A MULTIDIMENSIONAL APPROACH FOR EVALUATING BUS SERVICE

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Abstract: Evaluating urban public transport system, especially bus system, comes up as a crucial activity in Jakarta since the local government currently imposes various performance measurements to urban transport systems for efficiency and effectiveness. On one hand the service capacity of city bus service has been declining due to the continuing economic crisis for highly tremendous maintenance cost. On the other hand the policy of local government has been shifted to encourage more use of public transport as to reduce urban traffic congestion, and inviting more roles of private sector for the undertakings. To such extent, scrutinized evaluation on bus service is required to identify critical service components for further investment. In this work a multidimensional approach to evaluate such service is developed wherein the canonical correlation analysis (CCA) is proposed as a tool. Data from main city bus operators in Jakarta is extracted and analyzed to indicate the main service indicators. This approach is further expected to provide sound tool for private sectors in evaluating prominent service indicators to justify their participation and investments in the urban public transport service.

1. INTRODUCTION

Jakarta as capitol city has a long history of urbanization, and this situation keeps on while the country has been experiencing an economic crisis that makes most socio-economic activities stagnant if not declining. Other problem of urban transport in Jakarta city is the limited space availability through which the transport infrastructures to be continuously developed. Air and noise pollutions, although are not yet considered as critical counter-measure has made the urban environment worse off. As an illustration, in 1998 it was identified that no less than 16 million person trips per day were recorded. Their mobility would then split as 50.8% using their private vehicles including motorcycles and 49.2% using public transport with majority of urban bus mode.

These worsening situations in the city has made Jakarta local government impose different paradigm to solve urban transport problem from which the transport demand management is aptly adopted. Basically within such approach physical development on infrastructure would be strictly limited, and instead the more utilization of existing facilities would be encouraged. In consequence role of bus system as major urban transport service is to be enhanced to cope with existing demand as well as potentially shift passenger car users.

In spite of worsening condition of declining urban public transport system evaluation criteria are hard to define. Literature review has shown that evaluation studies which focus on transit system vary in scope, emphasis and methodology. Some studies emphasized financial and economic indicators (Heathington and Graeub, 1975; Lee, 1976), efficiency and effectiveness

(Fielding, et.al., 1978), and equity and impacts (Fielding and Lyons, 1981; Savas, 1978). Other investigated the effects of environmental factors (Guiliano, 1980) and government policies (Pucher, et.al., 1983). Recently, a group of studies has tried to determine the impacts of service area characteristics on transit performance (Cervero, 1990; Yu, 1990).

Route level performance evaluation studies have focused on two broad approaches: a) service standards related to design and operations, and b) economic and financial measures. Despite the advancement of research in the development of performance indicators for evaluating transit services in 1970's and 1980's, problems in their applications still prevail. Further indication can be made in the literature that three broad limitation of current research in public transport or transit service evaluation remain.

The first limitation pertains to the conceptualization of service performance. Research studies have tended to see service performance in terms of dichotomous classifications such as best-performing routes versus worst-performing routes or good routes versus bad routes. While these labels may be appropriate in one set of circumstances, such as assisting transit managers to implement simple improvement packages, forecasting service impacts and satisfying equity and disabilities' requirements. Thus, an expanded conceptualization of the notion of service performance is needed.

The second limitation pertains to public transport systems' almost exclusive use of performance standards. While service standards seem to be the only logical measure of performance levels, there are a number of problems associated with their development and application. These include lack of clear achievable service objectives from which performance standards ca be derived, inconsistent measurement and application of standards by different public transport system, lack of timely and proper review of standards and the almost exclusion of exogenous measures, such as network structure, area density patterns and service area characteristics. Other problems include cost and quality of data collection and processing, budgetary and financial constraints and political pressure exerted on the 'rational' application of standards.

