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Performance of Mass Transit Service Operators in Addis Ababa City Using Data Envelopment Analysis Approach

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ABSTRACT

Measuring Performance is one of the major tools for decision making and managerial control to assess the utilization level of various inputs to obtain the desired outputs. Efficiency and Effectiveness are the two relevant issues related to the performance measurement of any sector. Hence, this study evaluates the efficiency and effectiveness of the Mass Transit System in Addis Ababa city using Data Envelopment Analysis (DEA) approach. Data have been collected from Annual Reports of each Transit Agency for two years (2016/17-2017/18). In this study, Fleet Size and Total Number of Employees are considered as inputs as well as covered Vehicle-km and Total Passengers Transported per year are considered as output for efficiency and effectiveness measures; respectively. The results indicate that the State-Owned Mass Transit Operators; Anbessa and Sheger city bus utilize their inputs efficiently and effectively so as to deliver the desired output. But Alliance city bus and Public Service Employees Transport Service Enterprise utilized their inputs inefficiently and ineffectively in to deliver the desired output. Hence, they need great improvements in utilizing their resources to enhance their performance and deliver services incompetent with other operators in the city. Besides, the Government should encourage privately owned mass transit operators in the city and provide subsidies and other incentives to all mass transit operators based on their existing performance.

Introduction

The transport sector plays a significant role in the overall development of a country. The movement of people and goods is mainly depending on the transport and it is also an important factor for every country to maintain a strong economy, for military defence and access to and between country's people. It is performed by various modes; such as air, rail, road, and water. However, road transport is the dominant mode of transport in most cities in developing countries (Iles, 2005; Verma & Ramanayya, 2014).

Particularly, the provision of adequate and appropriate mass transit services is one of the most important components for the well-being of growing and expanding urban areas. These are transport systems with fixed routes and schedules, available for use by all persons who pay the established fare (Ibid). Due to its low running and initial cost, route flexibility and permeability into town and city centers, the conventional bus is the most common mode of public transport in most cities of developing countries (Pratibha, 2010; Verma & Ramanayya, 2014; and Iles, 2005).

Mass Transit System in Addis Ababa is composed of mainly Light Rail Transit and Bus operations. Transit Operators; such as AALRT, Anbessa city bus, Sheger city bus, and Public Service Employees' Transport Service Enterprise (PSETSE) are Owned by the Government. The only Privately Owned city bus is Alliance City Bus. The State-Owned mass transit operators are also subsidized by Addis Ababa City Administration (AACA). For instance, in 2017/18, 52.2% of the revenue for Anbessa city bus obtained from AACA through Subsidy and 41.2% is from traffic revenue and the remaining is from other sources. Similarly, for Sheger city bus on the same year subsidy cover, 49% of the revenue and 43.4% is obtained from traffic revenue (AATA, 2017/18). So, almost half of the revenue for the State-Owned Transit Operator was covered by the city administration. Though the Government invests a huge amount of capital on mass transit systems in the city, the

problem of public transport is still a huge challenge for all stakeholders. Therefore, giving important attention to measuring and improving the performance of a mass transit system is a burning issue due to severe operating environment and financial challenges in which the sector provides service in the city. This because measuring performance of a transit system is a vital tool for ensuring continuous improvement of the quality of service and for allocating resources and other incentives among competing transit operators in the city.

Therefore, this study aims is to measure the Efficiency and Effectiveness of Road-based Mass Transit Operators in the city based on selected inputs and outputs used by the agencies for two years. To achieve this objective, it uses Data Envelopment Analysis (DEA) to develop a single measure for the efficiency and a single measure for the effectiveness of a transit agency relative to other agencies within the same peer group.

Literature Review

Transit Performance

Performance is a term that defines the purpose, namely the successful fulfilment of one or more activities performed by an organization (A. Leoveanu, 2016). As Litman (2005), performance measures are an extension of our personal senses – sight, hearing, touch, smell, and taste. They serve as a navigation tool that helps an organization to determine where it wants to go and how to get there. They have also many practical applications like trend analysis, comparisons, target setting, system improvement and incentives for managers and employees. They also help to identify potential problems and optimal solutions (Dhingra,2011). Performance measurement also involves the collection, evaluation, and reporting of data that relates to how well an organization is performing its functions and meeting its goals and objectives (TCRP, 2003).

According to Fielding (1987) transit performance measures are basically designed to capture two vital dimensions of the transit system: i.e efficiency and effectiveness. Efficiency is measured by comparing the amount of service produced with the input (resources) used to produce the output. It assesses whether the operator is making the best use of the resources or not. Effectiveness measures the consumption of transit services to evaluate the social impacts of the services.

Regarding performance indicators type, more than 400 performance indicators are used in the transit industry today (TCRP,2010). Each indicator is assessed based on its performance category (availability, service delivery, community impact, travel time, safety and security, maintenance and construction, and economic/financial viability), its data collection needs, and its potential strengths and weaknesses for particular applications (TCRP, 2010; Dhingra, 2011).

