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Simulation Modeling of Bus Ticket Sales Operations- A Case of Community Bus Service Company

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Abstract

The study focused on simulation of bus ticket sales operations of a company in South Africa using Arena software to evaluate the operations efficiencies and identify areas of improvement based on the modeling results. Structured interviews were first conducted over a period of two days where 97 ticket buyers were interviewed as population. 54.64% used buses for travelling to and from work , 26.80% used buses to purchase household items and 18.56% purchased tickets to visit friends and family. Furthermore, 88.66% of the population were employed full time at their workplaces , thus relying on bus for travelling to and from work as 59.79% did not own cars meanwhile 40.21% owned cars but relied on bus to travel to work daily for the purpose of reducing costs associated with purchasing of fuel to travel with their own cars. Purchasing of bus tickets on weekends was preferred by 50.52% , 35.05% preferred between Monday and Friday, while 6.19% preferred purchasing any day. Furthermore, bus ticket sales were also assessed to be sold online, however, only 8.25% preferred purchase online while 91.75 preferred purchase onsite. Simulation of 8 hours of operations indicated a potential of 53 bus ticket sales compared to actual average of 44 sold. Thus, this indicated 20.45% potential increase. An improvement scenario of operating time increases by 5.5 hours to make up 13.5-hour operations indicating a potential of ticket sales to 89 which is 67.92% increase of the 53-ticket sales potential on the current operating time. Furthermore, teller 2 on counter 2 from the current 8 hours operations and 13.5 hours operations indicated to be less utilized while counter 1 is utilized though processing lower ticket purchases. Teller 2 on counter 2 potentially contributed 54.72% and 52.22% in 8 hours and 13.5 hours ticket sales output compared to teller 1 on counter 1 who contributed 45.28% and 47.78% respectively. It was further concluded that increasing the current 8-hour operating time by 68.75% can potentially increase ticket sales by 69.81%, though additional assessment should be carried out such as financial evaluation to pay for the extra shift associated with increase in ticket sales.

Keywords

Arena, operations, population, simulation, and teller

1. Introduction

Background

The recent economic performance pressure in South Africa as indicated by inflation rates has pushed most citizens to find alternative means of optimizing utilization of their disposable income. This has been qualified by the decline in retail trade sale post covid 19 as noted on Table 1 as reported by (Stats sa 2023).

Table 1. Percentage change year-on-year in sales within the retail trade at constant 2019 prices

Source: Stats sa (2023)

Month	2018	2019	2020	2021	2022	2023	*2023 year-to-date*
Jan	3,9	1,3	1,5	-3,9	8,1	-2,1	*-2,1*
Feb	5,1	1,5	2,0	2,5	-0,6	-1,9	*-2,0*
Mar	5,8	0,3	3,7	-2,6	2,7	-1,4	*-1,8*
Apr	1,0	2,8	-47,6	87,2	4,8	-2,6	*-2,0*
May	2,9	2,0	-11,2	15,1	0,3	-2,9	*-2,2*
Jun	2,1	2,7	-6,9	10,6	-1,8	-1,8	*-2,1*
Jul	1,6	2,2	-8,3	-0,5	9,3	-1,0	*-2,0*
Aug	2,4	1,3	-3,8	-1,2	2,3	-0,3	*-1,8*
Sep	0,6	0,6	-2,4	2,2	-0,3	0,9	*-1,5*
Oct	2,3	0,8	-2,0	2,0	-1,1		
Nov	2,9	2,9	-4,8	2,2	0,7		
Dec	-1,6	-0,2	-1,2	3,1	-1,3		
Total	**2,2**	**1,5**	**-6,5**	**6,3**	**1,7**		

Furthermore, this has been further indicated by the unstable Consumer Price Index (CPI) which trended the highest at 6.90% on average in year 2022 compared year 2019 util 2021 meanwhile as at November 2023 the average is at 5.98% compared to an average of 6.28% for November 2022. This meant a slight improvement of 0.3% compared to previous year. This has been reported by (Stats sa 2023) as shown on Table 2.

