

Operational Analysis of BRT Trans Jateng

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Abstract. The existence of BRT Trans Jateng corridor I Semarang Area gets 98% interest and supportive response for the development of public transport based on BRT by Priyatno in [16]. The Society's response who support and interest in the development of BRT indicated that the application of BRT Trans Jateng Especially corridor I Semarang Area quite successful. Based on that information, an Analysis operation of BRT Trans Jateng was conducted to know about the parameter which influences the operation of BRT Trans Jateng. Two methods are being used, they are Data Envelopment Analysis and Analysis of Association. The result of the Data Envelopment Analysis shows that Covid 19 influences the operation of BRT Trans Jateng. There is a decreasing efficiency of BRT Trans Jateng around 51.3% from the two routes that are being tested. Further, the analysis association of operational of BRT Trans Jateng gives a result that the parameter which influences the total passenger of BRT Trans Jateng is a population that has a positive correlation. Every 1% increase in population will influence a 0.491% increase in the number of total passengers. The other parameter such as mileage, fleet, bus stop, number of employees, and traveling time has a positive correlation to the number of passengers although it is not significant while citation have a negative correlation.

Keywords: *brt Trans Jateng, Data Envelopment Analysis, Analysis Association, Operational.*

1 Introduction

Central Java Province is one of Indonesia's provinces that applied a Bus Rapid Transit (BRT) as one of their policy to provide intercity public transport. Bus Rapid Transit (BRT) of Central Java Province which is known as BRT Trans Jateng applied BRT Agglomeration which connected one region to other regions at affordable rates. Bus Rapid Transit is one alternate choice of public transport which promising, sustainable and could provide good accessibility and affordable rates from one region to another region compared to rail-based transit such as light rapid transit (LRT) and commuter train (United States Government Accountability by Nelson, etc, in [13]. Bus Rapid Transit (BRT) plays a role in a development region, especially for the road that is passed and also gives an

agglomeration effect for the surrounding area and could promote a city reconciliation of design, increasing the value of land and environmental improvement by Cui, etc, in [6]. Hossain in [12] also said that BRT is a choice for public transport which have the potential to be applied in developing cities that have limited funds.

In 2017, Balai Transportation of Central Jawa towards UPT from the Department of Transportation announced an official BRT Trans Jateng Corridor I with a route from Tawang Station (Semarang) to Terminal Bawen (Bawen) with the expectation it could help the public, especially student and labor to get access to public transport which safe, comfortable and affordable. The existence of BRT Trans Jateng corridor I Semarang Area gets 98% interest and supportive response for the development of public transport based on BRT (Priyatno (2018)). The Society's response who support and interest in the development of BRT indicated that the application of BRT Trans Jateng Especially corridor I Semarang Area quite successful. That public response also gets some evidence from the load factor of BRT Trans Jateng Corridor I Tawang Station-Terminal Bawen which reach 97% in 2019. That two conditions are an indication that the application of BRT Trans Jateng has been a success and got a positive response, especially from the public in Central Java Province. Based on that, this research does an analysis of the operational application of BRT Trans Jateng to analyze a factor that could support an application of BRT Trans Jateng.

2 Literature Review

2.1 Efficiency and Effectiveness

The definition of efficiency and effectivity based on Potocan in [15] was based on previous research and it differs in two groups. A first group is a group that uses an approach and a meaning to separate efficiency and effectivity. The separation is based on a difference in criteria among them such as an approach to investigating an aspect and the scope of the study. Based on this group, efficiency is a concept of organization which is focusing on the internal organization. Further, efficiency is a relation of quantity from the input used (need) to get an output. Meanwhile, the effectivity is a comprehensive study about an operational organization that is based on an understanding of the definition and goals of an organization and also a strategy of the organization in the operational process. Effectivity is an action of a process to achieve goals in the research area. For these cases, the research focuses on the operational (habit) of an organization (in whole or a part) in a way to achieve a goal or hope from the organization by Potocan in [15].

For the second group, Potocan in [15] said that efficiency and effectivity are understood as synergic research in the whole or part of the organization. Efficiency and effectiveness are analyses as a process of investigation of an organization which differs by an aspect that being research. Efficiency and effectivity joined in content with connected based on synergy and the dependency from an operational and behavior of the organization. The fundamental things that are based on this theory are efficiency and effectivity is a unity method that is being used in the research.

