International Journal of Computer Information Systems and Industrial Management Applications.
ISSN 2150-7988, Volume 5 (2013) pp. 722-728

Performance Analysis on Public Bus Transport of the City of Addis Ababa

Eshetie Berhan[1], Birhanu Beshah [2], Daniel Kitaw[3]

[1] School of Mechanical and Industrial Engineering, Addis Ababa institute of Technology,
Addis Ababa University, P. O. Box: 33033, Addis Ababa, Ethiopia
Berhan.eshetie@gmail.com

[2] School of Mechanical and Industrial Engineering, Addis Ababa institute of Technology,
Addis Ababa University, Addis Ababa, Ethiopia
bireabesha@yahoo.com

[3]School of Mechanical and Industrial Engineering, Addis Ababa institute of Technology,
Addis Ababa University, Addis Ababa, Ethiopia
danielkitaw@yahoo.com

Abstract: **Providing and improving urban public transport service is becoming highly important to meet the demand of rapidly growing mass mobility due to high population growth and galloping urbanization in and around the city of Addis Ababa. This paper tries to assess the existing operational and financial performances of Anbessa City Bus Service Enterprise (ACBSE), which is the sole and government owned transport enterprise. The research used primary data, and secondary data collected from ACBSE for the last nineteen months. The findings of the study showed that the overall operational and financial performance of the enterprise is inadequate. In all the parameters of the operational performance, the enterprise operates under the international standard and could not recover its operational cost from the traffic revenue. Moreover, the enterprise has deficiency to meet the level of service quality required as well as to attract more passengers in the future. Therefore, the enterprise should design an optimum bus assignment and bus scheduling system so as to serve passengers' need with maximum satisfaction and minimize its operating costs.**

Keywords: Operational Performance, Financial Performance, Public Bus Transport, Ethiopia

I. Introduction

Mass transport facilitates efficient mobility of society in any city with less costly in the developed world. It provides a versatile form of public transportation with the flexibility to serve a variety of access-needs and unlimited range of locations throughout a metropolitan area [13]. It services the public at a cheaper operating cost, with less amount of fuel, more safely and environmental friendly as compared to the private cars, small and collective taxicabs [2]. With a motive to provide public transport service in Ethiopia, ACBSE was started before 60 years after the Italian invasion.

Currently, though the enterprise has large coverage in and around the city of Addis Ababa, it faces a lot of challenges in providing adequate service. Moreover, in terms service satisfactions of its customers, the enterprise unfortunately leaves much to be desired and remains long to go. To address this problem, in the short run, the Ethiopian government has made interventions to introduce midi buses (495 China made Higer buses with seat capacity of 25 passengers) and encouraged private owners to participate in the public transportation. In the long term, the government has considered the establishment of bus assembly lines and railway systems as remedies in the Growth and Transformation Plan [11]. These will have, in fact, played an essential role in preserving and revitalizing the downtown areas of major Ethiopian cities.

Notwithstanding the efforts made, the short run interventions could not address the high demand rather created high congestion in the mixed traffic system. The long run interventions namely the railway system, cannot fully substitute the bus service; and expansion of city roads and increasing the number of buses could not address the problem without efficient utilization and scheduling of buses. Whatever systems are in place as a solution, if there is no efficient use of that system, it may rather create additional problem. Thus, the bus service operation of ACBSE requires a continuous performance assessment for efficient and proper utilization of buses to serve the current and future customers' demand. The objective of this paper is therefore to assess the existing operational and financial performances of ACBSE to increase its efficiency.

The remainder of the article is organized as follows: section2 gives brief literature review and background about ACBSE; section3 states the research methodology; section4 presents the result and discussion, and at last, section5 gives the conclusion and future research directions.

II. Literature Review

In this section, a brief overview of the public bus transport of ACBSE is given. Moreover, different international standards

on the performance of public bus transport are also reviewed for the purpose of comparison with the performances of ACBSE.

A. Public Bus Transport in Addis Ababa

Addis Ababa lies at an altitude of over 2,300 meters above sea level and is located at 9˚1'48"N and 38˚44'24"E coordinates. The city has a population size of more than 3.8 million with 3.8% annual growth rate [5]. The history of the public transportation service in the city of Addis Ababa is dated back to the end of the Italian invasion. It was started in 1942, when fascist Italy was driven out of Ethiopia, by collecting vehicles and spare parts used by the invader. In 1952 it was reorganized as Share Company and started its service with ten buses, which were dispatched in four routes each containing two buses. In 1982 the Share Company was nationalized by the government. Currently it is named as Anbessa City Bus Service Enterprise (ACBSE) and owned by the Federal Government of Ethiopia. Its operations are also financially supported by the city administration.