Table 2. CPI headline year-on-year rates

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average[1]
2019	4,0	4,1	4,5	4,4	4,5	4,5	4,0	4,3	4,1	3,7	3,6	4,0	4,1
2020	4,5	4,6	4,1	3,0	2,1	2,2	3,2	3,1	3,0	3,3	3,2	3,1	3,3
2021	3,2	2,9	3,2	4,4	5,2	4,9	4,6	4,9	5,0	5,0	5,5	5,9	4,5
2022	5,7	5,7	5,9	5,9	6,5	7,4	7,8	7,6	7,5	7,6	7,4	7,2	6,9
2023	6,9	7,0	7,1	6,8	6,3	5,4	4,7	4,8	5,4	5,9	5,5	..	..

Source: Stats sa (2023)

Furthermore, the fluctuation in high costs of fuel experienced in year 2023 as noted on contributions to the annual percentage change in Producer Price Index for final manufactured goods as at November 2023 which was 0.7% for coke and petroleum based products (Stats sa, 2023), this continues to apply pressure to most motorist by finding alternative means of travelling to their routine destinations such as workplace.

For these reasons, utilization of train, buss, taxi, and motorbikes are expected to ramp up as alternatives compared to one motor car owner travelling alone to work which cost significantly. However, trains and buses are preferred by most passengers mainly because they operate on time schedules which makes it easier for users to plan their trips. Availability of train network is a challenge though, due to consistent thefts of cables on railway lines which affects movement of trains. Thus, busses are gaining attraction as alternatives.

Efficient operations management of bus service companies is important to continuously attract more passengers which ultimately reduce traffic on roads and less carbon emissions associated with transport industry as few numbers of cars will be driven for reaching same destinations. Simulation and modelling are one of the useful options in managing operations through mimicking the behavior of real systems through usage of computer software tools such as AnyLogic and Arena. Thus, simulation is one of the techniques used in the operational research areas in numerous applications such in design and analysis of systems of manufacturing, assessment of financial systems, transport system analysis, analysis of military and service systems (Law 2014).

To date by far, three methods in simulation modeling exist which is system dynamics, discrete event modeling and agent-based modeling. The choice of the method is dependent on the system that is being modelled and modelling purpose thereof (Borshchev and Grigoryev 2013). The simulation software tools offer the advantage

of generating system scenarios to conduct predictive analysis on the operations behavior as a function of modelling parameters such as staffing, operating times, addition, and subtraction of processes on existing operations systems, moreover, building a new model for new case scenarios such as facility design and planning. Many research outputs have been published where usage of Arena as a simulation tool for optimization of existing operations and design of new systems has seen a success. Similarly, performance evaluation and monitoring of existing operations can be achieved through simulation modelling processes.
Seshoene et al. (2019) stated that Garrido (2009) indicated that Arena as a simulation software is easy to use and powerful tool which permits the user to construct several simulation model rans as experiments. Furthermore, reports are generated out the simulation ran which aid in identification of areas that are inefficient or rates of utilization which ultimately enables the process of decision making to be easy particularly in situations where there is a need for attempt to effect improvement initiatives in processes.

The application of monte Carlo simulation for modelling of sales process for the purpose of forecasting future sales has a potential to be deployed in research applications. This was a need as for many years forecasting of sales has been noted as an important baseline for company' planning process associated with their operations. Furthermore, sales forecasting has potential to change company's business model to be proactive instead of reactive and simulation modeling assist with forecasting (Merisalo and Kuula, 2018). A multi-stage sales process of a Finnish recruitment company was modelled through usage of the internal data of Customer Relationship Management and usage of Monte Carlo Simulation of repeated random sampling. The model results were used to analyze the whole process of sales and identify areas of improvement in certain stages of sale process. Furthermore, results can be used to forecast volumes of sales on a short term and long-term basis for a business, while the dual-sided role of the model has a potential to act as a decision-support-system (DSS) when the case company is assessing options such as alternative resourcing and the associated outcomes throughout their value chain. Comparison of simulation modelling proposed sales forecasting results are benchmarked with various used quantitative forecasting methods to identify accuracy and bias associated with the forecasting technique (Merisalo and Kuula 2018).