The third limitation is of a methodological nature and relates to the approach used to specify and test relationships between service evaluation characteristics and service performance. Previous research has treated service evaluation and its performance components as if they were unidimensional. Analysis of their interrelationships has been done using longitudinal methods such as means, time series, and regression analysis, peer comparisons, performance rating or ranking based on established standards, and portfolio technique.

To overcome the foregoing limitations, this study aims to redirect service evaluation research by addressing evaluation process and performance outcome as two different dimensions. The primary purpose of this study was to examine conceptual and methodological bases of service evaluation by developing and testing, as case of Jakarta Urban Bus System, a multi dimensional framework that looks comprehensively at somewhat wider span of evaluation including the context, process and outcome of the evaluation. After discussing the concept and necessary criteria for public transport service performance, it describes the choice of multi dimensional analysis, surveyed data, analyses and results.

2. NECESSARY CRITERIA FOR BUS SERVICE

To measure the service performance of urban bus service is a big task since it involves various perspective dimensions of criteria. This research would deliberately look at two perspective dimensions of such criteria, namely evaluation process and service performance. The first dimension would certainly focus on use of data evaluation to increase effectiveness of service performance. The second dimension would focus on specific performance level related to efficiency, effectiveness, and approach to performance prediction. Furthermore, first dimension may have to comprise various criteria such as planning and design, operational, and service area. While second dimension may comprise object performance fulfillment, use of evaluation data, and improvement of agency capacity and public image. In brief Figure 1 illustrates the relation of the two dimensions.

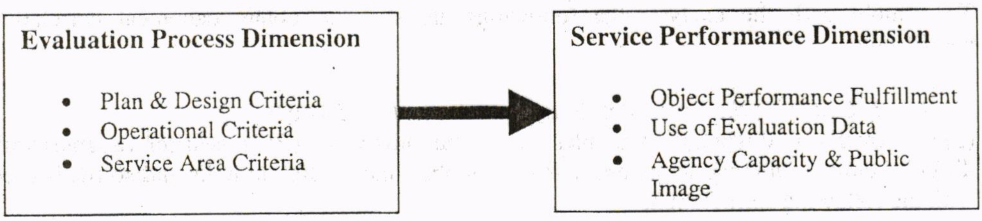

Figure 1. General Concept of Multidimensional Service Analysis

For each the dimension within the scope of evaluation would further consist of criteria used as indicators. In this multidimensional analysis the service performance evaluation dimension is supposed to have: a) Planning & Design Standard Criteria (e.g., route length, passenger travel time savings, spacing between stops, area coverage, route duplication), b) Operational Standard Criteria (e.g., available fleet during peak hours, vehicle ratio at peak hours, vehicle revenue per trip kilometer, vehicle revenue per operating hour, driver's skill improvement) and, c) area coverage criteria (e.g., population density, minority population, medium to low income households, car ownership).

As for service performance dimension it covers: a) Object Performance Fulfillment (e.g., vehicle hour revenue per operating cost, total number of passengers per vehicle hour, operating revenue per operating cost, total vehicle hours per operator, total of vehicle kilometer per peak hour), b) Use of Evaluation Data (e.g., number of data collected, capability of top management to convey vision/mission/target to staff, sound communication with customers, minimum political pressure) and, c) Agency Capacity & Public Image (e.g., periodic route evaluation, customer satisfaction, service standard achieved).

This hump of criteria is quite general and has practical implications. It is, however, worth noting that data on such information for the Jakarta City Bus System may hardly be found in practice. So in this research, as would be explored in the ensuing section, only some of them are affordable and explored further within the multidimensional analysis.

3. CANONICAL CORRELATION ANALYSIS FOR BUS SERVICE

Given the task of examining the interrelationships between a set of service evaluation dimensions and a set of service performance dimensions a proper method of multi dimensional analysis is required. Canonical correlation analysis (CCA) is chosen as the most appropriate, because CCA lends itself well to a multi dimensional approach to observing a complex phenomenon (expressed as a set of variables) via its relation to other phenomena (expressed as individual variables). Thus the CCA would allow the complex phenomenon involving the technical and social processes of service evaluation to be addressed.