Farel in [8] in his research about “The Measurement of Productive Efficiency” also mentions about efficiency on the part of a firm is a successful process to produce a maximal product with a given input. Efficiency is the process to produce a product in constant return to scale conditions. Further, Farel in [8] explains that to calculate an efficiency we need to define the assumption that would be used to determine the production function of efficiency. In other words, there is a comparison between the performance of a firm toward an ideal standard from an efficiency which is considered the best one. Depending on that, the process to define a production function of efficiency need to be done before calculating a significance of the measuring an efficiency.

A Discussion of efficiency in public transport according to Daraio, etc., [7] is more focused on the result of efficiencies such as a direct impact of the implementation of public transport (the increasing efficiency and quality that is offered by public transport) and external impact such the decreasing of pollutant and congestion also increase the need of a worker in the city center. Further, Daraio, etc., [7] declare that efficiency analysis in the implementation of public transport not only focuses on the number of the passenger but also on the impact on intervention from the transportation system which influences an environmental footprints, land cover use, accessibility, and also the objective of the region. This analysis would be a deliberation for implementing a new policy as an impact from efficiency analysis which occurs such as developing new infrastructure.

2.2 Data Envelopment Analysis

Data Envelopment Analysis is a mathematical approach that is being used to evaluate performance from a group of an entity known as Decision Making Unit (DMUs) by converting a multiple-input to be a multiple outputs Cooper, etc, in [5]. Data Envelopment Analysis is introduced by Charnes, Cooper, and Rhodes in 1978 as a mathematical model which provides new ways to estimate an empiric relation from a production function that is part of the modern economy. The analysis process to determine an efficiency from DMU using a Data Envelopment Analysis does not need any assumption for formulation and variation for a model

such as being needed in linear regression or nonlinear regression. It would be helpful to analyze the process without depending on any formulation. An Efficiency result from every analysis in Data Envelopment Analysis is an Efficiency which based on two things i.e (a) a DMU defined as maximally efficient (100 %) if only there is no input or output which could be added without decrease or increase in input and/or output, (b) a DMU defined as maximally efficient (100%) if only performance from another DMU didn't show any increasing value without any decreasing an input or output (Cooper, etc., in [5].

Georgios, etc., in [10] used Data Envelopment Analysis (DEA) to evaluate the performance of a route bus in the public transport system in Thessaloniki. In that research, DEA used to provide tools used to find the most efficient route and the not efficient one and also a relation in the condition that the goals of performance do not meet the standard value which needs some improvement. Further, Georgios, etc., in [10] discuss an initial definition of relative efficiency from DMUs which is determined from a basic calculation of Data Envelopment Analysis which forms an equation for a linear combination that connected a group number of observations from a group of a sample. An explanation for relative efficiency, Georgios, etc., in [10] give a sample if we have $j = 1, 2, \dots, n$ which DMUs with m input ($X1j, X2j, \dots, Xmj$) and s output ($Y1j, Y2j, \dots, Xsj$) then the value of efficiency from each DMU k (K is a value from $1, 2, \dots, n$) could be calculated with this equation.

$$Max \theta = \frac{\sum_{r=1}^s U_r Y_{rk}}{\sum_{i=1}^m v_i Y_{ik}} = 1 \quad (1)$$

$$subject \ to \ \frac{\sum_{r=1}^s U_r Y_{rk}}{\sum_{i=1}^m v_i Y_{ik}} \leq 1 (j=1, \dots, n) \quad (2)$$

$$u_1, u_2, \dots, u_s \geq 0 \quad (3)$$

$$v_1, v_2, \dots, v_m \geq 0 \quad (4)$$

Based on the equation above, DMU which has a maximal efficiency is a DMU with θ value is near 1.

Another Research is done by Hirschhausen in [11] using an approach CRS and VRS from Data Envelopment Analysis to analyze the efficiency of public transport in Germany. In that research, the analysis done with input is a vehicle and worker while the output is a passenger/km. At the end of that research, there is a further analysis that uses a bootstrapping mechanism as a process to test the result of the Data Envelopment Analysis.

Data Envelopment Analysis is also being used by Pina in [14] for research in comparing the efficiency of the public and private sectors to provide public transport in Spain. In his research, Pina in [14] uses Data Envelopment Analysis which collaborates with logit regression and cluster analysis. Logit regression and cluster analysis are used to could give a justification for the compatibility of a result, data, and process. Depending on the research done by Pina in [14], know that km/vehicle, price/pesangger, and fuel/100km are a parameter that influence Efficiency.

