

Study of Key Factors Determinant Choice of Rail-Based Mass Transit

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ABSTRACT

Pursuant to regulations of the Ministry of Transportation in 2002 about the type of transport based on the city size, the metropolis with a population of more than 1 million inhabitants are required to have the urban mass transit. Nevertheless, until now not all city-scale population of more than 1 million have mass public transport, either bus or rail-based. Especially for rail-based mass transit, indicated the existing regulations have not been able to challenge the development of rail-based urban mass transit. Learning from the literature study and the experience of countries that already have rail-based urban mass transit it has acquired nine main factors to be taken into account in developing a rail-based urban public transportation. This study was conducted by using Analytical Hierarchy Process method which was further validated through the implementation of the On Focus Group Discussion in the Jakarta City Transportation Council (DTKJ) as well as in the City Development Planning Board (Bappeko) Surabaya. Finally, the initial result shown five sequences determining factor for the determinant choice of rail-based mass transit, namely: fiscal or economic capacity of the region and society, transport policy, integrated public transport, land use, fare and travel time. Furthermore, the acquisition results of this study can be applied to the selected cities to address the challenges to urban mass transit development.

Keywords: metropolitan, Analytical Hierarchy Process, Focus Group on Discussion.

I. INTRODUCTION

Mobility is an essential part of human life especially in cities. Indeed mobility is perceived as a right especially in large cities in developed economies [1]. One of the main issues of major cities in Indonesia today is mobility barrier and traffic congestion. Along with the growth of population and urban economies in developing countries including Indonesia [2][3] the city will expand and tend to occur agglomeration with the cities around it, e.g. Jabodetabekjur which includes the city of Jakarta, Bogor, Depok, Tangerang, Bekasi and Cianjur or Gerbangkertosusila, namely Gersik, Bangkalan, Mojokerto, Surabaya, Sidoarjo, and Lamongan. Furthermore, the number of trips will increase, which will also mean an increase in mobility in the urban areas. This condition requires readiness to support the movement (mobility) of citizens in the activity and support the mobility of the urban economy (economic urban mobility).

Recorded that the role of public transport in Indonesia reached in average of 23%, while in developed countries the role of public transport more than 50%, and even public transport in Singapore reached 60% and Hong Kong reached 90% (Bappenas, 2013). Public transport is available today in several major cities in Indonesia tend not to thrive, even its performance is getting worse and this

is seen with increasing dominance of private vehicles dominate the road, especially motorcycles. Comparison of the number of motorcycles and cars in Yogyakarta is 85% and 15% [4]. Public transportation is still not optimal in terms of capacity, level of services, providing inadequate support infrastructure, and a lack of integration between modes of transport. Disruption of the citizen's mobility may result in disruption of economic growth. Department of Transportation [5] has issued a directive on the type of mode that is used for public transport by size cities such as Table 1 below. The larger the size of the city and the area, the more the population, the more activities. This requires appropriate transport modes. larger city size and area, more populated, it will be the more activities, so this requires appropriate transport modes.

Table 1 Type of mode based on city size

City Size	Metropolitan (> 1 million inhabitant)	Big City (500.000 – 1.000.000 inhabitant)	Medium City (250.000- 500.000 inhabitant)	Small city (< 250.000 inhabitant)
Main Route	-Railway/LRT -Big bus	-Big bus	-Big bus/ medium	-Medium bus
Strech Branch	-Big bus / medium	-Medium bus	-Medium bus/ small	-Small bus
Strech Twig	-Small bus	-Small bus	-small bus	-Small
Straight	-Big bus	-Big bus	-Medium bus	-Medium bus

Source: Hubdar, 2002

The main route is the lifeblood of the economy of a city, so if noncurrent would interfere with the citizens mobility thus will disrupt economy of the city. The main route attempted pass land use with potential high demand, such as Commercial Business District (CBD) and other activities centres. In addition, the region with a high population density a priority in determining the route, as more and more population, the greater potential demand created (Surabaya City Government, 2012)[6]. The huge demand should be facilitated with other transport modes to ensure simple mobility, safe, convenient and cheap, Department of transportation suggested in cities with populations over 1 million people must have a mass public transport, both road (large bus) and rail- based. The main route usually through arterial road width equal to or greater than 8 m and a speed of 30 km / h. Public transport services, in addition to pay attention to potential areas, also should reach out to all the existing urban area. In addition, the route is also planned in accordance with the population pattern mobility, so that the transfer modal public transport can be minimized. Therefore, on the collector road will be served by the stretch branch and on local roads will be served by the stretch twig with smaller mode and can be a feeder to the main route.