To summarize, the CCA was chosen over other approaches for three basic reasons: a) it can specify, test and explain relationships in one data set as well as between two data sets, b) it captures the interactive effects of the dimensions through canonical structure (loading and cross-loading) and redundancy analysis and c) it is most suited and empirically accepted method for analyzing multi dimensional evaluation problems (Ramanujam and Venkatraman, 1987; Yu, 1990).

To comply with the analysis the followings are steps to obtain canonical correlation coefficients;

- *Step 1. Construct the Covariant (S) or Correlation (R) Matrices.*

(S) is normally used when the variables have same units while (R) is used for variables with different units. In this particular analysis the variables have different units and so (R) is used with the following formulation;

$$R = \begin{bmatrix} R_{xx} & R_{xy} \\ R_{yx} & R_{yy} \end{bmatrix} \qquad \text{(1)}$$

, and in accordance with the variables analyzed each component would have the following dimension;

$$R_{xx} = 8 \times 8$$
$$R_{xy} = 6 \times 8$$
$$R_{yx} = 8 \times 6$$
$$R_{yy} = 8 \times 8$$

Each matrix can further be determined as following;

$$R_{xy} = \frac{\lambda \Sigma XY - \Sigma X \Sigma Y}{\sqrt{\lambda \Sigma X^2 - (\Sigma X)^2}\sqrt{\lambda \Sigma Y^2 - (\Sigma Y)^2}} \qquad \text{(2)}$$

- *Step 2. Search the Eugen Value (λ).*

Eugen values are to be determined since they become the canonical coefficients (canonical weights). Such eugen values can easily be derived from the followings;

$$\left| R_{xx}^{-1} R_{xy} R_{yy}^{-1} R_{yx} - \lambda^2 I \right| = 0 \qquad \text{(3)}$$

$$(R_{xx}^{-1} R_{xy} R_{yy}^{-1} R_{yx} - \lambda^2 I)a = 0 \qquad \text{(4)}$$

$$(R_{xx}^{-1}R_{xy}R_{yy}^{-1}R_{yx} - \lambda^2 I)b = 0 \qquad \text{.................................} (5)$$

where a and b are the specific vectors.

- *Step 3. Perform Canonical Variables.* These variables are composed by specific vectors amount to the $\min(p,q)$ pairs with the followings;

$$\begin{array}{ll} V_1 = a_1 X & W_1 = b_1 Y \\ V_2 = a_2 X & W_2 = b_2 Y \\ \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \\ V_p = a_p X & W_q = b_q Y \end{array} \qquad \text{...} (6)$$

where;

$$X = \begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ \cdot \\ X_p \end{bmatrix} Y = \begin{bmatrix} Y_1 \\ Y_2 \\ \cdot \\ \cdot \\ Y_q \end{bmatrix} \qquad \text{...} (7)$$

- *Step 4. Determine Canonical Correlation Coefficients.* These coefficients can be calculated with the following formulation;

$$\Gamma = \frac{a' R_{xy} b}{\sqrt{[(a' R_{xx} a)(b' R_{yy} b)]}} \qquad \text{...} (8)$$

- *Step 5. Determine the dominant variables.* Dominant variables can be calculated with following formulation;

$$r^{(1)}{}_{xx} = R_{xx} a^{(1)} \qquad \text{...} (9)$$

$$r^{(1)}{}_{yy} = R_{yy} b^{(1)} \qquad \text{...} (10)$$

4. JAKARTA CITY BUS PERFORMANCE ANALYSES AND RESULTS

Evaluating the service performance of city bus in Jakarta is big task since it covers large scale of bus network involving heterogeneous capacities (e.g., small, medium and large size). Apart from such coverage data availability is hard to search, and only large size buses normally operated by big companies could be located with fairly reliable information. In this research five main operators of large bus service were identified and explored for the related data, they are namely PPD, Mayasari Bhakti (MB), Steady Safe (SS), Bianglala (B), and Kopaja (K) (see Appendix). To anticipate any bias in data capture some primary data were collected nearby the terminals (e.g., Blok M, Kalideres, Tanah Abang, Senen, and Lebak