Public transport performance evaluations can reflect various perspectives. Many commonly- used public transport performance indicators such as load factor and cost-per-vehicle-kilo- meter, measure operating efficiency. Other indicators, such as rider comfort, travel speed, and reliability, affordability, integration, and satisfaction, reflect the user experience. User-oriented indicators are important for developing public transit systems that respond to user demands and so are able to attract even choice riders. This is an area that needs serious attention in most developing cities today (Dhingra, 2011). To sum up, as most literature on performance measurement indicates the model of transit performance forwarded by Fielding, et. al. (1985) used in common and it is shown as follows:

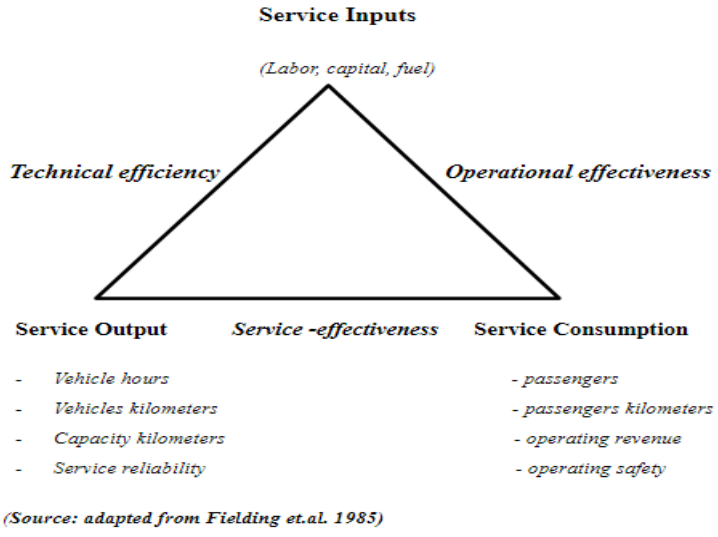

Fig 1. Framework for a Transit Performance Concept Model

Figure 1, shows the relationship between the three performance measures and lists the indicators related to inputs and outputs variables in the Mass Transit system.

i. Technical efficiency (Cost- efficiency) :

It represents the process through which service inputs (resources) are transformed into outputs. It means that a transit service provider invests capital for vehicles, fuel, employees and other inputs and produces a certain output for a community; such as vehicle-km, seat –km and service hours. Therefore, an operator is considered efficient if it can minimize inputs to produce a fixed amount of outputs, or maximize output while using the same or fewer inputs.

ii. Operational effectiveness (cost-effectiveness)

It shows the relationship between service inputs (resources) and consumed service. Thus, a transit operator spends capital to deliver its service, a number of passengers consume its service per day/month/year. Hence, an Operator will achieve higher operational or cost-effectiveness, if it enhances the

number of passengers without increasing the total cost of producing the service.

iii. Service effectiveness

It measures the relationship between produced output and consumed service or it shows how well the delivered services by operators are consumed by the community. This is because all of the delivered services (i.e. vehicle –km, seat-km, etc.) are not used by a community. Hence, if it attracts more users without enhancing services or minimizes service but still serves the same number of passengers, it will be more effective.

Therefore, the main emphasis of this study is also to evaluate the performance of Mass Transit Service Operators in Addis Ababa city based on the Transit Performance Concepts Model forwarded by Fielding, et.al.(1985).

Empirical Studies

DEA is one of the powerful techniques used for measuring the performance of various DMUs that consume multiple inputs to generate multiple outputs. And, it has been widely used to measure the performance of Mass /public transport systems. Some studies used DEA are summarized as follows and shown on the next table.

Table 1. Studies Applying DEA in Mass Transit System

Author(s)	DEA Model	DMUs	Inputs	Outputs
Devaraj, et. al.(2015)	DEA Bootstrapping	4Depots, 7routes, 11 routes to the airport	-fleet size, number of employees, fuel consumption, number of schedules and effective km	-revenue and profitability, vehicle utilization, fleet utilization, fleet utilization, staff productivity,breakdown rate, fuel efficiency, and accident rate
Kral, P. and Rohacova, V. (2013)	VRS-DEA	20 Transport companies	-average number of employees, total km driven, the total number of vehicles, tangible fixed asset and operation cost	-total number of passengers, total sales
Obeng (1994)	DEA	73 bus agencies	-labor, fuel and fleet size	-vehicle-km
B.R. Sampaio, et al. (2008)	DEA	19 transport system	-operational cost, number of vehicles, number of employees	-number of passengers transported
Hokey M, et. al. (2015)	CCR DEA VRS DEA	24 mass transit system	-total operating expenses, total funds, vehicle revenue miles, vehicle revenue hours	-fare revenue measured, unlinked passenger trips, passenegers mile
Hen and Hayasn (2008)	DEA	652 Urban transport system	-number of employees, number of vehicles, energy consumption	-number of passengers
Ayadi (2013)	DEA Regression model	12 urban transit system in Tunisia	-total number of bus park, number of staff, fuel consumed	-traveled km
Barnvma, et. al. (2007)	DEA and SFA	16 park and ride lot	-number of parking spaces, operating cost	-number of the parked car, revenue
Lao, et.al (2009)	DEA GIS	24 fixed routes in Monterey country, USA	-operation time, round trip distance, number of bus stops, person with disabilities and commuter 65 and above	-total number of passenger