ACBSE has a monopoly exclusive right to provide transportation service with great responsibility to serve the public and improve/upgrade its service to satisfy its passengers' need as well as to cut costs at large. At the moment, the enterprise uses two types of buses with a seat capacity of 30 and 50 passengers. As of October 2012, the service is provided from 3 central depots, 4 bus terminals, 110 routes, 16 check points and 1,400 bus stops throughout the city. The numbers of buses operating are fluctuating due to maintenance problems. As of the same year, there are 320 DAF, 27 Mercedes, 315 Bishoftu buses with a seat capacity of 30 passengers and 97 articulated locally assembled buses with a seat capacity of 50 passengers.

As it is evident from the Statistical Report of ECSA [5] and Africa-Trans (2010) the numbers of bus user dwellers in and around the city of Addis Ababa have increased from time to time due to the galloping urbanization and rural exodus. The estimate showed by Africa-Trans [2] in the year 2020, 5% of the African population will be living in urban areas, with no exception for Ethiopia and in particular Addis Ababa. A similar study made by Gebeyehu and Takano [10] showed that, by the same year, the population of Addis Ababa will be estimated more than 5.5millions. From the same forecast, the population and bus user dwellers of Addis Ababa by the year 2012 were also estimated 4 and 3.4millions respectively. With reference to the bus user dwellers estimated by Gebeyehu and Takano [10], Addis Ababa has a greater number of populations that is 3.6millions with annual growth rate of 3.8% [5].

B. Route Characteristics of the Study Area

The bus routes of ACBSE are both radial and tangential. Most of them are radial starting from the center and extends outwards to the suburb of the city. The enterprise currently operates with an average route length of 14.6Km, most of which are radial routes to the central business and commercial areas of the city. It has expanded its routes with two phases, from 93 to 110 routes, just in a short period from 2011 to 2012. As of October 2012 the enterprise operated with a total route length of about 1606Km. Each route has a number of bus stops spaced at a distance of 350-500 meters unless exceptional policy and/or topographic restriction exists. A brief summary of the route characteristics are shown in Table1. The Enterprise has experienced long dead mileage with an average of 19.31Km per bus per day.

	Route length (km)	**Travel Time (min)**	**Trips per route**	**Buses Per Route**	**Dead Mileage (Km)**
Min.	3.8	20	12	2	8.40
Max.	52	110	188	8	47
Mean	14.6	52	61.5	4	19.31
Total	1606	5728	6764	435	1740.44

Table 1 Route Information of ACBSE (October 2012)

C. Public Bust Transport Performances

Public bus transport provides an important mobility for people within urban area throughout the world. Therefore, improving performances of the urban bus service could essentially contribute for improving the mobility of passengers and productivity of the Enterprise. This is because efficient operation of urban bus system is contributing to the development of any society [12]. However, as different literature shows, improvement in urban bus system is not an easy task. The difficulty in doing this is because those urban bus systems are affected by many overlapping factors.

The performances of a public bus transport systems are affected by several criteria, such as increasing the number of buses, number of bus stops, number of passengers, and changes along roadways [8]. Therefore, the various issues causing inefficient operation of bus services need to be identified and appropriate measures should be formulated to resolve it. As discussed earlier, efficient urban bus system can play an essential role in reducing urban travel congestion, air pollution, energy consumption, and in the long run it can decrease highway investment and associated impacts [18]. In order to make an improvement on the bus operation, therefore, the performance of the existing bus operation has to be studied well.

To this effect, performance measurement has become the focus of attention in a variety of public sectors. Unfortunately, too little has been done to develop valid operational definitions of performance, or to identify the weaknesses and biases inherent certain types of performance measures. Among the many other parameters, according to CIRT [3] bus and labor productivity, fleet fuel efficiency is used as a measure of performance in the urban bus transport system. However, the consideration of computing these parameters may vary. For example, Badami and Haider [7] modified the parameters: Percentage Load Factor (PLF) using passenger-kilometer per carrying capacity of buses rather than passenger kilometer per seat capacity; the financial parameter by passenger-kilometer per litter rather than kilometer per litter and the labor productivity by passenger-kilometer per employee per route rather than buses per staff which were used in CIRT [3].