Bulus). The flat tariff for each service is different (i.e., Regular = Rp. 500,-, PATAS = Rp. 800,-, PATAS AC = Rp. 2,500,-), and different operating hours (i.e., Regular = 2 x 8 hours, PATAS = 2 x 8 hours, and PATAS AC = 12 hours). As for number of routes for each company are PPD = 18 routes, MB = 22 routes, SS = 14 routes, B = 5 routes, and K = 2 routes. In consequence with number of routes and fleetsize the number of operators/drivers are PPD = 2,812 persons, MB = 2,872 persons, SS = 1,162 persons, B = 438 persons, and K = 176 persons). The operating cost/vehicle for each company is different in the following PPD Rp. 110,000,-, MB = Rp. 100,000,-, SS = Rp. 100,000,-, B = Rp. 105,000,-, K = Rp. 105,000,-, in which Rp = Indonesia rupiah.

In order to achieve high accuracy in calculation some variables are rationalized in such a way that only 14 variables would be analyzed further. These 14 variables are then divided into two sets of dimensions, namely service evaluation dimension (*X*) and service performance dimension (*Y*). Evaluation dimension comprises the following operational variables (refer to Table A. in appendix);

X1 = route length (*E*)
X2 = passenger travel time savings (*M/J*)
X3 = travel time (*M*)
X4 = route duplication (e.g., number of similar/overlapping routes)
X5 = number of vehicles at peak hour (*L*)
X6 = vehicle ration at peak hour (*L/G*)
X7 = vehicle revenue per trip kilometer [(%LF x Number of Seats x Number of Trips x Cost)/distance] = [(*I x F x J x Cost)/E*]
X8 = vehicle revenue per operating hour [(% LF x Number of Seats x Number of Trips x Cost)/operating hour] = [(*I x F x J x Cost*)/(*J x O*)]

Service performance dimension comprises the following operational variables (refer to Table A. in appendix);

Y1 = vehicle revenue hour per operating cost (*X8/operating cost*)
Y2 = total number of passengers per vehicle revenue hour (*K/X8*)
Y3 = operating revenue per operating cost [(*X8 x operating hours*)/*operating cost*]
Y4 = total number of vehicle hours per total number of operators [(*no. of operating vehicles x no. of shifts*)/(*Σoperators x Σ routes*)]
Y5 = total number of vehicle kilometers per vehicle at peak hour [(*E x J x G*)/*X5*]
Y6 = number of data collected (*N*)

To have reliability values of service measures some statistic is done and values of mean and standard deviation for each are summarized in Table 1.

Testing the strength of correlation among variables (***X,Y***) is necessary to adopt the most appropriate or influencing variables. Results of correlation test are summarized in Table 2. It can be learnt from the table that most of correlation appears weak although most of them show positive correlation. Correlation among the service performance variables are apparently stronger than the service evaluation ones, and correlation between the vehicle revenue hour per operating cost and vehicle revenue per operating hour (e.g., 0.9891). This implication has apparently addressed further investigation on multidimensional analysis (i.e., CCA).