Urban mass transit that exists today is more likely based on the road (road-based), such as Transjakarta and Transjogja. Unfortunately, the development of public transport is not yet as expected. In fact, Transjakarta passengers decreased [5] as well Transjogja not developed yet and even with load factor was only 35% [4]. Basically, in order to be developed then its load factor must be at least 70%. Ironically, number of passenger in Surabaya urban buses during the period 2010-2015 was reduced to 25% [6]. Alternatively, an integrated rail-based modes with other modes need to be strengthen so that it can serve door to door mobility. Unfortunately, Department of Transportation policies that exist today indicated that no answer to the challenges of developing Rail-based mass transit due to there is only one factor that is taken into account, namely the city size, though there are other major factors that also determine the selection of Rail-based mass transit.

II. LITERATURE REVIEW

According to Nanang [7], public transport can be grouped into two categories, namely road-based and rail-based. Furthermore, the rail-based transport can be divided into rapid system and conventional. Rapid system known as the Mass Rapid System (MRT) while the conventional divided into two; Electrical Light Rail (KRL) and Diesel Light Rail (KRD). Munawar [8] and Haring [9] has stated that Rail-based mass transit divided

into several types, namely: a). HRT (Heavy Railway Transit) trains operated in a special way and does not intersect with the highway; b). LRT (Light Railway Transit), an electric tram that operates in the city, generally operate on a highway alongside the other vehicle (traffic mix), but can also be operated in the basement or on the highway; c). Metro, a type of HRT, an urban railway with separate lines and not a plot by the highway; d). Commuter train, a type of train that operated in urban areas.

In addition, Haring [9] mentioned that LRT and tram does not need a wide space so that it can be operated in various conditions of the city, such as : a). along with other vehicles on the highway; b). together with the bus, the tram and bus lane; c). pedestrian; d). the green line on the wide road. If the road surface is not available on-site, can be operated in the underground (tunnel) or on the ground (elevated).

2.1 The Key Factors

A detailed study of literature found the other key factors that will determine the choice of public transport other than the city size or population [10]. At least there are nine major factors, namely:

1. City Size or Population
2. City Functions
3. Land Use
4. Cost and Travel Time
5. Current Public Transport/Integration
6. Technology Used
7. Ability of Regional Economic and Community/Fiscal
8. Transport Policy
9. Infrastructure

2.2 Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) is one of the methods for decision making with diverse criteria and considering the complexity of problems in a simple way, but still ensure the consistency of decisions taken [11]. This method utilizes the perception of respondents who are considered experts as the main input. Criteria expert here is not genius or smart but rather refers to a person who understood the problems posed, feeling the effects of a problem, or have an interest to the problem [12]. Some basic principles that must be understood as follow:

1. Decomposition, which broke the whole issue into its elements to the smallest detail, this process is called hierarchy.
2. Comparative Judgment, the principle of comparative judgments is applied to construct pairwise comparisons of all combinations of elements in a cluster with respect to the parent of the cluster. Questions commonly asked is:

which is more important elements? How many times is more important? The benchmark used in the preparation of interest is the Saaty scale, ranging from 1 to 9 weight.