Moreover, other performance analysis such as route design urban bus planning [16], as well as bus and driver schedule [6] which tried to combine bus and driver schedule are other examples in bus scheduling. Some also set standards such as

the number of passengers in a given bus [17], the average kilometers per day [1, 17]. Others such as Hawas et al. [18] evaluated urban bus performance using Data Envelopment Analysis (DEA) based on some selected input (i.e. travel time per round trip, total number of stops, total number of operators, total number of buses) and output (i.e. daily ridership and vehicle-kilometer) variables. Other Key Performance Indicators (KPI) is also studied by Randall et al. [4] and used Financial, Customer, Learning and Growth, and Business Processes as KPI.

As shown in various literatures, performance is a broad term and it depends on how the organization defines it. The methods may differ from one another depending upon their objective, the field they are applied to, the approach they employ, the basis of the metrics and the data they used.

In this paper, the performance of ACBSE is evaluated based on two broad performance measurement parameters namely: operational and financial performances. According to Iles [14] there are wide international variations in geographic, climatic, demographic, political, institutional, economic, environmental and cultural factors which influence the operation of a transport undertaking. However, for comparison purpose considering all the above factors would be very difficult to quantify and involve in the performance measurement. Therefore, the standard performance indictors from different authors are used for comparison purpose. According to Iles [14], urban buses on all day service will normally operate between 150 and 300 Km per vehicle per day (KPVPD); however, Armstrong-Wright and Thiriez [1] stated that, for a reasonably run of urban bus service recommended that the average should be in the range of 210 to 260.

The bus utilization of an urban bus transport can also be computed based on different approaches. It can be measured by the number of passengers transported in a given day per bus or the ratio of the number of passengers getting on the bus and passengers capacity of bus [15]. The numbers of passengers carried per vehicle per day (PPVPD) for a bus with capacity of 80 to 100 passengers is in between 1000 to 1200. Moreover, the vehicle utilization and the PLF are normally in between 65% to 75% and 80% to 90% respectively. But with regard to fuel consumption they came up different findings. Iles [14] estimated between 35 and 45 ltrs/100kms for a single deck bus but for Armstrong-Wright and Thiriez [1], the estimate is between 25 and 55 ltrs/100kms. In addition, the expenditure per kilometer on salaries and wages in developing countries, with low wage and salary, will generally be between 10% and 40%. Operating surplus or deficit and ratio operating cost to revenue are expected to be positive and in the range of 1.05:1 [1, 7, 12, 14].

III. Research Methodology

Both primary and secondary data were collected and analyzed for this research. The primary data were collected through interviews of officials of ACBSE, which are expected to have high relevancy to the problem. The interviews include the General Manager of ACBSE, Research and Planning Officers, Ticket Daily Service Officers and Financial Officers in ACBSE. The interviews were conducted thoroughly related to bus scheduling, route design, and challenges faced in the transportation service. Moreover, direct observations were also made in different depots, terminal, routes, bus stations and bus stops.

The secondary data related to the number of passengers, number of buses, revenue generated and different expenses to operate the bus services were also collected. The Kilometer coverage of each route, the tariff charged the number of working days and the total daily trips made by each bus were collected from the secondary data. From the data collected the route performances of ACBSE were organized to measure its performance in monthly bases from the year 2010/11 to 2011/12 for about 19 months. Though the enterprise operates on 110 routes, as of November 2012, only 93 routes were considered in the study. This is because the remaining routes were very new and they did not have sufficient data for the study.

Using the data different operational and financial performance analysis was made. With regard to operational performances fleet utilization, PPVPD, KPVPD, and PLF are computed. Whereas in the case of financial performances, a much better measure of the actual utilization of buses which are: profit earned, ratio of cost to revenue, revenue to labor cost, revenue to fuel cost, revenue to spare parts and revenue to labor cost are assessed. The comparisons are mad in two approaches to assess the performances of the transportation system of ACBSE. This is either by comparing with standards or by measuring and assessing the relative efficiencies if no standards are available [18].

IV. Result and Discussions

The result and discussions are organized in two parts for clarity and readability. The first part covers the operational performances then followed by the financial performances.