As shown above, various scholars used DEA to measure the performance of mass transit systems in various countries. For instance; Kral, P. and Rohacova,V.(2013); B.R. Sampaio, et al.(2008); Hokey M, et. al. (2015); and Hen and Hayasn(2008) were using DEA model to measure the efficiency of mass transit system and identify the efficient and inefficient DMUs in their studies. Besides, Devaraj, et.al.(2015) measuring the efficiency of routes and depots in public transportation system using DEA and Bootstrapping model. Barnvma, et. al. (2007) also applied DEA in measuring the efficiency of park and ride lot in public transport system using DEA.

By observing the above studies, this paper measures the performance of Mass Transit Service Operators in Addis Ababa using the Input-oriented CRS DEA model.

Materials and Methods

Materials

For this study, the data was collected from Four Mass Transit Service Operators in the city: namely Anbessa, Sheger, Alliance and Public Employees buses. Secondary data especially Annual Reports of the Agencies were collected for the year 2016/17-2017/18. Last, DEAP 2.1 software used to compute efficiency scores of all operators based on the CCR input-oriented model.

Methods

Data Envelopment Analysis and Its Components

Data Envelopment Analysis (DEA) is a linear programming based technique to assess the efficiencies of Decision-Making Units (DMUs) handling multiple inputs and outputs, and presenting results in relative form. As Cooper, Seiford, and Zhu (2004), it is also a relatively new *data-oriented* approach

for evaluating the performance of a set of peer entities or DMUs which converts multiple inputs into multiple outputs. DEA was suggested by Charnes, et. al. (Charnes, et. al., 1978) and was built on Farrell's (Farrell, 1957) idea. It is referred to as the CCR model in the literature, which assumes the constant returns to scale (CRS) production technology. This model implies that any proportional change in every input usage would result in the same proportional change in every output produced. A more flexible model developed by Banker et al. (Banker, et al. 1984), called BCC model relaxes the assumption of CRS to variable returns to scale (VRS). These models are basic DEA models.

DEA has been applied in many sectors (e.g. Banks, hospitals, education, health care, finance, utilities, Agricultural sectors). In particular, there are many applications of DEA in transportation. Thus, DEA has been applied to ports, railways, airlines, urban transit, airports, etc.

The most basic DEA model is the CCR model that was proposed by Charnes, Cooper, and Rhodes in 1978 (Cooper & Seiford, 2001). It was developed to evaluate the relative efficiency of homogeneous DMUs with multiple inputs and multiple outputs.

Suppose there are n DMUs to be evaluated where each DMU has m inputs and s outputs. The relative efficiency of a DMU_K (where o ranges over 1, 2,…., n) is evaluated by solving the following fractional programming problem:

Maximize
Wo=U1Y10+U2Y20…….+UsYso/V1x10+V2X20+VmXmo

Subject t U1Y1j+…+UsYsjV1X1j+…+VmX $\leq$ 1 (j = 1, 2, ….n) u1, u 2,……us $\geq$ 0

v1, v2,….. vm $\geq$ 0 …….. (1)

Where j is the DMU index where j= 1,2,...n.

This model can be converted to a linear programming model below:

Maximize $W_o = u_1 y_{10} + ... + u_S y_{SO}$

Subject to $v_1 x_{10} + ... + v_m x_{mo} = 1$

$u_1 y_{1j} + ... + u_S y_{Sj} \leq v_1 x_{1j} + ... + v_m x_{mj}$ (j = 1, 2….n)

$u_1, u_2, \ldots\ldots, u_s \geq 0$

$v_1, v_2,$ .....(2)

If $W_o = 1$, it means that DMU_o is efficient relative to other similar DMUs. If $W_o < 1$, then the DMU_o is inefficient. So, for this study the above model; i.e CCR model in input orientation is used.

Decision-Making Units (DMUs)

Homogeneity of DMUs is one assumption in DEA where all DMUs must satisfy the following criteria; first, the DMUs must carry out similar activities and have the same objectives; second, they should utilize similar inputs to produce the same outputs; and last they should operate within similar environments (Dyson et al., 2001).

