, direction 1
$s.PS^{d2}$	:	set of passenger volume by segment, direction 2
$P^{d1}{}_{n}$	:	number of passenger in segment n direction 1
$E^{d1}{}_{n}$	:	number of passenger, embarking on bus stop n, direction 1
$DE^{d1}{}_{n}$	:	number of passenger disembarking on bus stop n, direction 1

Due to the number of page limitation, the detail of the Trip Assignment modeling can not be presented in this paper and will be presented on the following paper.

4. Demand Modelling Method Testing

4.1. Trial Case

Mamminasata BRT Corridor 1 : Airport – Mall GTC, which is will be soon implemented, were taken as a Method Trial Case to implement the designed Special Demand Modelling Method.

4.2. Notes on Modelling Method Trial

The BRT Corridor 1 has a long line with a lot of crossing street. In term of street segment, the BRT line has more than 25 segments and more than 40 crossing street. The existing public transports, which are in-line and across-line, are also quite alot of more than 20 lines. Therefore, doing OIS for the public transport users and RSIS for the motorcycle user is enormous. The direct modeling is not practical, it needs a enormous effort. While unconventional model cannot be used.

The Modelling Method implementation is not yet finished completely. But it can be concluded that in principal "Conventional Transportation Modelling with Special Steps Sequence" can be used and is the most appropriate method to cover the potential demand which consists of 76% public transport users and 24% motorcycle users.

Thus, a paper on General Modelling Method can already be written. Special paper on each four steps model calculations will be written separately.

5. Conclusions

Research objective has been succesfully achieved. Two principal conclusions can be drawn as follows :

- The most appropriate demand modelling method to cover the entire various potential demand is a Special Conventional Model with a Special Steps Sequence : $(TG+MS)^{MA}$ – TD^{MA} – MS^{1BRT} – TA^{1BRT}. The modal split is done twice differently.
- The whole calculation steps must be well designed.

This modeling method should be considered as new. Because, it deals with a new four steps sequence inwhich the MS modelling must be done twice. Also it deals with special potential users charactristics, modeling area definition, sampling design, four steps special calculation method for each modelling steps, sample accuracy measuring method and validation-and-calibration method. Reflexion on all of these aspects cannot be found in existing modeling textbook and papers. Sciencetifically, these all modeling aspects are very important to be developed and refined. These discusions will be written in separate following papers.

Acknowledgements

This paper present a part of research results to develop a New BRT Line Passenger Demand prediction method. Mamminasata BRT network, in Makassar City, is taken for case study.

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