In this research, the model which is used to be a reference for analysis is the model Data Envelopment Analysis from Fitzova, etc., in [9] in her research about “Determinants of urban public transport efficiency: a case study of Czech Republic” which use a Data Envelopment Analysis for identified a factor which influences an efficiency from a public transport system in Republic Czech. The method used for analysis in Fitzova, etc., in [9] research is a Data Envelopment Analysis and Tobit Regression. Data Envelopment Analysis in the early step is used to identify an efficiency value from DMU while Tobit Regression is used to find a relation between an efficiency value and every parameter. There is 4 step that is done in Fitzova, etc., in [9] research which is (a) determine a DMU, determine an input and output variable, (c) determine a model and calculate a DEA Score, and (d) descriptive analysis for the result of efficiency.

3. Method

The analysis method that is being used in this research is Data Envelopment Analysis and Association Analysis. In the first stage of analysis, there is Data Envelopment Analysis to find an efficiency value from each DMU. In the second stage, there is Association Analysis to find a relation between a variable independent and variable dependent in each DMU. Detailed discussion about Data Envelopment Analysis and Association Analysis is contained in the following discussion.

3.1 Data Envelopment Analysis Method

In Data Envelopment Analysis, there is a process of comparing every Decision-Making Unit (DMU) to a determined benchmark by Santos [17]. Data Envelopment Analysis has 2 (two) kinds of approaches to analyze the DMU to reach maximal efficiency. The two kinds of approaches are to increase the output until reaches MO (maximization of output) and decrease the input until reaches MI (minimization of input) which is known as variable return to scale (VRS) and constant return to scale (CRS). Data Envelopment Analysis is an analysis model which is used to find a parameter that directly affects the efficiency from implementing BRT Trans Jateng.

Data Envelopment Analysis was introduced by Charnes in [3] in their research about “Measuring the efficiency of decision-making units”. The goal of the research by Charnes in [3] is to develop a method that can be used to measure efficiency from every choice based on the special reference which can be used to evaluate a “public program”. Further, the “public program” in the research which done based on decision-making units (DMUs) which have input and output values known by Charnes in [3] as Data Envelopment Analysis (DNA) Constanta return to scale (CRS). Efficiency in Data Envelopment Analysis is a total value of output / total value of the input. The mathematical equation form of the CRS Data Envelopment Analysis Model which was developpt by Charnes in [3] with input-oriented is,

$$\min \theta - \varepsilon (\sum_{i=1}^m S_i^- + \sum_{r=1}^s S_r^+) \quad (5)$$

$$\sum_{j=1}^n X_{ij} \lambda_j + S_i^- = \theta X_{i0} \quad (6)$$

$$\sum_{j=1}^n Y_{rj} \lambda_j - S_r^+ = Y_{r0} \quad (7)$$

With value $\lambda_j \geq 0$, $S_i^- \geq 0$, $S_r^+ \geq 0$; $\theta \geq 0$, $\varepsilon \geq 0$; $i = 1, 2, \dots, m$; $r = 1, 2, \dots, s$; $j = 1, 2, \dots, n$. When θ is efficiency, S_i^- is a slack variable based on input; S_r^+ is a residual variable based on output; λ_j is a coefficient index from input and output. While equation form of the CRS Data Envelopment Analysis Model with output-oriented is,

$$\max \phi + \varepsilon (\sum_{i=1}^m S_i^- + \sum_{r=1}^s S_r^+) \quad (8)$$

$$\sum_{j=1}^n X_{ij} \lambda_j + S_i^- = X_{i0} \quad (9)$$

$$\sum_{j=1}^n Y_{rj} \lambda_j - S_r^+ = \phi Y_{r0} \quad (10)$$

With value $\lambda_j \geq 0$, $S_i^- \geq 0$, $S_r^+ \geq 0$; $\theta \geq 0$, $\varepsilon \geq 0$; $i = 1, 2, \dots, m$; $r = 1, 2, \dots, s$; $j = 1, 2, \dots, n$. When θ is efficiency, S_i^- is a slack variable based on input; S_r^+ is a residual variable based on output; λ_j is an coefficient index from input and output.

