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ANALYSIS OF THE EFFICIENCY AND EFFECTIVENESS OF THE MUNICIPALITY-OWNED PUBLIC BUS TRANSPORT SERVICE ENTERPRISE IN ADDIS ABABA, ETHIOPIA

Summary. To make decisions and exercise managerial control over the degree of input utilization, and produce desired outputs, it is important to assess the efficiency and effectiveness of the municipality-owned public transit service operators. This study uses the Data Envelopment Analysis approach to assess the efficiency and effectiveness of the public transit companies operated by the city administration in Addis Ababa. The size of the fleet and the total number of personnel serve as inputs, and covered vehicle kilometers and the number of passengers carried annually serve as outputs. Based on secondary information gathered from each firm, the technical efficiency and operational effectiveness of service providers are then examined. The study's findings show that the Anbessa city bus was efficient in using resources to produce output in 2019/20 and 2021/22, but wasteful in other years. In the same way, the Sheger City Bus was efficient in 2017/18 and 2021/22 but ineffective in all other years. However, the aggregate findings show that both research's efficiency levels are rising annually. Besides, with mean scores of 0.85 and 0.874, respectively, Anbessa and Sheger Bus were technically flawed. On the other side, operational effectiveness reveals that the Anbessa city bus was only effective in 2021/22. Furthermore, the Sheger city bus' effectiveness result has improved and started to be effective in 2017/18, 2018/19,

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and 2021/22. In conclusion, the Anbessa and Sheger city buses' efficiency and effectiveness ratings improved year over year and peaked in 2021/22. Hence, to support the business and boost its operational capabilities, the city administration should encourage public bus transit operators in the city and offer subsidies and other incentives to them based on their existing performance.

Keywords: technical efficiency, operational effectiveness, municipality-owned

1. INTRODUCTION

The development of the nation as a whole is significantly influenced by the transport industry [1]. Transport is mostly responsible for the movement of people and products, and it also plays a significant role in a government's ability to maintain a healthy economy [2]. The primary means of public transportation in the majority of developing country cities is a conventional bus because of its low initial and operating costs, adaptable route system, and accessibility to town and city centers [2, 3]. Buses are also the most popular option for most commuters because they are the most affordable form of transportation [4]. Therefore, one of the most essential elements for the well-being of developing metropolitan regions is the provision of enough and proper public bus transit services [5].

However, Addis Ababa and other cities in the developing world are facing a growing urban population and a convergence of private vehicle ownership and resource scarcity, creating a chaotic environment for urban transport systems [6,7]. Notably, a sharp rise in private vehicle ownership has put a strain on the urban transportation infrastructure in the majority of developing-world cities. Congestion, noise, and air pollution issues have become worse as the number of people driving their cars has increased. Additionally, it undermines citywide public transportation operations and the effectiveness of transit service providers [8].

As a result, the government should implement various programs to encourage people to use public transit in such circumstances [9, 10]. Promoting public transportation is a crucial way to reduce the issues with urban transportation that plague most developing-nation cities. Additionally, it makes a substantial contribution to lowering air pollution, providing an alternative mode of transportation, and increasing the value of urban life [11]. As a result, authorities in these cities should act swiftly to develop and put into place performance-improving measures for their urban transportation systems that are commensurate with the difficulties they are facing. As a result, it necessitates the capacity to conduct performance evaluations, absorb lessons from other industries' best practices, and identify the scope and areas for future progress [6].

Light rail transit and bus services make up the bulk of Addis Ababa's public transport system. Government-owned public bus companies such as Anbessa City Bus and Sheger City Bus are subsidized by the city of Addis Ababa [12]. Urban transport remains a major concern for all stakeholders, despite the government's heavy investment in urban public transport networks. Due to the difficult business environment and financial challenges facing the urban sector, it is imperative to pay special attention to evaluating and improving the performance of transport systems.