Table1. Mean and Standard Deviation for each Operational Variable

Variable	Mean	Standard Deviation
X1	25.6756	7.2535
X2	6954.7108	4238.5712
X3	10210	5327.6321
X4	2.1081	0.9062
X5	10.3783	5.4076
X6	0.6769	0.1821
X7	3993.4864	1978.7250
X8	7703.4540	4798.9658
Y1	0.0737	0.0475
Y2	0.3013	0.3178
Y3	1.0098	0.5364
Y4	0.1619	0.1001
Y5	63.1659	23.3469
Y6	34.2703	27.5173

Table 2. Correlation Value of Operational Variables

	X1	*X2*	*X3*	*X4*	*X5*	*X6*	*X7*	*X8*	*Y1*	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*
X1	1													
X2	-0.041	1												
X3	-0.107	0.931	1											
X4	0.208	0.129	0.042	1										
X5	-0.314	0.426	0.665	-0.082	1									
X6	-0.175	-0.225	0.017	-0.235	0.481	1								
X7	-0.14	0.316	0.35	-0.102	0.354	0.155	1							
X8	0.488	0.375	0.345	0.075	0.064	0.015	0.739	1						
Y1	0.486	0.37	0.346	0.067	0.092	0.06	0.728	0.989	1					
Y2	-0.493	-0.227	0.01	-0.18	0.613	0.331	0.032	-0.465	-0.455	1				
Y3	0.44	0.27	0.241	-0.023	0.008	0.003	0.701	0.933	0.928	-0.431	1			
Y4	-0.384	0.211	0.425	-0.043	0.809	0.228	-0.013	-0.353	-0.336	0.798	-0.336	1		
Y5	0.797	-0.287	-0.327	0.125	-0.409	-0.427	-0.192	0.244	0.218	-0.209	0.253	-0.261	1	
Y6	-0.407	0.026	0.275	-0.173	0.792	0.339	0.431	-0.043	-0.042	0.868	-0.05	0.74	-0.195	1

The CCA would suggest to develop canonical variables amount to *Min [X,Y] = Min [8,6] = 6* pairs of canonical variables. So implicitly there will be 6 independent canonical variables (*V*) and 6 dependent canonical variables (***W***) {i.e, *Vi : Wi*), wherein *Vi* is a linear combination of {*X*}, and *Wi* is a linear combination of {*Y*}. Having these canonical variables coefficient of each linear combination known as canonical weight is to be determined. Due to different units used for each of operational variables the coefficient to be determined would have to comply with standardized canonical coefficients as summarized in Table 3 and 4 for $\{V\} \rightarrow A_{ij}$ $\forall$i,j and $\{W\} \rightarrow B_{ij}$ respectively.

Table 3. Standardized Canonical Coefficients for the 'VAR' Variables $\{A_{ij}\}$

	V1	*V2*	*V3*	*V4*	*V5*	*V6*
X1	-0.0096	-0.1202	1.0899	-0.1567	-1.6657	-0.6883
X2	-0.0733	-0.1824	-1.6707	1.1428	-0.6706	0.0749
X3	-0.0337	0.1959	1.2859	-0.5199	-0.1262	-0.5818
X4	-0.0171	0.0377	-0.0149	0.1143	-0.3989	-0.8468
X5	0.3105	0.7121	0.5744	0.4186	0.7509	0.7252
X6	-0.0757	-0.0502	-0.8431	-0.0248	-1.3042	0.0636
X7	0.0452	0.4336	0.5653	-1.1493	-1.7044	-1.8391
X8	0.9597	-0.5519	-0.8537	0.6529	2.3690	1.8550

Table 4. Standardized Canonical Coefficients for the 'WITH' Variables $\{B_{ij}\}$

	W1	*W2*	*W3*	*W4*	*W5*	*W6*
Y1	0.8207	0.0065	-0.0551	0.4467	-2.8377	-0.9086
Y2	-0.2768	-0.3177	-0.1768	-1.6428	-3.0356	1.7257
Y3	0.0723	-0.1367	-0.1784	-0.7574	1.5803	2.0498
Y4	0.0870	0.4064	0.4163	1.4334	-0.0120	0.7272
Y5	0.0023	-0.3772	0.9848	0.0741	0.1202	-0.1904
Y6	0.4096	0.7530	0.3658	0.0333	2.6453	-2.0616