Table 2 Saaty Scale

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one activity over another
5	Strong importance	Experience and judgment strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8		Intermediate values

Source: Oktariadi (2009)

- Synthesis of Priority is pairwise matrix contained in each level, so to determine a global priority, it should do the synthesis between local priorities.
- Logical Consistency is the consistency that has two meanings. The first is that similar objects can be grouped by the diversity and relevance. The second is the level of relations between multiple objects based on specific criteria. AHP measuring the consistency assessment using Consistency Ratio (CR), which was formulated; $CR = CI/RI$, with $CI = (Z_{maks} - n) / (n - 1)$, with Z_{maks} is the maximum eigen values of pairwise comparisons matrix. The value of Random Consistency Index (RI) can use the benchmark table below.

Table.3. Random Consistency

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

Source: Saaty in Otok (2014)

CR value should not be more than 10%, if not, then the judgments made may be carried out at random and needs to be revised.

2.3 Focus Group Discussion

According to Masadeh [13], Focus Group Discussion (FGD) is a technique used in qualitative research approach with common characteristics in the form of a structured discussion in a small group of participants, led by a facilitator/moderator. Discussion aims to produce qualitative data based on specific topics according to the study. On the other hand, the discussion is done through a set of open questions. Furthermore, some of the advantages and

disadvantages of FGD according Masadeh [13] are listed below:

Advantage

- FGD become effective and efficient techniques to collect information from a small group of resource persons;
- FGD produce quality data and information;
- FGD allows researchers to obtain deep insights about the topic that has been determined.

Disadvantages

- FGD implementation is relative expensive
- FGD implementation takes a long time
- FGD process through technical analysis is quite complicated and requires more research data instrument.

Furthermore, Masadeh [13] suggested that FGD implementation should consider the following points:

- The size and number of participants in the FGD can be broadly divided into three (3) groups, small-sized group, middle-size group and large-sized group.
- The small group with participants between 4-6 people is an ideal group for FGD, because each participant can play a more active to express their opinions, so it can produce a lot of specific ideas about the topics discussed within a certain time limit.
- The timing of the FGD is usually between 30 minutes to 2.5 hours. The principle is the minimum time gain maximum input regarding topics discussed.
- The facilitator in the implementation of FGD has an important role in the success of the discussions. The facilitator can be done by researchers concerned with the consideration that the researchers have some knowledge of the discussion subject so that can be run according the topics covered. The facilitator can also be done by someone other than the researcher to produce exploration better and avoid biased results of the discussion. Krueger R.A. [14] also mentioned in his research that main task of the facilitator is to bring as many ideas and opinions varying with the time provided.

III. RESEARCH METHODOLOGY

The study has three phases, Comparative Study, Analytical Hierrarchie Process (AHP), and Focus Group on Discussion (FGD). The flow chart of this study as follows:

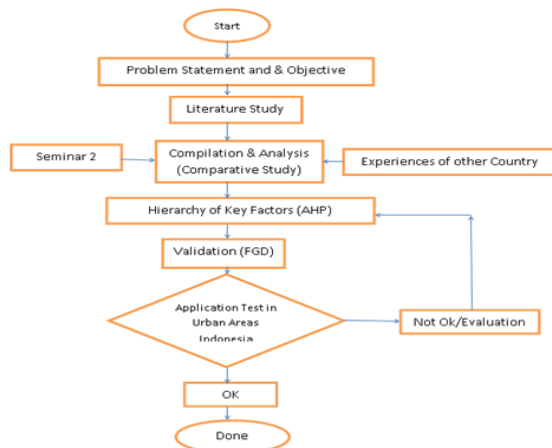


Figure 1 Flow-chart of research

A comparative study was conducted on 20 selected cities in the world that have already implemented Rail-based mass transit. This comparative study aims to look at the extent to which the role of the key factors that have been discussed previously. The results of a comparative study of most cities can be seen as table 4 below (10 cities).