There have been previous studies on the city's public transport system, but most of them focused primarily on evaluating how it works [13-15]. In addition, there is not much research done in this city to investigate the effectiveness of transit companies using the DEA approach, creating a need for this research. However, some research has been conducted domestically using DEA in various fields, such as a study on the effectiveness of the Ethiopian banking

system using the DEA [16, 17]. Others have used DEA to assess the effectiveness of certain municipal hospitals [18] and the Ethiopian agricultural system [19]. The purpose of this study is to explore the city's public bus transit system to fill gaps in the empirical literature.

2. LITERATURE REVIEW

Performance can be characterized quantitatively or qualitatively, the term referring to an evaluation or comparative measure [20]. Assessing the performance of an organization as a result of the management of its internal resources (money, people, vehicles, and buildings) and the environment in which it operates is a well-defined definition of performance appraisal [21]. Furthermore, it is defined as a method of evaluating how well or poorly a transit service is performing in its current operational environment [22].

An important tool for the transport services industry is public transport performance measurement [6]. Identify potential areas of performance improvement, determine community and customer satisfaction, and determine where decision-making bodies deliver services, as they can generally ensure that services are delivered effectively and efficiently, when and how [6]. By allocating funds and measuring transport performance among competing carriers, we can ensure continuous improvement in the quality of service provided [20].

In conclusion, most of the literature on performance measurement points to public transport performance models widely used to measure the effectiveness of public transport systems, which measure technical efficiency as the output of a service relative to its inputs (production) and define operational efficiency as the ratio of consumption to input [23]. Lists the metrics related to the input and output variables of a public transit system and shows the relationships between the three key performance indicators.

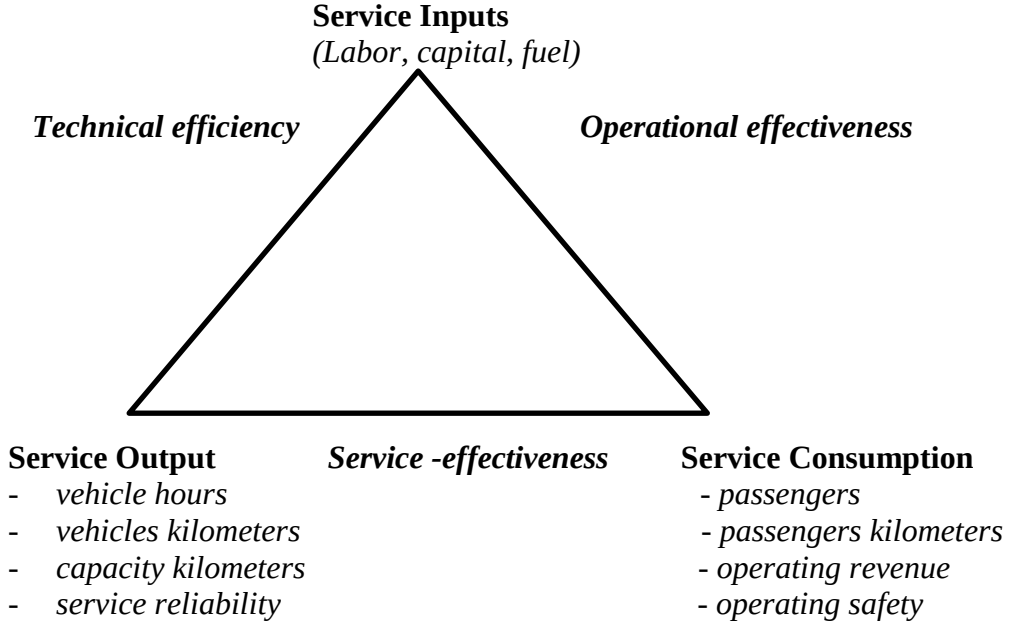


Fig. 1. Structure for a Transit Performance Notion Model
Source: adapted from [23, 24]

i. Technical efficiency refers to the method by which resources (service inputs) are transformed into outputs. To create a specified yield for the public, such as vehicle km, seat km, and service hours, a transport service provider must invest capital in cars, fuel, workforce, and other resources.
ii. Operational effectiveness demonstrates the relationship between service inputs (resources) and the service that is used. As a result, a transportation operator invests capital to provide its service, and numerous customers use it every day, month, and year.
iii. Service Effectiveness assesses how successfully the community uses the services that are provided by operators, or demonstrates the relationship between a created product and a consumed service. Society does not use all of the provided services (such as car -km, seat -km, etc.).