Problem statement
The unstable inflation rates and high rates of unemployment in South Africa continues to propel most citizens to explore alternative way of living to meet their livelihood needs. For example, most citizens are reducing purchasing on non-essential goods and service offerings to save disposable income. Furthermore, most motorists are opting for alternative means of transport to reduce cost associated with purchasing of fuel for them to drive at their intended destinations. For these reasons, the transport industry, particularly in bus service companies are expected to experience a in spike in potential bus passengers demand due to some of the motorists' owners opting to reach their routine destinations such as workplaces. This initiated the need to assess a community bus service company's current bust ticket sales operations from a potential number of ticket sales, resource utilization and use the current operations performance to identify areas of improvement to maximize bus ticket sales output. Simulation modeling using computer aided software have proven to be one of the relevant tools to help manage existing operations and potential identification of improvement areas.

Objective
Overall objective
The main objective was to model bus ticket sales operations of a company in South Africa to evaluate potential number of ticket sales and resource utilization at current operating time and use simulation modeling results to identify areas of improvement through scenario simulation modelling.

Specific objective
1.1.1.1. To characterize the bus ticket buyers through structured interview
1.1.1.2. To simulate the current 8 hours ticket sales operations using Arena software
1.1.1.3. To simulate the 13.5 hours ticket sales operations as an improvement scenario using Arena software.

2.Literature review
Many research studies have been conducted in the past to solve industry problems such as transportation issues by making use of techniques such as simulation and linear programming.

Zulkepli et al. (2017) developed a discrete event simulation model for bus shuttle operations at a university for students. This because providing shuttle buses for students at university to attend lecture session is crucial particularly when there is many students and distances to be travelled between their lectures classes and residential place is far. Students experienced longer waiting times at bus shuttles which eventually resulted with them complaining of service. A discrete event simulation model approach using Arena software for the current services of student shuttle buses at the university was conducted and is performance measures was reported. This aided in reducing the waiting times of students at bus shuttle.

Göçmen and Derse (2018) conducted bus capacity planning by making use of simulation modelling due to its ability to offer analytical outcomes and Arena software was used. The study purpose was through providing benefits associated with simulation modeling in bus line planning and determination of efficiencies of capacities associated with bus to meet the demand and solutions that are present in real life problems.

Lindberg (2019) also used discrete event simulation modeling to conduct a study at bus terminals operations to evaluate terminal design and traffic control policy. This is because public transport is important to many societies as it provides spatial accessibility and reduction of congestions and pollution when compared to other mode of modes of transport. Reduction of delays, congestion and ques at bus terminals are important to efficiently utilize the capacity. The path of a vehicle through terminal can be used readily as described by sequence of events it undergoes, such as arrival and commencing to drive to a stop. The model further indicated the potential to be used as a useful tool for the evaluation and comparison of numerous scenarios that are linked to layout, number of passengers and traffic situations. Furthermore, the model output for the terminal study can be used for comparison with the empirical data.

In a manufacturing sector, the net present value forecast is of great importance to sustain production plant. The implementation of monte Carlo simulation model for revenue and profitability forecast of a company under the impact of risk and uncertainty for making investment has been explored. The outcome of monte Carlo simulation results indicated an expected met present value which was acceptable based the company's financial targets as the frequency charts indicated a higher certainty of return on investment at current. Furthermore, the results confirmed 50.73% chances pf achieving the forecast on net present value for the next period of investment and the results also validated that the inflow of cash had a greater sensitivity level of 21.1% and the cash inflows of 19.7% in the next year. Cumulative frequency distribution further validated the probability of achieving certain financial forecast at 90% Hussain (2019).

Sales and operations planning (S & OP) is an integral process within planning of business through which managers gather and exchange information with regards to various areas of functional departments within the business to make decisions that lead to firm performing at the right level (Thome´et al. 2014). For this reason, DuHadway and Dreyfus (2017) studied a simulation for management of complex sales and operations planning decisions as a key lessons to students school of business administration in Portland State University and students within the department of supply chain management in Rutgers Business School of Rutgers University. The simulation exercise was demonstrated as a useful modelling tool as one of the forecasting techniques, concepts of management of inventory and as one of selection process of suppliers.