Based on that, for this study, all selected Mass Transit Agencies are using similar resources and produce the same outputs. Moreover, they share the same objectives and goals. Besides, as a rule of thumb, Dyson, et. al. (2001) suggest that if there are M inputs and N outputs, there need to be at least 2M*N DMUs in the set to be compared. So, there are two inputs and one output and four DMUs (n $\geq$ 2*2*1).

Variables Selection

The choice of inputs and outputs is very important for using DEA. The relative efficiency of DMUs depends significantly on input-output factors chosen for assessment. There are no common rules in defining inputs and outputs for this sector. The most important principle is that the input and output factors defined must comply with the mission and the objective of the sectors or operators.

Many kinds of literature that applied DEA in measuring the performance of public transport sectors use different sets of input and output factors. Some of the commonly-used input and output variables in DEA analysis of urban transit systems are identified from the literature review and summarized as follows: Kral, P. and Rohacova,V.(2013); B.R. Sampaio, et. al.(2008); Hokey M., et.al. (2015); Barnvum, et. al. (2007) and so on.

Table 2. Commonly used input and output variables in DEA

Input Variables	Output Variables
Number of Employees	Number of passengers
Fleet size	Covered kilometre
Fuel consumption	Passenger kilometres
Effective kilometers traveled	Fleet size per unit distance per employee
Number of bus stops	Revenue
Number of schedules	Revenue per day
Service hours	Vehicle utilization
Cost per kilometer	Staff productivity
	Accident rate
	Profitability
	Vehicle utilization

Therefore, based on the objective and mission of the transit agencies, literature review on input and output factors used in other studies, and availability of data the following indicators are used as inputs and output in this study:

A. Input variables

Number of Employees: this input is an indicator of human capital. In the operation of mass transit services, the role of employees (i.e operators, maintenance and others) is huge.

i. *A number of operated buses (Fleet size)*: this is another indicator of a measure of capital.

B. Output Variables

iii. *Total covered – km*: this is the other common output in the operation of mass transit. This is used to measure the efficiency of units.

i. *A total number of passengers transported*: any transit operators need to enhance the number of passengers that uses their buses. This indicator reflects the measure of effectiveness.

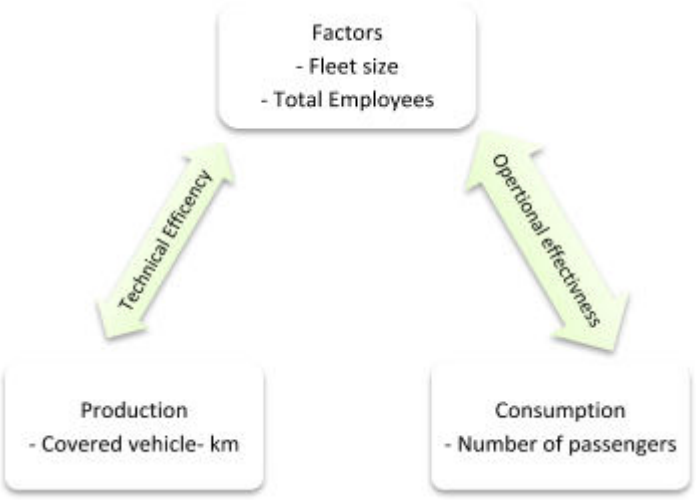

Fig 2: Summary of used variables for the study

Model Orientation

There are two choices of model orientation in DEA that are input orientation and output orientation. The aim of input orientation is to minimize the inputs at a given output level and the aim of the output orientation is to maximize the output given at the input level.

This study will employ input orientation because it is assumed that the inputs in an organization are controllable compared to outputs. Agencies can control its resources that used in providing transit services (number of buses, number of employees, etc. but cannot control the number of passengers transported on their services.

Return to Scale

There are two types of scales that are Constant Return to Scale (CRS) and Variable Return to Scale (VRS). CRS assumes that an increment in inputs results in proportion increment in outputs. In other words, there is no significant relationship between the size of DMU and efficiency. On the other hand, VRS assumes that an increment in inputs results in a disproportionate increment in outputs (Cooper & Seiford, 2001). By considering the above assumption, CRS is used for this study.

Results and Discussion

The mathematical processing of the primary data was performed by the application of DEAP version 2.1 software, which was developed by Coelii, 1997.