As a result, the main focus of this study was to evaluate the efficiency and effectiveness of the municipally owned public transportation system in Addis Ababa city using the Transit Performance Concepts Model from 2016/17 to 2021/22 (as proposed by [23]. Besides, this study creates the conceptual framework described below (Fig. 2). Thus, fleet utilization, bus productivity, and service usage for the relevant years were highlighted when evaluating the operational performance of each operator. Finally, the DEA technique was used to analyze the enterprise's operational effectiveness and technical efficiency.

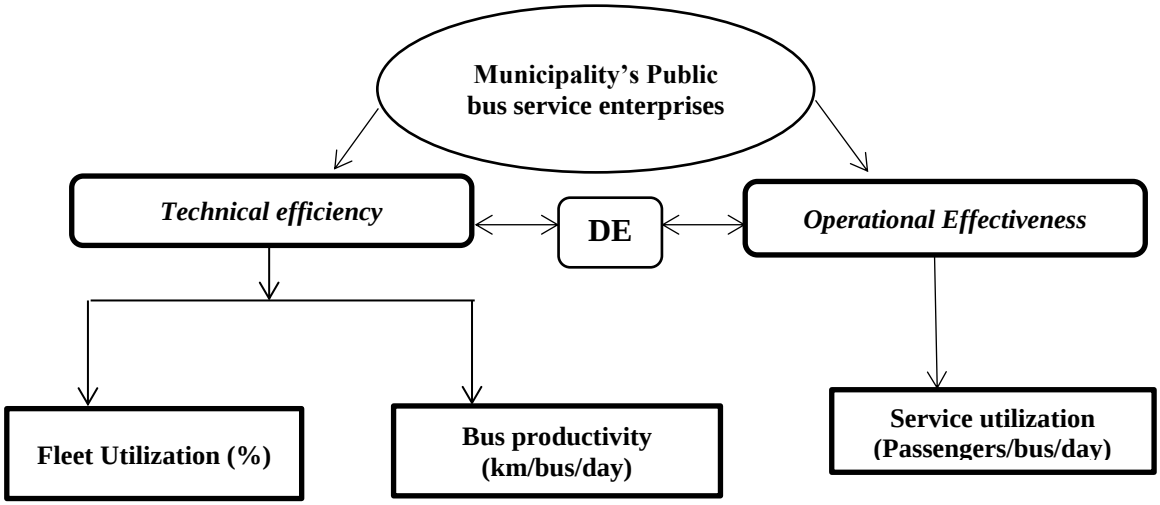


Fig. 2. Conceptual Framework

3. DATA AND METHOD

3.1. Data

Secondary data for the fiscal years 2016/17 and 2021/2022 were gathered from the two municipally owned public bus service providers; namely Anbessa City Bus Service Enterprise and Sheger Mass Transport Service Enterprise.

3.2. Method

Data Envelopment Analysis (DEA) is a method to assess the efficiency and effectiveness of decision-making units (DMU) or enterprises that deliver related products [7, 25]. It is also a relatively new "data-centric" technique for evaluating the efficiency of a group of peer units by transforming different inputs into different outputs [26]. Each variable in DEA can be assessed in its typical measurement units, such as the hectare, meter, or number, and it is a non-parametric formulation that requires the declaration of non-functionality [27].