Table 4 Comparison Result

NO	CITY	INHABITANT (million)	CITY FUNCTION	LANDUSE	INTEGRATION	TECHNOLOGY (Modul)	FISCAL (ECONOMY)	POLICY	INFRASTRUCTURE
1	AMSTERDAM	1.317	Business, culture	compact	good	Metro, Tram, bus	US 46.440/cp	Good, TOD	Good
2	DENHAAG	0.510	Government, culture, urban	compact	good	LRT, tram, bus	US 32.249/cp	TOD, redeve	good, route via activity centre
3	UTRECHT	0.330	Business, art, education	compact	good	Metro, Tram, bus	no	Station open 24 hrs	Good, halte in every road
4	PARIS	2.241	Government, culture, business, tourism	Old city and sub urban	good	Metro, Tram, bus	US 46.800/cp	PhR, Traffic restriction	Good, provide all around city
5	PRAHA	1.259	Government, culture, urban	Old n New City	good	Metro, tram	US 43.384/cp	good, facility for disable	Good, 213 inhabitant used PT
6	FREIBURG	0.220	Art n tourism	Old city, farming	good	Tram and bus	US 33.353/cp	good, priority for PT	Good, provide all around city area
7	ZURICH	0.440	Business, culture	compact, development around city	good	Tram and bus	no	Good, priority for public transport	Good, provide all around city
8	BEIJING	18.59	Government, business, urban	Old n New City	good	Metro and BRT	US 16.150/cp	Good, PhR	Good, provide all around city
9	HONGKONG	7.2	Government, business	Compact	good	Metro, LRT, tram	US 42.437/cp	Good, TOD	Good, priority for public transport
10	SINGAPORE	5.389	Government, business	Compact, city area	good	MRT, LRT, BRT	US 56.193/cp	Good, TOD	Good, about 10 minute to halte

Source: Data processed

Tabel.4 above shows that these towns have a strong economy and its integrated intermodal. Freiburg and Zurich with a population under 1 million, and even become a pilot city for rail-based mass public transport which pursuing a policy of prioritizing public transport, for example, always green for public transport in the intersection, the route through residential areas and activity centres, which is able giving a direct impact on the increasing of public transport passengers and significantly reduce private vehicle ownership [14]. Other transport policy-making is the park n ride facility in the transit area that is useful to provide the

ease of shifting to public transport or vice versa. Integration among modes becomes an important factor, since it determines the total travel time and ensure a trip door to door. People will shift to public transport if shorter lead times and lower costs than if using a private vehicle.

Furthermore, the key factors that have been obtained are analysed and determined in term of sequence using Analytical Hierarchy Process (AHP). Respondents involved are experts, academics, practitioners, bureaucrats, consultants and all those involved in the area of transport, particularly railways. Furthermore, the results are validated by a discussion on the Focus Group on Discussion (FGD) in the Jakarta City Transportation Council (DTKJ) and the City Development Planning Board (Bappeko) Surabaya. Table 5. Shows initial research of key factors hierarchy based on AHP.

Tabel.5 Key Factors Hierarchy

Criterion	Comment	Weights	Rk
1.City Size	Depends on number inhabitant, bigger more important	8.0%	8
2.City Function	Business, education, tourism	8.3%	7
3.Landuse	Compact, sprawl, satellite	11.8%	4
4.Cost & time	Ticket and Travel time	10.2%	5
5.Public Tranport	Integration with existing public transport	11.8%	3
6.Technology	HRT, LRT, monorel	4.2%	9
7.Fiscal/economy	The ability of regional economy and society	21.6%	1
8.Policy	Transport policy, including park n ride	14.2%	2
9.Infrastructure	Transportation infrastructure	10.0%	6

Source: AHP processed

1. Rank 1: Fiscal (the ability of regional economy and society) 21.6%

The ability of the regional economy is necessary financial ability to hold due to transportation infrastructure-based railways require expensive start-up costs. As an illustration, the results of the feasibility study for development of mass rapid transit in Surabaya for the track and monorail infrastructure (elevated) will cost about Rp. 360 billion per km and tram (at grade) Rp 60 billion per km [15], while the economic ability associated with the ability (ATP) and willingness (WTP) to pay for services (tariffs). The difference between the cost of operating public transportation vehicles and the ability to pay is a burden on the government (subsidies).

2. Rank 2: Transport Policy 14.2%

Transport policy suggested in this regard is as a rule to prioritize public transport in the intersection, develop Park n Ride and etc [16][17].