A. Operational Performances

The operating performances of ACBSE are evaluated using some performance measuring parameters, namely; passenger volumes, fleet utilization, vehicle-kilometers and PLF. In this section, the paper tries to address the extent to which available fleet is utilized by the public. Utilization normally varies between different times of the day (i.e. between peak and off-peak periods), different days of the week, and different times of the year. During peak times, fleet utilization and PLF on urban bus services should normally be between 95% and 100% [14].

In the study the PLF, PPVPD, KPVPD, the fleet utilization and ltrs/100kms of ACBSE on daily basis are computed. The findings of the study show that ACBSE has significantly low operational performances in almost all the parameters evaluated as compared to the standards. In order to compare with the standards, a thorough investigation for each performance parameter is required. The PPVPD is one of the parameters that measure the operational performances of a bus transport company. It is a significant indicator of productivity, which is the number of passengers carried in relation to the capacity of the system. It is measured in terms of the average number of passengers per operating bus per day. As shown in Figure1, the average PPVPD of ACBSE is found to be 786.63

with stdv. = 151.59. As compared to the standard, which is 1000 to 1200 with mean of 1100 [1], the performance of ACBSE is significantly low with higher standard deviation. The maximum PPVPD, which is Max. = 955.41, in the last 19 months even could not attain the standard minimum. Moreover, Figure1 shows the PPVPD is fluctuating from month to month with higher standard deviation. The increase in passengers carried is certainly due to the rapid demand growth, which actually increased dramatically from month 9 to month 11 and slightly afterwards in the last months.

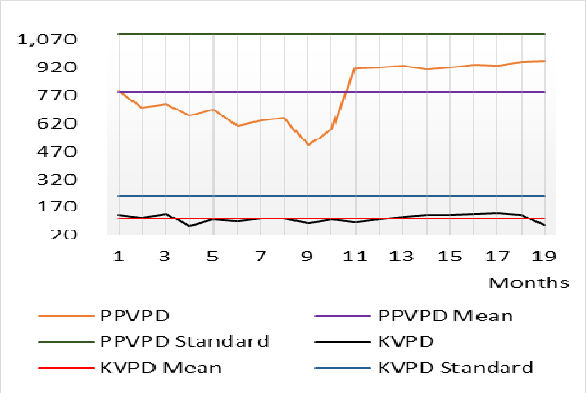

Figure 1. Comparison of PPVPD and KVPD with the standard

A further indicator of the productivity of a bus fleet is the total distance traveled by buses in service, i.e., KPVPD. This is usually expressed in terms of average kilometers per operating bus per day. The KPVPD of ACBSE is also reported in Figure1. In this regards, the performance of ACBSE with respect to KPVPD (Mean = 109.32 and Stdv. = 20.42) is significantly low as compared to the range of the standard reported in [1, 14].

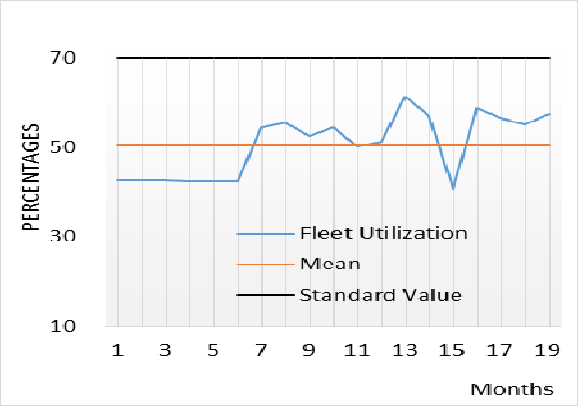

Figure 2. Comparison of Fleet Utilization with the standard

The proportion of a bus fleet that can be put into service each day has a direct bearing on the productivity of the system. It has an implication on the effectiveness of bus maintenance, spares and procurement, and stock keeping as well as staff recruitment and management. Fleet utilization, expressed as a percentage of total fleet, is usually calculated by dividing total buses running during the morning or evening peak period by the total fleet size (excluding any buses that are beyond repair). With adequate maintenance and staff management, it should be possible to achieve fleet utilization of between 65% to 75 (mean =70%). As shown in Figure2, the average fleet utilization of ACBSE is 50.53% of the total available fleet. From the finding, as compared to the standard 70%, ACBSE has very low operational performance with regards to its fleet utilization but has improved with slight fluctuation.