DEA has been used in a variety of industries, including banking, healthcare, education, the financial sector, utilities, and agriculture. It has also been used in transportation-related fields such as ports, railroads, airlines, public transportation, airports, etc. The efficiency of each unit in the group relative to other members is determined by the Data Envelopment Analysis (DEA). The Charnes, Cooper, and Rhodes (CCR) model, which assumes there are n DMUs, each using m inputs and producing s outputs, is considered to be the most widely used method [28]. A CCR model compares different sets of DMUs with the same inputs and outputs to determine the relative efficiency of the DMUs. This is how the CCR model is presented:

Maximise:

$$h_o = \frac{\sum_{j=1}^{s} W_j Y_{jo}}{\sum_{i=1}^{r} V_i X_{io}} \quad (1)$$

Subject to:

$$\frac{\sum_{j=1}^{s} W_j Y_{jm}}{\sum_{i=1}^{r} V_i X_{im}} \leq 1 \quad (2)$$

$m = 1,2, \dots, n$
$W_j \geq 0;\ j = 1,2, \dots, s$
$V_i \geq 0;\ \ i = 1,2, \dots, r$

Where:
$Y_{jo} = Output\ j\ of\ DMUo$
$X_{io} = Input\ i\ of\ DMUo$
$W_j = Weight\ for\ output\ j$
$V_i = Weight\ for\ input\ i$
$n = No\ of\ DMU$
$s = No\ of\ inputs$
$r = No\ of\ outputs$

If $h_o = 1$, it means that DMU_o is efficient relative to other similar DMUs. If $h < 1$, then DMU_o is inefficient.

Hence, if the organization/the unit has an efficiency score of less than 1, it is considered technically inefficient. Also, it shows that the operational effort used to produce the results in question is unreasonable. Therefore, it is necessary to reduce the input or increase the output, depending on the type of orientation model used. For this reason, an inefficient DMU can use an examination of the slack variables to uncover the main reasons for its inefficiency and move forward. To improve the operational efficiency of inefficient DMUs, this study categorized the utilization of variables (inputs and outputs) to determine how much more the output needs to be increased and/or how much the input. It shows how much needs to be reduced and then creates an inefficient DMU efficient [27].

The choice of input and output variables has a large impact on the company's year-to-year efficiency. Therefore, the following variables are used as inputs and outputs for this study based on the transport company's goals and missions, a literature review of input and output components used in other studies, and data availability. The total of covered km is used as an output variable for calculating technical efficiency. Input factors include the number of staff and the buses used. The total number of passengers carried annually is used as an output variable to assess operational effectiveness. The study then used cross-sectional data and the CCR-DEA input-oriented model to assess firm efficiency levels over the study period. This is because input orientation assumes that an organization's inputs are easier to control than its outputs. Enterprises can regulate the resources they use to provide transit services (number of buses, staff, etc.), but they cannot control how many people get favored in a year when using their services. Finally, the DEAP 2.1 software, based on his input-oriented CCR model [29] was used to calculate operator efficiency values for a given year.

4. RESULTS AND DISCUSSION

This part presents the technical efficiency and operational effectiveness results of municipal bus companies during the period covered (2016/17 to 2021/22).

4.1. Technical efficiency analysis

4.1.1. Fleet utilization

The percentage of a carrier's fleet that is used in a given year is known as fleet utilization. It serves as an efficiency indicator and a reflection of the standard of bus supply, maintenance, and servicing. Taking into account that not all agency buses are always on the road. Some buses are projected to remain in the shop for a variety of reasons, including maintenance and repairs. As a result, higher fleet utilization results in more buses on the road and a decrease in the frequency of service problems and breakdowns.

The usage of the Anbessa municipal bus fleet was therefore highest in 2021/22 (93.5%) and lowest in 2018/19 (38%), as indicated in the following figure. Similar to this, the fleet utilization for Sheger City Bus reached its highest points in 2020/21 (93.8%) and 2016/17 (48.4%). The fleet utilization of the state-owned transit firms has increased from 2019/20 through 2021/22.