A supply chain simulation case study has been conducted by Gallego-García and García-García (2020) for prediction of sales and operations planning as a function of statistical treatment of demand which results with an increase in efficiency. Gallego-García and García-García (2020) identified that good prediction of what is anticipated soon helps to prepare the company, department, and the environment they operate in for future developments and status. Thus helps to plan resource allocation to answer the future needs of the business in manner that is efficient. The research aimed at proposal of predictive technique that can assist business managers for the development of S & OP accuracy and stability that is high. The research was associated with methodological approach that aimed at combination of scenarios if demand, demand statistical analysis, techniques for forecasting, random number generation and system dynamics. This helped to further predict the S

& OP behaviour on systems of supply chains in order plan proactively on potential inefficiency issues where this methodology was assessed by application of the model in a software Vensim for a producer in an automotive industry Gallego-García and García-García (2020).

Machine learning algorithms has been used to forecast sales as most retail companies need to use their resources efficiently and make decisions that are strategic in order to grow and stabilise revenues , particularly in conditions of market where is becoming competitive and profit margins need to be protected due to the increasing pressure. The integrative literature review conducted revealed that three main methods such as time series, artificial neural networks and machine learning algorithms existed to forecast sales. Machine learning was more suitable with respect to its level of accuracy on results, especially on models which contained variables that are exogenous and endogenous in addition to permit the recognition of demand patterns that are hidden in order to identify trends in the market (Martins and Galegale 2023). Similarly, in the everchanging demand for bus ticket sales, the case company of this study need to conduct predictive analysis through evaluation of current operational efficiencies and the required efficiency in order to meet the demand of ticket sales. Simulation modelling can be a useful tool for the assessment of current operations and new required level of performance potential.

Methodology

Flow chart of research approach

Figure 1 shows the sequence of activities that were carried out to conduct the study for the case company.

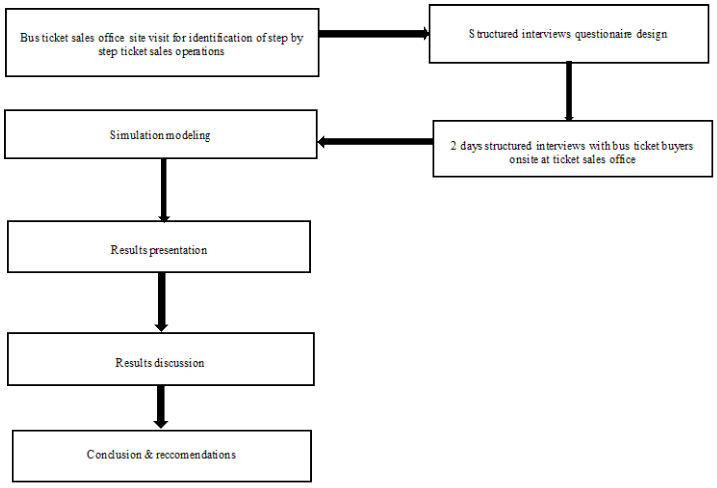


Figure 1. Step by step on sequence of activities carried to conduct study.

List of interview questions

Structured interviews were conducted with the potential bus passengers that arrived onsite to purchase bus ticket. The interviews were conducted over 2 days period from 07h00 until 16h00 by making use on questionnaires as outlined on Table 3.

*T*able 3. Structured interview questions

Reasons for bus ticket purchase
Trip to work
Trip for household shopping
Trip for family & friends visit
Other bus ticket sales questions
Do you own a car (Y/N)
Do you work full days in a month (Y/N)
When do you prefer to purchase ticket either: Between Monday and Friday Weekend, Any day or Would prefer online

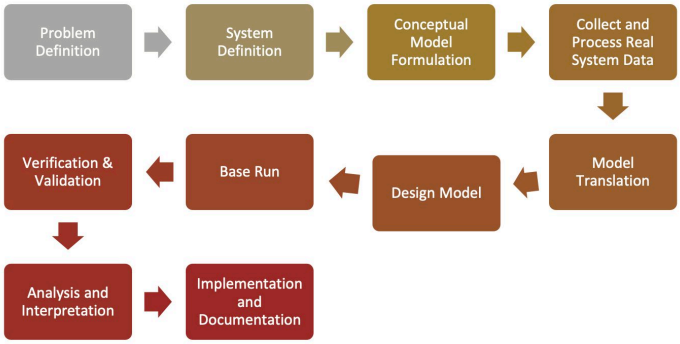
The outcome of the questionnaire was used as a motivation to conduct simulation modeling using Arena software, student version.