Descriptive Statistics

Table 3. Descriptive Statistics of the Variables 2016/17 and 2017/18

	Input variables				**Output variables**			
	# of Operated buses		**# of Employees**		**# of passengers (for effectiveness measure)**		**Vehicle-km (for efficiency measure)**	
	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Max	447	438	3398	3559	133,770,900	105,758,047	18,759,848	16,220,017
Min	70	80	333	339	8,064,000	6,763,518	644,965	653,622
Average	217.333333	230	1449.33333	1455.5	51,942,436	42,322,041	7,520,084	7,771,630
SD	170.008578	155.3984	1450.3235	1496.682	61125633.32	46659006.3	8367299.89	7769753.6

Performance of Mass Transit Operators in 2016/17

The next figures indicate the efficiency and effectiveness score of Mass Transit Services Operators in the city. Efficiency and effectiveness score equal to 1 means the Operators are efficient and effective in providing transit service in the city. Efficiency and effective score lies between 0.6 and 1 mean an operator is a fairly efficient and fairly effective in using its resources to provide service. A score lies less than 0.6 means the system is inefficient and ineffective. The categories for efficiency and effectiveness score is based on the scale of Lao and Liu (2009). Then based on the above categories, figure 3 indicates the efficiency and effectiveness score of transit operators in Addis Ababa.

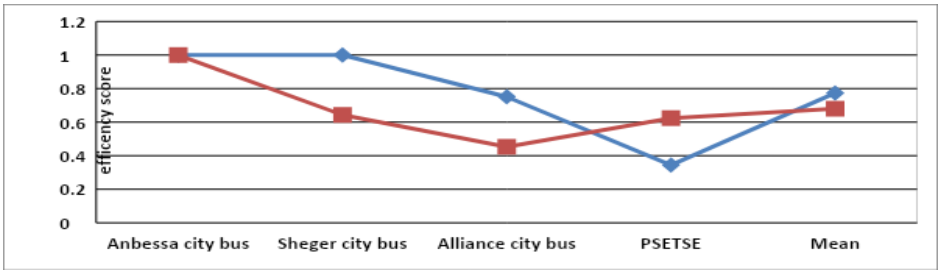

Fig 3. Performance of Mass Transit Service Operators: 2016/17

It can be observed from the above figure, the efficiency score for Anbessa and Sheger city bus is equal to one. This shows that they are efficient in utilizing their resources (i.e vehicles and staff) to provide the defined output (covered km) as compared to their peer operators. As well as, the score for Alliance (0.751) and PSETSE (0.344) indicates that they are fairly efficient and inefficient; respectively, in using their resources to provide transit services in the city. Besides, the average score shows transit operators in the city is to utilize their resource fairly efficient (77.4%).

Therefore, the inefficient DMUs should improve their input variables so as to enhance their efficiency level and to become efficient. This is possible by either increasing or decreasing the input levels. For instance, Alliance city bus needs to improve its efficiency by 24.9% and PSETSE by 65.6% to become efficient in using their resources. Figure 4, shows the changes in the improvement of each transit operator to become efficient.

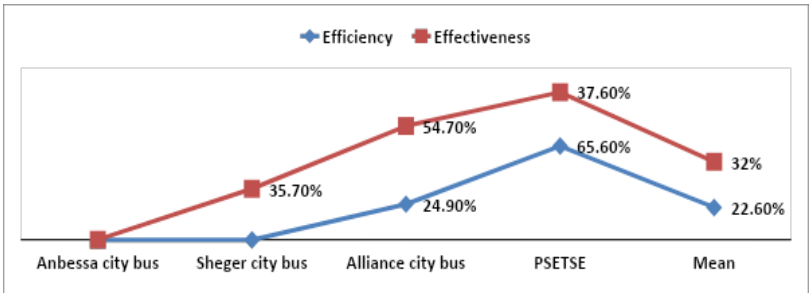

Fig 4. Percentage Change for Improvement of each inefficient transit operator

On top of that, the mean score indicates Mass transit Operators in the city are fairly effective and efficient in using resources to obtain the above-mentioned output in the year 2016/17. In addition, figure 3 indicates the effectiveness score for each transit operator using the same input but with different outputs (i.e the number of passengers per year). Thus, the effectiveness score for Anbessa city bus is equal to 1 and it implies that Anbessa is the only effective transit operator in the city in the same year. Sheger city bus and PSETSE are fairly effective while Alliance city bus is ineffective in obtaining the mentioned output with their resources.

However, the general result shows Anbessa city bus is performing very well as compared to peer agencies in the city. This is maybe Anbessa city bus is very well organized and provides services for a long year and its coverage is also very well as compared to others. The other major point here state-owned transit operators also obtained subsidies from the government and it had a significant impact on their performance. Last, except Anbessa city bus others need improvements in various ways on their input variable so as to enhance their performance and to become competent operators in the city.

Performance of Mass Transit Operators in 2017/18

Similarly, the next figure indicates the efficiency and effectiveness of Mass Transit operators in the city.