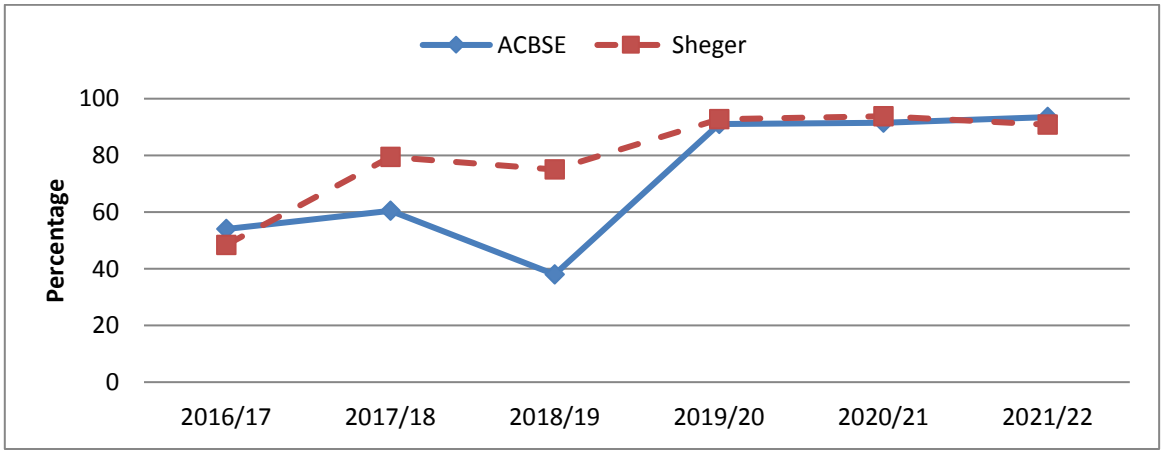


Fig. 3. Fleet utilization (%)

Moreover, 80-90% fleet utilization is viewed as acceptable, similar to Urban Bus Toolkit 2011. The combined results show that both businesses meet the requirements. This emphasizes how both companies must keep fleet utilization rates high to improve operational efficiency.

4.1.2. Vehicle productivity

This crucial measure of managing public transportation, also referred to as "bus productivity," demonstrates efficient working capital management. This is the amount of road travel a car has made in a single day, measured in kilometers. Additionally, it exemplifies how well cars are used within the system.

As a result, when vehicles travel more kilometers that are beneficial, they are being used more effectively. The productivity of each city's transit firms' fleet is depicted in the graph below.