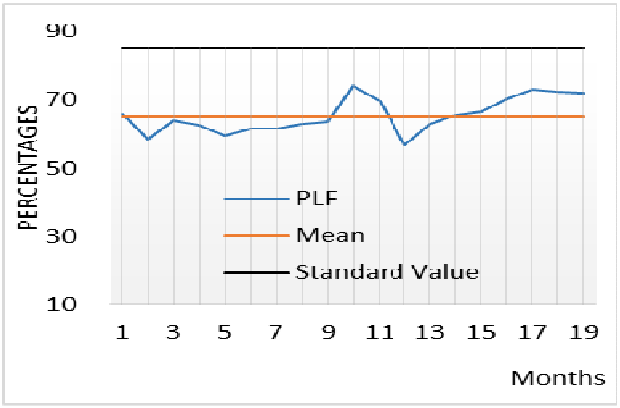

Figure 3. Comparison of PLF with the standard

The PLF of ACBSE is also computed and reported in Figure3. It is computed using the ratio of Passengers-Kilometer to carrying capacity of buses for the last nineteen months. The PLF, with an average value of 65.33% and shown in Figure3, shows very low performance as compared to the standard stated in Armstrong-Wright and Thiriez [1]. It is in fact has been improved slightly in the last nineteen months. In some months the load factor was close to 73.86% showing fair improvement on the average bus loadings, but still low as compared to the standard which is in between 80% to 90% with mean of 85%.

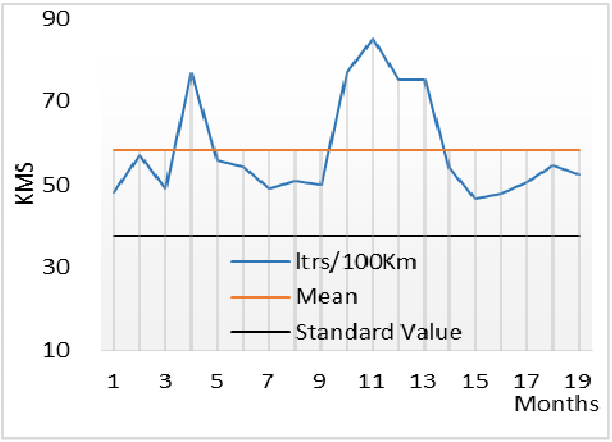

Figure 4. Comparison Ltrs/100Km with the standard

The other productivity indicator parameter is the fuel consumed in 100km covered. In this regards, ACBSE consumes an average of 58.36liters of fuel in every 100kms. The finding is shown in Figure4. It also exhibits large fluctuation from month to month. The overall performance

indicates that low range of kilometers covered with high fuel consumption per 100kms. This may happen due to the large number of old buses that can cover short range of kilometers and consume too much fuel (see Figure 4).

B. Financial Performances

ACBSE is usually working on loss; indicating that the revenue of the enterprise is far lower than its operating costs. The ticket sold for a given trip varies based on the route length and its value is much lower than other fares such as minibus taxi [2]. The public bus operations in Addis Ababa had losses even before tax for the last nineteen months. Based on the interview, such losses had happened almost since its establishment.

S/No	Losses (ETB)**	(%) Ratio of Reveune to			Total Cost
		Fuel cost	Labor cost	Spare Part	
1	6,855,072.10	66.44	37.59	28.14	0.69
2	6,336,531.85	76.36	35.55	15.84	0.71
3	3,852,178.00	63.15	28.76	12.91	0.86
4	5,342,081.15	74.11	30.71	10.43	0.78
5	6,962,531.85	86.81	35.15	10.51	0.68
6	7,138,531.85	85.23	35.43	9.81	0.67
7	5,532,210.10	76.62	30.62	7.18	0.79
8	5,676,339.15	77.14	31.90	5.25	0.80
9	14,033,579.90	81.48	34.29	53.81	0.55
10	12,464,582.45	98.63	38.31	19.12	0.59
11	7,361,554.80	78.83	29.81	16.68	0.84
12	22,014,407.65	77.20	36.40	26.14	0.52
13	22,423,467.40	76.40	28.91	17.14	0.55
14	13,419,662.10	80.40	28.12	7.23	0.73
15	10,863,503.60	75.26	28.83	5.92	0.94
16	12,978,214.40	73.84	29.07	5.57	0.66
17	5,663,757.70	77.99	26.82	6.35	1.20
18	15,170,332.70	41.02	24.99	3.18	1.11
18	13,848,498.50	49.42	24.01	4.82	1.16
Min*.	22,423,467.40	41.02	24.01	3.18	0.52
Max.	3,852,178.00	98.63	38.31	53.81	1.20
Mean	10,417,738.80	74.54	31.33	14.00	0.78
Stdv.	5,503,569.12	12.77	4.24	11.99	0.20