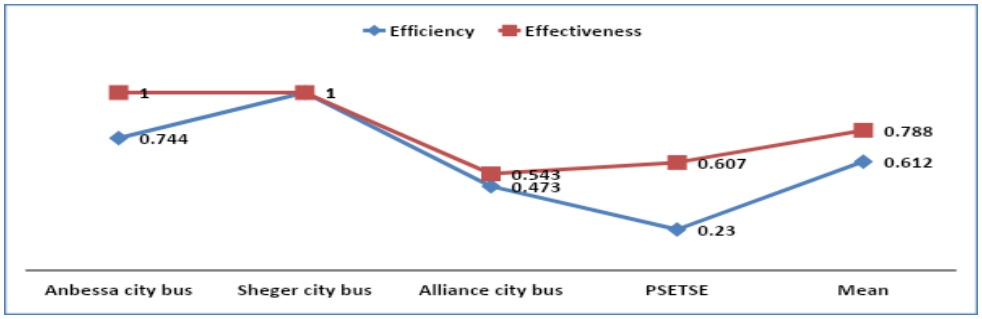

Fig 5. Performance of Mass Transit Operators

As shown in figure 5, the efficiency score for Sheger city bus is equal to one and it implies that it is an efficient and effective transit agency in using its resources to obtain the above-mentioned output. Besides, Anbessa city bus is fairly efficient (i.e. 74.4%) while the other Alliance city bus and PSTESE are inefficient with an efficiency score of 47.3% and 23 %; respectively.

Similarly, the above figure shows Anbessa and Sheger city buses are effective with efficiency scores equal to one; PSETSE is fairly effective with a score of 60.7% and Alliance city bus is ineffective with a score of 54.3%.

Thus, in 2017/18 Sheger is the only efficient and effective Mass Transit service provider in the city. The others need to improve their resources so as to give services efficiently and effectively. For instance, Anbessa should improve by 25.6%, Alliance by 52.7 and PSETSE by 77% to reach the efficiency score equal to one. Figure 6, shows the percentage of changes for the improvement of each inefficient DMU.

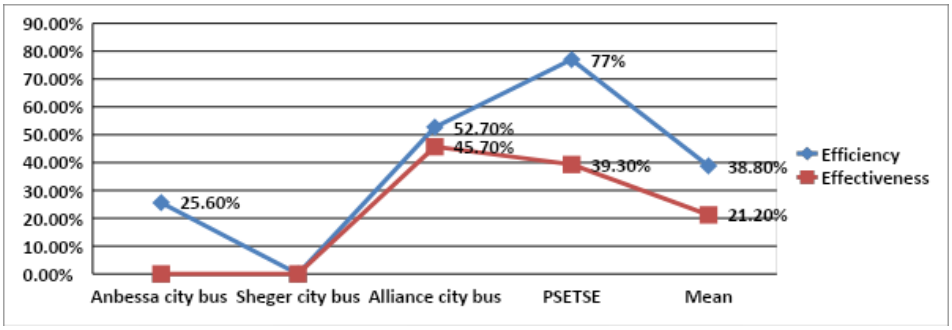

Fig 6. Percentage Change for Improvement of Inefficient Transit Operator

Efficiency and Effectiveness Trend in 2016/17-2017/18

The next figures show the trend of efficiency and effectiveness result of mass transit operators in the city in the years of 2009 e.c (2016/17) and 2010e.c (2017/18).

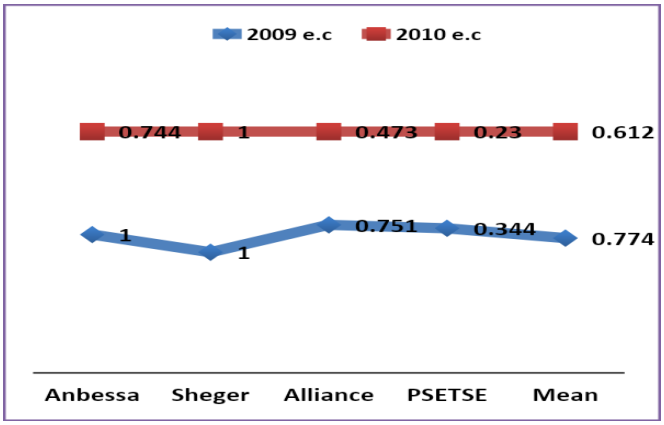

Fig 7. The trend of efficiency

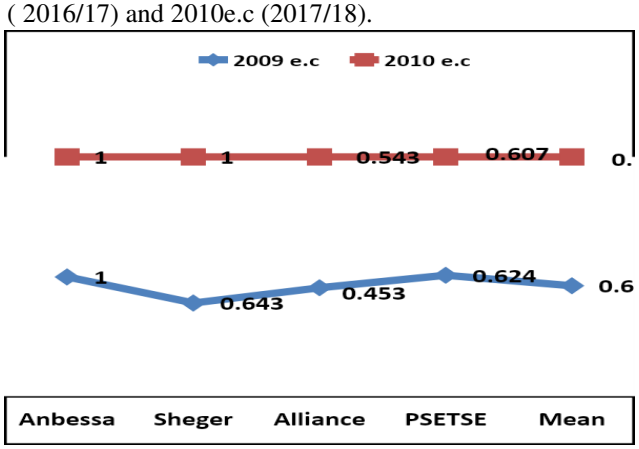

Fig 8. The trend of effectiveness

As shown in figure 7, except for the Sheger city bus, the efficiency score of other transit operators are declined from 2009e.c(2016/17) to 2010e.c.(2017/18). And the mean efficiency score of the city also declined from 77.4 to 61.2 %. This indicates in 2009e.c (2016/17) most of the transit operators did not use their resources efficiently so as to produce their desired output in the city.