3. Rank 3: Integration with Existing Public Transport 11,8%

At locations that were not covered transport route, feeder transport needed to carry passengers to the rail-based mass transit . Integration among modes is required in order to ensure underserved passenger door to door. For example, the Dhaka government managed to increase the number of public transport passengers for better integration between modes [18].

4. Rank 4: Land Used 11,8%

Land use is strongly associated with transport. Land use with uncontrolled urban sprawl (sprawl) is very harmful for the transport especially the provision of infrastructure. Otherwise a solid (compact) city with various activities (mixed land use) is very favourable on transportation. Some cities in Europe rebuilt (re-development) with reference to the transport-oriented development (TOD) [19].

5. Rank 5: Cost (tariff) and Travel Time 10,2%

One of the main attraction of people to shift to public transport is cheaper costs and a faster travel time than if using a private vehicle. Here is strongly associated with factors no.1, 2 and 3 [20].

6. Rank 6: Infrastructure 10%

Infrastructure is one of the main factors in modal choice. Logically, if transportation infrastructure is well established in terms of its network covers all or most urban areas, the mass transit movement could serve citizens well. Thus, it will facilitate the mobility of citizens and, in turn, would leave private vehicles to switch to public transport [21].

7. Rank 7: City Purpose/ Functions (Business, Tourism, Study) 8,3%

The function of a city is also one of the key factor that determine modal choice of Rail-based mass transit. Demand for transportation in a city-based business will be much different from the city of students or pensioners.

8. City Size (small, medium, large, metropolitan) 8%

The more the population of a city, the greater the need for transport, so that in cities with populations of more than 1 million people are advised to have a mass transit [5].

9. Technology Used 4,2 %

Technology used is in term of type of technology used in a city such as monorail, tram, LRT ? Elevated, at grade or underground? Related to the cost and field condition.

IV. RESULT ANALYSIS

From the three stages on research implementation and analysis it was found that a comparative study in selected cities in the world shows that the factors obtained from literature and seminars as well as the field observation data (first stage) gives the fact that these factors are relevant and play an important role in determining choice of Rail-based mass transit . Furthermore, early finding of study (second stage) obtained by the implementation of AHP method successfully indicate the hierarchy of key factors which start with high rank on the ability of regional economy and society, transport policy, integration with existing public transport, land use, cost/fare include travel time, infrastructure, city functions, city size/number of people, and technology used respectively.

The third stage shows with FGD activities in DTKJ approve the hierarchy mentioned and factors identified, further revealed that the integration between modes in Jakarta until now still not going well. Continuously, in its report DTKJ add one more factor namely cultural factors which complements into ten major factors. Cultural factors such as discipline, order, obey traffic rules will define rail-based urban mass transit goes according to plan. Likewise, the discussion results in Bappeko Surabaya, it was revealed that the Mass Rapid Transport in Surabaya integration with existing public transport still an issue, and are still trying to find a resolution. Integration can be in the network, modes, schedules, rates and facilities. In addition, the FGD results indicate that the key factors determinant choice of Rail-based mass transit can be grouped into three, namely the significant factor, relevant factor and less relevant factor. The significant factors are the ability of the regional economy capability, transport policy and integration with existing public transportation. Whereas the relevant factors are land use, cost/tariffs and travel time and infrastructure. The last one is factors that are less relevant such as city functions, technology used and culture such as driving attitude and obey to traffic regulation, etc.

V. CONCLUSION AND ECOMMENDATION

5.1 Conclusion

To build a Rail-based mass transit is depend on key factors and city size factor or total population alone is not enough, there are other key factors that need to be considered accordingly. The hierarchy of key factors that significant enough to be considered are first six key factors which strongly relevant in development of rail-based public transportation such as the ability of regional economy and society, transport policy, the integration between mode, land use, and tariff as well as travel time and infrastructure.

5.2 Recommendation

The key factors as discussed above need further study to determine the choice of rail-based mass public transport more precise and accurate. On the other hand, result finding in this study can be applied to the selected cities to address the challenges of developing rail-based mass transit.

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