**Min = Minimum, Max. = Maximum and Stdv. = Standard Deviation of the sample; ETB = Ethiopian Birr (As of February 27, 2013 1USD = 18.13ETB)

Table 2. Financial Performance of ACBSE for the Last 19-Months

As shown Table 2, the consistent losses ranges from 3.852 to 22.42 million of Ethiopian Birr with an average losses of 10.42 million Birr. The operations obviously show that the total costs even before taxes consistently exceeded total revenues (mainly from passenger fares or traffic revenues

The costs of bus services are mainly dependent on local labor, fuel and spare part cost but are also greatly influenced by the efficiency of operations management, road traffic and conditions. The first point to note in ACBSE is that a much higher share of operating costs was recovered through fares or traffic revenue. However, though the traffic revenue improved steadily, the high fuel and labor costs absorbs the large proportion of it. As reported in Table2, the mean proportion of fuel and labor cost consumed 74.54% and 31.33% of the total traffic revenue generated. Moreover, on average the spare part also consumes 14.00% of the total revenue. The average proportion of the labor cost is within the ranges of the industry standard. This may be due to the high number of unclassified labor force with lower costs.

In order to be self-sufficient and to avoid the subsidies, revenue should cover costs and show a small surplus to stimulate investment and growth. To meet these requirements, the operating ratio (total revenue divided by operating costs, including depreciation) has to be computed and checked. However, as different development stages and financial methods result in different depreciation of bus assets, the depreciation cost in this study is therefore, removed from the operating cost for a fair comparison purpose.

As compared to the standards, the overall financial performances of ACBSE were significantly very low except the last three months. In most of the time the operating ratio was fluctuating and in the last three months showed good recovery. But overall mean shows less than 1 with higher standard deviation (Average = 0.78 and Stdv. = 0.20). Indicate that ACBSE could not recover its operating costs from the traffic revenue generated in its services.

V. Conclusions and Future Works

The paper tries to assess the performances of ACBSE using operational and financial performance measurement parameters. From the findings of the study it can be concluded that both the operational and financial performances of the enterprise, as compared to the standard, are relatively low in most of the performance measuring parameters. In the case of operational performance, the enterprise has experienced low operational performance in all the parameter. In the case of PLF, though the overall average exhibits very low, it has shown slight improvement from month to month. Similar improvements also observed on the PPVPD after month nine.

Though there are many new buses in the enterprise, the operational fleet still includes many old buses which have more than 10 years of age. This adversely affects the performances of the enterprise with regard to fuel consumption and distance covered. Moreover, the cost to revenue ratio is less than one in most of the time, even after excluding the depreciation cost, indicating that the enterprise is operating at a loss even before tax.

Therefore to support and fully utilize the interventions made by the government as well as the enterprise itself, there should be a continuous performance evaluation system that can

measure key performance parameters of the bus service based on the international standards. In addition, proper bus scheduling and assignment would also improve the performance of the enterprise.

It is evident that the low PPVPD is resulted from the poor bus scheduling system used in the enterprise. That is a fixed number of buses per route are scheduled almost in all the operating times. This increases the dead mileage of buses during off-peak and adversely affects the quality of the service quality during peak hours. The bus utilization during off-peak hours is very low and most of the time buses run empty and incurs additional cost without serving passengers. Whereas, in peak hours buses are forced to carry more passengers than their riding capacity per trip which negatively affects the service quality. Thus, balancing the number of buses to be assigned to routes in different time periods based on passengers' demand and seat capacity of buses to the standard allowable carrying capacity is required to reduce the costs and also improve service quality.

The enterprise should also strategically design a means to replace the old buses with the new one so that KPVPD and the fuel consumption would be improved significantly. This also would have a subsequent effect on the fleet utilization of the enterprise. A study shows that making a marginal profit from public bus transport is unlikely. However, as most public bus transport companies do in the rest of the world, ACBSE should also supplement its revenue by other side activities. In this regard ACBSE has an exemplary start up and should be encouraged to generate revenue by providing different services such: maintenance, annual vehicle checking, etc. to the public. Furthermore, future research can address the gap observed on bus scheduling and optimum allocation of buses for each route by considering the passengers' demand distribution. Since the operational and the financial performance measuring parameters do not address the level of service quality, future study can address this gap.