In 1984, Banker, Charnes, & Cooper do further research about a modification from the method of DEA CCR. In that research, Banker, etc., in [2] use a segregation variable that could be identified as an operational process that could produce an increase, keep or decrease in multiple input and multiple output situations. The result from the calculation is not only a single output, but also a modern version of economics. Further, Banker, etc., in [2] provides a model to estimate technically and scale efficiency from decision-making units (DMUs) based on reference from an efficiency value of production frontier. The

fundamental difference between DEA CCR model and DEA BCC model is a constraint in BBC model which always get a 1 value or in mathematically $\sum \lambda_j = 1$.

The Data Envelopment Analysis model which would be used in this research to analyze the efficiency of BRT Trans Jateng is DEA model developed by Charnes, Cooper, and Rhodes (CCR) with constant return to scale. This model was used by Fitzova etc, in their research in 2018 that has been discussed in theory.

3.2 Association Analysis Method

Association Analysis which would be used in this research is an association analysis with multiple linear regression techniques. This technique is being used to compose a relation equation of a variable using interval data or ratio data which have more than one predictor (variable independent) by Angelia in [1]. The process of association analysis in this research with multiple linear regression technique was using Predictive Analytics Software (PASW) from IBM SPSS.

4. Discussion

4.1 Result of Data Envelopment Analysis

The Data Envelopment Analysis process in this research is done by comparing the performance of existing operators (bus consortium companies) from the various route in BRT Trans Jateng. That various route in BRT Trans Jateng is a Data Measurement Units (DMUs) of the research. In this stage, applied an assumption was used to find an implementation of BRT Trans Jateng which was based on the influence of external factors such as a Covid 19 and a year of implementation BRT Trans Jateng.

In the first process of Data Envelopment Analysis of implementation of BRT Trans Jateng, a few assumption and limitation is being used. This assumption and limitation were caused by a limitation in data from Central Java Transportation Service. Based on that, the assumption and limitation that are being used in this analysis is,

- a) Parameter which being tested in this research is a result of the parameter from a deduction process from previous research. Further, the parameter is being conducted by an adjustment with data from Central Java Transportation Service.
- b) Data measurement unit (DMUs) being used in this process is a route of BRT Trans Jateng. Each route of BRT Trans Jateng has a different

operator which is customized based on a consortium of existing operators.

- c) There is a variation in the process analysis, in the first variation, there's an assumption that covid 19 does not affect the number of total passengers who use BRT Trans Jateng. Depending on that assumption, the analysis process is done with current year data.
- d) In the second variation, there is an assumption that covid 19 affects the number of total passengers who use BRT Trans Jateng. Depending on that assumption, the analysis process is divided into two cases which use data from DMUs before Covid 19 and also data from DMUs after Covid 19.
- e) In the third variation, there is an assumption that the year of implementation of BRT Trans Jateng affects the number of total passengers. Depending on that assumption, the analysis process is divided into two cases which use data from DMUs in the first year of implementation and data from DMUs in the second year of implementation.
- f) The whole process of Data Envelopment Analysis in this research uses a method of DEA CRS (Constanta return to scale) model developed by Charnes, Cooper, and Rhodes (1978).

variable output for the parameter used in this research. The parameter of a variable input is bus stop, mileage, ritation, traveling time, number of employees, vehicle operating process, and population. While the parameter of variable output is load factor and number of passengers. A detail of the parameter used in this research could be found in the attachment.

In the first variation, the analysis process uses an assumption that covid 19 does not affect the number of total passengers who uses BRT Trans Jateng. Depending on that assumption, the value of a parameter in the analysis process that is used is a value from the current year which is 2020 for 5 (five) existing routes BRT Trans Jateng. That 5 existing router of BRT Trans Jateng is route of Semarang-Bawen, route of Purwokerto-Purbalingga, route of Semarang-Kendal, route of Purworejo-Magelang, and route of Surakarta-Sragen. The result of the analysis process from the first assumption shows that route of Surakarta-Sragen has an efficiency value that is lower than 4 other routes with a value of efficiency is 53,28 %. That lower value of efficiency from route Surakarta-Sragen could be because that route was recently operated in 2020 when Covid 10 occurs. But in this analysis process couldn't be concluded if the covid 19 affect the implementation of BRT Trans Jateng or not.