On the other hand, as shown in figure 8, the effectiveness score for Anbessa city bus is the same and equal to one during the two periods. It implies that Anbessa city bus provides its services effectively with its resources as compared to peers in the city. Effectiveness score for Sheger city bus was also increased from 64.3% in 2016/17 to 100% in 2017/18. Alliance and PETSES provide also fairly effective services during the two years in the city by using their input variables.

Lastly, based on the above results, this study suggests the inefficient and ineffective transit operators should improve their performance. And it has attached projected values of DEA for them to improve and enhance their performance and to become efficient transit agencies in the city.

Conclusion

This study has evaluated the performance of Mass Transit Service Operators in Addis Ababa using the Data Envelopment Analysis approach. There are four DMUs and analysis was done on Secondary data collected from each Transit Agency for the year 2016/17 and 2017/18. Two inputs and one output are selected and used for the analysis of their performance using DEA. The efficiency and effectiveness score for two years indicates the State-Owned mass transit operators; Anbessa and Sheger city buses are obtained one. This means that these agencies were used their inputs efficiently and effectively so as to produce the desired output and consumed by their users. However, Alliance city bus and PETSES obtained the efficiency score less than one and it implies that they are utilized their resources inefficiently to produce the desired output and consumed ineffectively by the users. So, they need great improvements in utilizing their resources to produce the desired output and to enhance their performance and deliver services incompetent with other operators in the city. Moreover, the Government should encourage privately owned mass transit operators in the city and provide subsidies and other incentives to all mass transit operators based on their existing performance.

References

Addis Ababa Transport Authority (2017). *A Study on Allocation of Subsidy for Public Transport Agencies in Addis Ababa.Ethiopia*

Andy Leoveanu. (2016). *Performance Evaluation Systems in the Public Sector*, *66*(3), 26–38.

Annual Reports, (2010e.c and 2011e.c) , Selected Transit Agencies.

Ashish Verma, and T.V. Ramanayya. (2014). *Public Transport Planning and Management in Developing Countries.* CRC press.

Ayadi, A. (2013*). The Evaluation of the Effectiveness and Efficiency of the Public Transport System in Tunisia. Application of DEA*. Valahian Journal of Economic Studies, 4(1), 7.

Banker, R. D., Charnes, A., & Cooper, W. W. (1984*). Some models for estimating technical and scale inefficiencies in data envelopment analysis*. Management Science, 30(9), 1078-1092. http://dx.doi.org/10.1287/mnsc.30.9.1078

Barnum, D. T., McNeil, S., & Jonathon, H. (2007*). Comparing the Efficiency of Public Transportation Subunits Using Data Envelopment Analysis*. Journal of Public Transportation, 10(2). http://dx.doi.org/10.5038/2375-0901.10.2.1

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). *Measuring the efficiency of decision-making units.* European Journal of Operational Research 2, 429-444. http://dx.doi.org/10.1016/0377-2217(78)90138-8

Coelli, Tim. 1996a. " A guide to DEAP Version2.1.: *A Data Envelopment Analysis (computer) program."* Cepa working paper, 96/08, Department of Econometrics, University of New England, Australia:1-49

Cooper, W. W., & Seiford, L. M. (2007). Tone 2nd K., editors. *Data envelopment analysis: a comprehensive text with models, applications, references, and DEA-solver software.* Boston: Kluwer

Cooper, W. W., Seiford, L. M., & Zhu, J. (2011). *Handbook on Data Envelopment Analysis(Vol. 164).* International Series of Operations Research & Management Science, Springer Science & Business Media. http://dx.doi.org/ 10.1007/978-1-4419-6151-8_ 11

Dhingra, C. (2011). *Measuring Public Transport Performance : Lessons for Developing Cities. Sustainable Urban Transport Technical Document, 9.* https://doi.org/10.1017/CBO9781107415324.004

Dyson, R.G.,Allen,R.,Camanho,A.S.,Podinvshi,V.V.,Sarrico,C.S. and Shale,E.A.(2001),*"Pitfalls and protocols in DEA"*. European Journal of Operational Research,38:245-259

Fielding, G.J., Babitsky TJ, Brenner ME(1985).*Performance Evaluation for bus transit*, Transportation Research,19(1), pp 73-82

Fielding, G., Glauthier, R. and Lave, C. (1978), *"Performance Indicators for Transit Management*", Transportation, Vol. 7 No. 4, pp. 365-37.