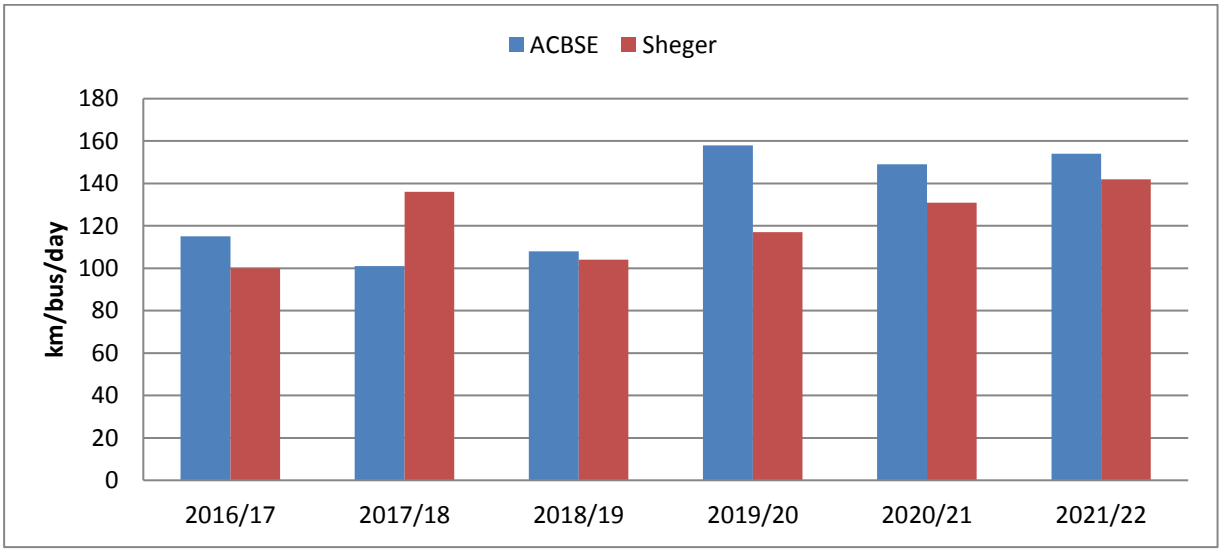


Fig. 4. Vehicle productivity: km/bus/day

As can be seen in Figure 4, the Anbessa city bus company has the highest vehicle productivity than the other city's state-owned transit provider. For instance, in 2019/20 and 2021/22, Anbessa had the greatest distance at 158 km/bus/day and 154 km/bus/day, respectively, whereas Sheger city bus recorded 117 km/bus/day and 142 km/bus /day in the same years. Overall, the Anbessa city bus was more productive in the city throughout the specified period than the Sheger city bus.

4.1.3. Technical efficiency using DEA

The technical efficiency of the municipality-owned transportation service providers is attempted to be measured and examined in this study using the aforementioned input and output variables across the years they offered services in the city.

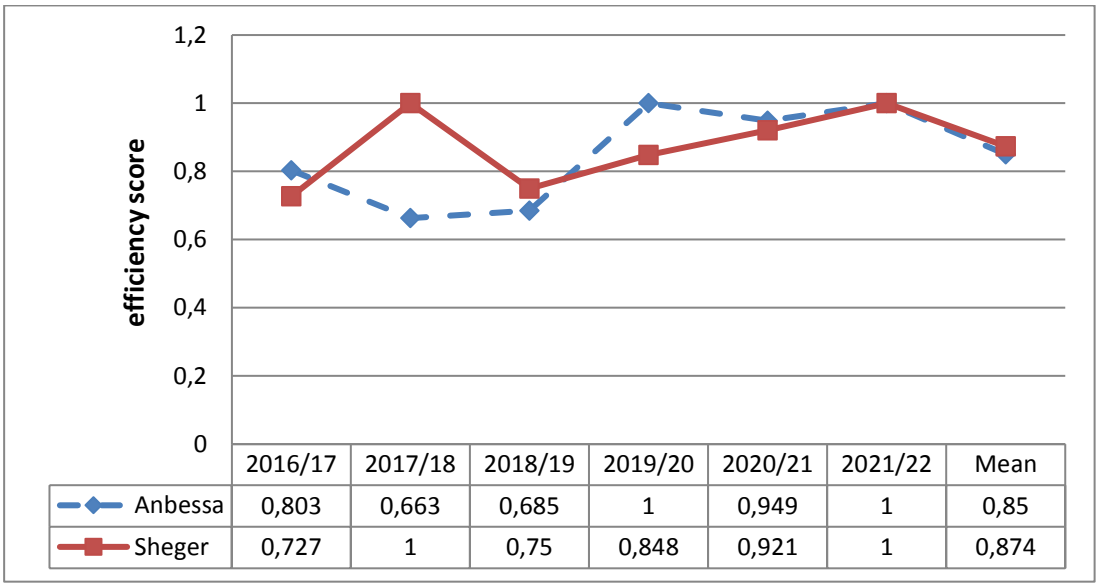


Fig. 5. Technical efficiency score

Consequently, Figure 5 shows the outcomes of the technical efficiency of the Anbessa and Sheger city buses in the city. As a result, the Anbessa bus had an efficiency score of one in both 2019/20 and 2021/22. It shows that the company used resources efficiently to deliver the intended services. In contrast, the business performed poorly in the other years, although it was still close to being efficient. Similar results are shown in the above figure, showing that Sheger city buses were technically efficient in 2017/18 and 2021/22, but inefficient in other years.