In the second variation, the analysis process uses an assumption that covid 19 affects the number of total passengers who use BRT Trans Jateng. Depending on that assumption, the data that is used in this analysis process is data from a route that has been operated before covid 19 occurs such as Semarang-Bawen route and Purwokerto-Purbalingga route. DMUs for this analysis process are Semarang-Bawen route Pracovid-19, Purwokerto-Purbalingga route Pracovid-19, Semarang-Bawen route Postcovid-19, and Semarang Bawen route Postcovid-19. The result of the analysis process shows that the route from Postcovid-19 has a lower efficiency than a route from Precovid-19. Depending on that, could be concluded that Covid 19 affects the implementation of BRT Trans Jateng. The decrease in efficiency of BRT Trans Jateng route which occurs in Semarang-Bawen route is 51,12% which is a decrease from 100% to 49.88%. While the decrease of efficiency of BRT Trans Jateng which occurs in Purworejo-Purbalingga route is 46.78% which is a decrease from 100% to 53.22%.

In third variation analysis process use an assumption that the year of implementation of BRT Trans Jateng affects the number of total passengers. Depending on that assumption, the route that is used in this analysis is the route that has been operated for a minimum of two years such as Semarang-Bawen route and Purwokerto-Purbalingga route. DMUs for this analysis process are Semarang-Bawen route in the first year of implementation, Purwokerto-Purbalingga route in the first year of implementation, Semarang-Bawen route in the second year of implementation, and Purwokerto-Purbalingga route in the second year of implementation. The result from the analysis shows that an efficiency value for Semarang-Bawen route for both years of implementation has the same efficiency which is 100%. This result also occurs for Purwokerto-Purbalingga route for both years of implementation that has the same efficiency which is 100%. The result of efficiency value that didn't show the difference for both years for Semarang-Bawen route and also Purwokerto-Purbalingga route indicates that the year of implementation for BRT Trans Jateng did not affect the implementation of BRT Trans Jateng.

4.2 Result of Associate Analysis

The process of associate analysis in this research is used to compare the relationship between an independent variable and a dependent variable which affect the implementation of BRT Trans Jateng. The Parameter which becomes a dependent variable in this process of associate analysis is the number of total passengers. While the parameter which becomes an independent variable in this process of associate analysis is mileage, traveling time, rotation, bus stop, fleet, number of employees, and population. The initial hypothesis from this analysis

process is several passengers as a dependent variable are affected positively by mileage, traveling time, ritation, bus stop, fleet, several employees, and population as an independent variable. The result of this associate analysis is to test a relation between variable dependent toward variable independent.

The process of Variables Entered/Removed(a) shows that the chosen parameter that affected the number of passengers is a population. In the next step, there is the process to formulate an equation of variable independent (population) toward variable dependent (number of a passenger). The formulation process in this analysis depends on the B value from a table of coefficients. The equation that has been formulate by that value is,

$$Y = a + b X_1 + b X_2 + \dots + e$$

$$Y = -457253.870 + 0.491 X$$

with X being the population while Y is the number of passengers. From that equation, the population affects the number of a passenger with a positive trend. The increasing of the population would affect an increasing number of passengers i.e if there is an increasing number with 1 % amount of population, it would affect an increasing number of passenger with 0.491%.

In the final process of association analysis, there is a recalculation of parameters which not chosen in the process of variables entered/removed(a). Recalculation is a process to calculate an independent variable that has the most possibility to relate to a dependent variable. The process of determining a relationship between the parameter of the independent variable toward the dependent variable based in this research is based on t value from the table excluded variables. The result from that table is that the parameter mileage, traveling time, fleet, number of employees, and bus stop have a positive impact on the number of passengers. While a ritation have a negative impact to the number of passenger.

5. Conclusion

An identification process that affects the implementation of BRT Trans Jateng in this research could be divided into two parts of identification. The first one is an identification process for a parameter that comes from an external system BRT Trans Jateng. The second one is an identification process for a parameter that comes from an internal system of BRT Trans Jateng. The conclusion that could be reached from the discussion is,

- The results of Data Envelopment Analysis in this research show that Covid 19 affects the implementation of BRT Trans Jateng. This is based on the average decrease of the efficiency value of the two routes that are being tested with the average decrease is about 51.3%.
- The results of the Associate Analysis in this research show that the parameter which mostly affects the implementation of BRT Trans Jateng is the population. The effect of the population on the number of passengers is in positive relation with results that every increasing 1% in population would affect an increase in the number of passengers by 0.491%. Besides population, other parameters have a positive relationship with the number of passengers, they are mileage, traveling time, fleet, the number of employees, and bus stop. While a variation have a negative impact to the number of passengers. The positive relation shows that every an increasing of a parameter value in the independent variable would affect the number of passengers although it is not significant.

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