Han, J., and Y. Hayash. 2008. "*A Data Envelopment Analysis for Evaluating the Performance of China's Urban Public Transport Systems*." *International Journal of Urban Sciences*, 12 (2):173- 183.

Iles, R. (2005). *Public Transport in Developing Countries*. https://doi.org/10.1186/cc13998

Kral, P., & Rohácová, V. (2013). Measuring the Efficiency of Public Road Transport Companies in the Slovak Republic USING DEA and SFA.

Liao, Y., & Liu, L. (2009). *Performance evaluation of bus lines with data envelopment analysis and geographic information systems.* Computers, Environment and Urban Systems, 33(4), 247-255.

Marchus E.(2012). *Sustainable Transport, Mobility Management, and Travel Plans*. Ashgate Publishing Company

Obeng, K. (1994). *The economic cost of subsidy-induced technical inefficiency*. International Journal of Transport Economics/Rivista Internazionale di Economia dei Trasporti, 3-20

Pratibha D.(2010).*Urban Transport Planning and Management*. Sbs publishers and distributors.

Ramanathan, R.(2003).*An Introduction to Data Envelopment Analysis: A tool for performance measurement,* Sage, Thousand Oaks.

Todd Litman(2005).*Well measured- Developing Indicators for Comprehensive and Sustainable Transport Planning*. Transport Research Board/TRB/.

Transportation Research Board/TRB/(2003). *A guidebook for developing a transit performance measurement system.* TCRP Report 88. Washington DC. National Academy Press.

Annex – 1 Projected value (Suggestion for improvement) 2016/17

a. Efficiency

DMU	**Original value**		**Projected value**	
Anbessa city bus (Te : 1.000)	Output 1	Efficient	Output 1	Efficient
	Input 1		Input 1	
	Input 2		Input 2	
Sehger city bus (Te: 1.000)	Output 1	Efficient	Output 1	Efficient
	Input 1		Input 1	
	Input 2		Input 2	
Alliance city bus (Te: 0.751)	Output 1	1910880	Output 1	1910880
	Input 1	70	Input 1	52
	Input 2	452	Input 2	339
PESTSE (Te: 0.344)	Output 1	644965	Output 1	644965
	Input 1	149	Input 1	17
	Input 2	333	Input 2	114

b. Effectiveness

DMU	***Original value***		***Projected value***	
Anbessa city bus	Output 1	Efficient	Output 1	Efficient

(Te: 1.000)	Input 1		Input 1	
	Input 2		Input 2	
Sehger city bus	Output 1	19800000	Output 1	19800000
(Te: 0.643)	Input 1	121	Input 1	66
	Input 2	782	Input 2	502
Alliance city bus	Output 1	8064000	Output 1	8064000
(Te: 0.453)	Input 1	70	Input 1	26
	Input 2	452	Input 2	204
PESTSE	Output 1	8184814	Output 1	8184814
(Te: 0.624)	Input 1	149	Input 1	27
	Input 2	333	Input 2	207

ii. 2017/18

a. Efficiency

DMU	**Original value**		**Projected value**	
Anbessa city bus	Output 1	16220017	Output 1	16220017
(Te:0.744)	Input 1	438	Input 1	325
	Input 2	3559	Input 2	1936
Sehger city bus	Output 1	Efficient	Output 1	efficient
(Te: 1.000)	Input 1		Input 1	
	Input 2		Input 2	
Alliance city bus	Output 1	1712880	Output 1	1712880
(Te: 0.473)	Input 1	80	Input 1	34
	Input 2	432	Input 2	204
PESTSE	Output 1	653622	Output 1	653622
(Te:0.230)	Input 1	151	Input 1	13
	Input 2	339	Input 2	78

b. Effectiveness

DMU	**Original value**		**Projected value**	
Anbessa city bus	Output 1	Effective	Output 1	Effective
(Te:1.000)	Input 1		Input 1	
	Input 2		Input 2	
Sehger city bus	Output 1	Effective	Output 1	Effective
(Te:1.000)	Input 1		Input 1	
	Input 2		Input 2	
Alliance city bus	Output 1	7718400	Output 1	7718400
(Te:0.543)	Input 1	80	Input 1	39
	Input 2	432	Input 2	234
PESTSE	Output 1	6763518	Output 1	6763518
(Te: 0.607)	Input 1	151	Input 1	34
	Input 2	339	Input 2	205

Note i. Input 1: # of buses
Input 2: # of employees
For effectiveness measure output 1 is the number of people transported per year
For efficiency measure output 1 is total vehicle – covered km per year
Projected value is a value for improvement in the future to enhance their efficiency score

Note ii. Government Fiscal Year (FY) in Ethiopia: July 8- July 7
Ethiopian Fiscal year (EFY) Gregorian (European Year Equivalent)
2009 E.C……..……. 2016/2017
2010 E.C……..……. 2017/2018