On top of that, the mean result for both enterprises shows that they were inefficient during the specified times. Hence, to improve technical efficiency and become more efficient, a company first knows the year in which it was inefficient, and then, according to Slack variable analysis, improves the next year's input variables by increasing or decreasing input levels. For example, based on the mean results, Anbessa needs 15% more resources, and Sheger bus also needs 12.6% more resources to become efficient.

4.2. Operational effectiveness analysis

4.2.1. Service utilization

This shows what portion of the available capacity is being used by frequent users. The number of passengers a city's public transit system transports determines how many effective kilometers it generates. The figure below thus includes data on each operator's traffic, as well as specifics like the typical number of passengers transported per bus per day during the specified years.

According to Figure 6, which depicts the number of passengers per day on the bus, the Anbessa city bus had the highest ratio of passengers per day on board when compared to the Sheger city bus during this period. This shows that the Anbessa municipal bus service, when compared to another operator, is very well utilized, expanding every year and reaching the highest in 2021/22. (i.e., 1,108 passengers per bus per day). Therefore, it suggests that city inhabitants make excellent use of the Anbessa bus's services as they are given.

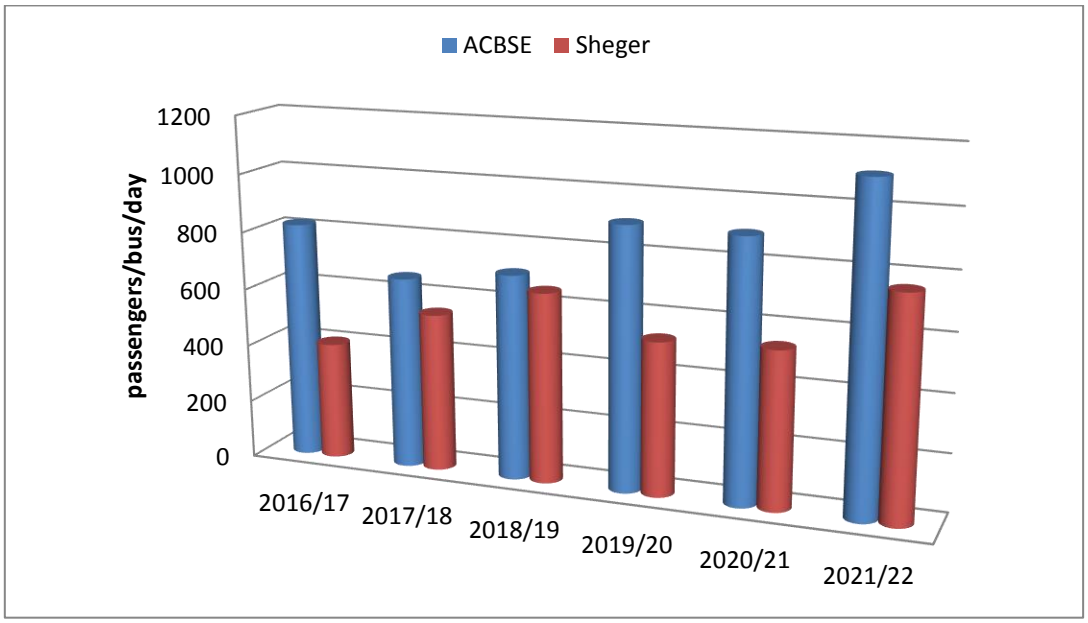
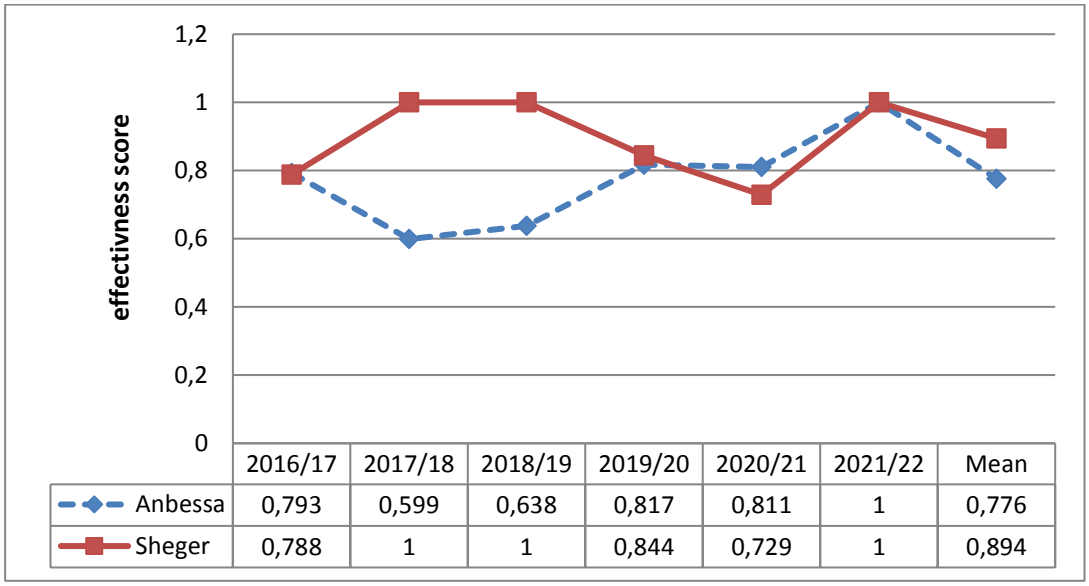