Based on Table 3 and 4 any linear combination equation of the canonical variables can be composed as [$Vi = \sum_j A_{ij}Xj$] and [$Wi = \sum_j B_{ij}Yj$] such like;

$$V1 = -0.0096X1 - 0.0733X2 - 0.0337X3 - 0.0171X4 + 0.3105X5 - 0.0757X6 + 0.0452X7 + 0.9597\,X8.$$

$$W1 = 0.8207Y1 - 0.2768\,Y2 + 0.0723\,Y3 + 0.0870\,Y4 + 0.0023Y5 + 0.4096Y6.$$

Since there are 6 pairs of canonical variables there would consequently 6 canonical correlation coefficients as analyzed and summarized in Table 5. It can be learnt from the table that there are strong correlations in the first, second and third canonical correlation coefficients. These coefficients have indicated strong relations between set of $\{X\}$ and set of $\{Y\}$ variables simultaneously. On the basis of such indication of strong correlation, it is necessary to determine which combinations would be significant and conclusive. To investigate further two examinations namely cumulative varied proportion and canonical correlation significance test are conducted. Results of such examinations are given in Table 6 and 7 respectively.

Table 5. Canonical Correlation Analysis

	Canonical Correlation	Adjusted Canonical Correlation	Approximate Standard Error	Squared Canonical Correlation
1	0.993381	0.988687	0.002199	0.986806
2	0.989484	0.979847	0.003487	0.979078
3	0.936104	0.922257	0.029618	0.876291
4	0.826540	0.801533	0.052805	0.683149

5	0.509402	0.441207	0.123418	0.259490
6	0.156245	0.001059	0.162598	0.024412

Table 6. Cumulative Varied Proportion

	Eigen Value	Difference	Proportion	Cumulative
1	74.7902	27.9930	0.5700	0.5700
2	46.7971	39.7137	0.4567	0.9267
3	7.0835	4.9272	0.0540	0.9807
4	2.1563	1.8058	0.0164	0.9971
5	0.3504	0.3254	0.0027	0.9998
6	0.0250	-	0.0002	1.0000

Eigen values of INV(E)*H = CanRsq/(1-CanRsq)

Table 7. Canonical Correlation Significance Test

	Likelihood Ratio	Approximate F	Num DF	Den DF	Pr>F
1	0.00000782	24.2092	48	117.23200	0.0001
2	0.00059242	14.3290	35	103.38870	0.0001
3	0.02831575	6.5506	24	88.42462	0.0001
4	0.22888904	3.3970	15	72.17595	0.0002
5	0.72243210	1.1915	8	54.00000	0.3214
6	0.97558751	0.2336	3	28.00000	0.8722

Test H_0 and H_1 (e.g., for no relation and a relation respectively)

The two examinations have suggested similar confirmation on which linear combinations significantly determine prominent variables in the multidimensional analysis for bus service. This determination would address further investigation to first and second combinations. To comprehend such correlations more specific and explicit relation is to be analyzed through evaluation of canonical loading that denotes correlation between original and canonical variables. Canonical loading of X would denote correlation of each X variable to its counterpart V variable, and likewise for canonical loading of Y that denotes correlation of each Y variable to its counterpart W variable. Summary of canonical loadings for $\{V\}$ and $\{W\}$ are given in Table 8 and Table 9 respectively.

Table 8. Correlation between the 'VAR' Variables and Their Canonical Variables

	V1	*V2*	*V3*	*V4*	*V5*	*V6*
X1	0.3714	-0.6708	0.4897	0.2278	-0.3197	0.1181
X2	0.4175	0.2543	-0.2280	07457	0.1930	-0.1380
X3	0.4507	0.4747	-0.1150	0.6662	0.1083	0.0054
X4	0.0292	-0.1355	0.0796	0.3447	-0.2379	-0.7537
X5	0.3022	0.8934	0.1168	0.2225	-0.1427	0.1541
X6	0.1166	0.4081	-0.2825	-0.2572	-0.6405	0.4468
X7	0.8202	0.2942	-0.2217	-0.3333	0.1252	-0.2000
X8	0.9667	-0.2438	-0.0647	0.0121	0.0008	-0.0278