References

[1] A. Armstrong-Wright, and S. Thiriez. “Bus services: reducing costs, raising standards World Bank”, Washington, D.C., 1987.

[2] Africa-Trans. “Statistical indicators of public transportation performance in Africa”, Report, final version 1.3, International Association of Public Transport (UITP) and African Association of Public Trasnport (UATP), 2010.

[3] CIRT. “Performance statistics of state transport Undertakings 1989–90 and 1990–91”, Report, Central Institute of Road Transport, Pune, 1992.

[4] E. Randall, B. Condry, and M. Trompet. “International bus system benchmarking: Performance measurement development, challenges, and lessons learned”, Transportation research board 86th annual meeting, South Kensington Campus, Lon-don SW6 2AZ, UK, Imperial College London, 2007.

[5] ECSA. “Ethiopian central statistics agency census report”, Report, Ethiopian Centeral Statistics Agency, Addis Ababa, Ethiopia, 2008.

[6] F. Orlando, C. Valouxis, and E. Housos. “Combined bus and driver scheduling”, Computers & Operations Research 29, 243-259, 2002.

[7] G. Badami, and M. Haider. “An analysis of public bus transit performance in Indian cities”, Transportation Research Part A: Policy and Practice 41(10), 961-981, 2007.

[8] IIT. “Operational Improvements For Buses On Urban Roadways”, Proceedings of the International Conference on Best Practices to Relieve Congestion on Mixed Traffic Urban Streets in Developing Countries, Chennai, 2008.

[9] J. Yu. “Transportation Engineering-Introduction To Planning Design and Operations”, Elsevier, New York, 1982.

[10] M. Gebeyehu, and S. Takano. “Diagnostic evaluation of public transportation mode choice in Addis Ababa”, Journal of Public Transportation 10(4), 27-50, 2007.

[11] MoFED. “Growth and transformation plans (GTP) for the year 2010/11-2014/15”, Report, Ministry of Finance & Economic Development, Addis Ababa, Ethiopia, 2010.

[12] P. Agarwal, and A. Singh. “Performance improvement of urban bus system: Issues and solutions”, International Journal of Engineering Science and Technology 2(9), 4759-4766, 2010.

[13] R. Borndorfer, G. Martin, and U. Jaeger. “Planning problems in public transit”, Report, ZIB, 2009.

[14] R. Iles. “Public transport in developing countries”, Report, Elsevier, Amsterdam, 2005.

[15] S. Mehmet, A. Mawada, and A. Jafar. “Scheduling and routing of city buses at Kuwait public transport company”, International Journal of Applied Operational Research 1(3), 11-32, 2012.

[16] T. Chua. “The planning of urban bus routes and frequencies: A survey”, Transportation 2, 147-172, 1984.

[17] TCRP. “Transit Capacity and Quality of Service: Part 4 Bus Transit Capacity Manual”, 2nd Ed., Kisttelson & Associates, Inc., 2012.

[18] Y. Hawas, B. Khan, N. and Basu. “Evaluating and enhancing the operational performance of public bus systems using GIS-based data envelopment analysis”, Journal of Public Transportation 15(2), 19-44, 2012.

[19] JM Corchado, J Bajo, DI Tapia, A Abraham, Using heterogeneous wireless sensor networks in a telemonitoring system for healthcare, Information

Technology in Biomedicine, IEEE Transactions on 14 (2), 234-240, 2010.

[20] C Grosan, A Abraham, A new approach for solving nonlinear equations systems, Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions, 2008.

[21] A. Abraham, NS Philip, P Saratchandran, Modeling chaotic behavior of stock indices using intelligent paradigms, archive preprint cs/0405018, 2004.

[22] H Izakian, A Abraham, V Snasel, Comparison of heuristics for scheduling independent tasks on heterogeneous distributed environments, Computational Sciences and Optimization, 2009

[23] F Xhafa, E Alba, B Dorronsoro, B Duran, A Abraham, Efficient batch job scheduling in grids using cellular memetic algorithms, Metaheuristics for Scheduling in Distributed Computing Environments, 273-299, 2008

[24] Y Chen, A Abraham, B Yang, Feature selection and classification using flexible neural tree, Neurocomputing 70 (1), 305-313 47, 2006.