Fig. 6. Service utilization (passengers/bus/day)

4.2.2. Operational effectiveness using DEA

In addition, as seen in the following figure, the Anbessa city bus was operationally effective only in 2021/22 using the DEA model, indicating that the enterprise service was well-used by city users. However, the business hasn't been productive in years, but the outcome has improved. Besides, Sheger Bus is operationally effective in the years 2017/18, 2018/19, and 2021/22; the rest of the years it was ineffective, the score for which is equal to 1.



	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	Mean
Anbessa	0,793	0,599	0,638	0,817	0,811	1	0,776
Sheger	0,788	1	1	0,844	0,729	1	0,894

Fig. 7. Operational effectiveness score

5. CONCLUSION

This study uses the DEA model to assess the technical efficiency and operational effectiveness of the city's public bus transit system over a specified period. The study's conclusions show that Anbessa City Bus was an efficient use of resources, producing the given output in 2019/20 and 2021/22, but was wasteful in other years. Similarly, the Shegar City Bus was efficient in 2017/18 and 2021/22 but inefficient in the remaining years of the study. However, the aggregate results indicate that the level of efficiency in both enterprises has improved over the years. But, with average scores of 0.85 and 0.874 respectively, the Anbessa and Sheger city bus service enterprises had technical flaws. On the other hand, operational effectiveness reveals that Anbessa city buses were only effective in 2021/22. Besides, the Sheger city bus effectiveness score improved and started to be effective in 2017/18, 2018/19, and 2020/21. In summary, the Anbessa and Sheger municipal bus efficiency and effectiveness ratings have improved over the years, peaking in 2021/22. To support the company and increase its operational capacity, the city government should promote both operators of the city's public buses and provide subsidies and other incentives based on existing performance.

6. THE STUDY'S IMPLICATIONS

This research has important implications for academics and practitioners. The results of this study will help city government managers and decision-makers understand the effectiveness of the city's businesses from a management perspective. They can develop a plan to transform an inefficient organization into an effective organization to help identify the causes of inefficient operators and company inefficiencies. In addition, it guides the application of DEA in numerous domestic industries such as banking, hospitals, etc. A similar approach can be used to assess the effectiveness of organizations in providing services to their communities, or to assess ineffective DMUs for developing policy knowledge to improve services.

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