Table 9. Correlation between the 'WITH' Variables and Their Canonical Variables

	W1	*W2*	*W3*	*W4*	*W5*	*W6*
Y1	0.9680	-0.2257	-0.0808	0.0248	-0.0696	0.0066
Y2	-0.2574	0.7945	0.3692	-0.3625	-0.1648	0.0873
Y3	0.9036	-0.2637	-0.0620	-0.0997	0.1585	0.2740
Y4	-0.1317	0.8525	0.3671	0.2324	-0.0851	0.2449

Y5	0.1546	-0.5969	0.7845	-0.0589	0.0245	-0.0176
Y6	0.1956	0.8582	0.3261	-0.3261	0.0181	-0.0545

Refer to only two canonical correlations analyzed, it would then suggest only two canonical loadings being analyzed, namely *V1, V2* and *W1, W2* with the following clarifications;

a) The first strong correlation has a value of 0.993381 that composed with 57% varied data. The Y variables that dominate are Y1 (vehicle hour revenue per operating cost) and Y3 (operating revenue per operating cost) with canonical loading values of 0.9680 and 0.9036 respectively. The X variables that dominate are X7 (vehicle revenue per kilometer trip) and X8 (vehicle revenue per operating hour) with canonical loading values of 0.8202 and 0.9667 respectively.

b) The second strong correlation has a value of 0.989484 that composed with 35.67% varied data. The X variables that dominate are X1 (route length) and X5 (number of vehicles at peak hour) with canonical loading values of –0.6708 and 0.8934 respectively. The Y variables that dominate are Y2 (total number of passengers per vehicle revenue hour), Y4 (total vehicle hours per total operators), Y5 (total vehicle kilometers per vehicle at peak hour), and Y6 (total number of data collected) with canonical loading values of 0.7945, 0.8525, -0.5969 and 0.8582 respectively.

5. CONCLUSIONS

In this research a case of evaluating city bus service in Jakarta is made based on multidimensional approach. Although, it is learnt that such multidimensional approach should consider both quantitative and qualitative components, only the quantitative one is discussed. Two dimensions of criteria have been explored and determined as process evaluation dimension and service performance dimension with several planning, design and operational variables in each.

The canonical correlation analysis (CCA) is adopted for analysis to determine the complex correlation of the sets of various variables mentioned above. Through CCA a linear combination of one dimension of independent variables correlates maximally with a linear combination of other dimension of dependent can be determined.

Sets of data from several major city bus companies were collected to comply with the above dimensions. CCA onto the data has resulted in two prominent correlations. The first strong correlation has a value of 0.993381 that composed with 57% varied data. The Y variables that dominate are Y1 (vehicle hour revenue per operating cost) and Y3 (operating revenue per operating cost) with canonical loading values of 0.9680 and 0.9036 respectively. The X variables that dominate are X7 (vehicle revenue per kilometer trip) and X8 (vehicle revenue per operating hour) with canonical loading values of 0.8202 and 0.9667 respectively. The second strong correlation has a value of 0.989484 that composed with 35.67% varied data. The X variables that dominate are X1 (route length) and X5 (number of vehicles at peak hour) with canonical loading values of –0.6708 and 0.8934 respectively. The Y variables that dominate are Y2 (total number of passengers per vehicle revenue hour), Y4 (total vehicle hours per total operators), Y5 (total vehicle kilometers per vehicle at peak hour), and Y6 (total number of data collected) with canonical loading values of 0.7945, 0.8525, -0.5969 and 0.8582 respectively.

As can be expected two prime correlations have practical implications for both individual and collective operators. Such findings are necessary for investor candidates that would take roles in providing service in city bus system. It is expected further that the proposed CCA can be utilized to perform financial calculation as part of investment policy.

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