Simulation modeling using Arena 16.10.00002

Theoretical simulation framework

Tau et al. (2022) and Zulkepli et al. (2017) indicated that Maria (1997) stated that simulation modelling is a step-by-step procedure to produce model which is a representation of a working system of interest. Source: Maria (1997)

Figure 2 depicts the step-by-step procedure associated in modelling studies which is still in use today in much research and was followed in this study.



Source: Maria (1997)

Figure 2. Step by step procedure on model development and analysis as initial reported

This procedure was followed to model the bus ticket sales operations of the case company using Arena computer simulation modelling software. However, implementation and documentation step has not being followed due to time constraint, however, it has been noted under conclusion and recommendations of the simulation results interpretation.

Development of simulation model

1.1.1.4. Simulation statement of bus ticket sales operations

In the bus ticket sales operations of a company in Mpumalanga province of South Africa, ticket buyer arrives onsite constantly every 9 minutes. As soon as the buyer arrive, he/she must follow at a queuing time of between 4 minutes and 7 minutes before deciding to be served by at counter 1 or counter 2 ticket sales line. The probability of be assisted by either at counter 1 or 2 is 50% as is dependent on first available counter. At the counters, tellers exist who process the sale of the bus ticket using their computer sales software. Teller 1 takes a minimum of 4 minutes and maximum of 6 minutes to process the ticket sales at counter 1, while teller 2 at counter 2 takes a minimum of 2 minutes and maximum of 4 minutes. After the buyer having purchased the ticket, he/she proceeds to queue to exit the ticket sales office of the company where he/she spends about 1 minute then proceed to exceed and proceed to catch a bus in the case of same-day travel or in the next days. Figure 3 describes this process further in the form of a flow diagram.

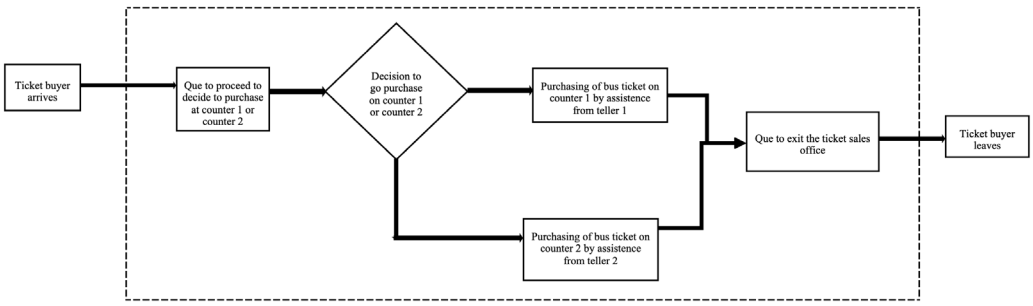


Figure 3. Sequence of processes in ticket sales operations that a buyer follows at a bus ticket sales office.

1.1.1.4.1. Input data.

The observed tine intervals per sequences activities for the bus ticket sales as described in section 3.3.2.1 was used as input data in the Arena simulation software. By using the system components built up in Arena simulation software such as:

- Entity: arrival of ticket purchaser
- Resources: teller 1 and teller 2
- Processes: Queuing for assignment of ticket buyer for either to counter 1 or counter 2 using the decision at 50/50% probability, purchasing of bus ticket at counter 1 or counter 2 and que to exit the ticket sales office.
- Attribute: ticket buyer at a constant rate of 9 minutes.

The model was ran for a replication length of 480 minutes and 4 number of replication lengths in order to simulate the current operating time. Then replication length of 810 minutes and 4 number of replication was carried out in order to mimic the behaviour of the new improved system as an optimisation scenario with respect to extended operating time to assess the extent of attracting demand and full usage of resources.

Model verification and validation.
Model verification entails the assessment of the correctness of the representation of real systems being modelled by either means of inspection of computer codes, running of tests and final performance checks on the statistical outcomes. These further assist in increasing the modeller confidence that the model is constructed correctly thus which further increases confidence level model key performance indicators of interest. Thus it further entails validation of the model which is associated with the assessment of the specifications within the model and its ability to do what it is constructed to do in order to be closer to model's real world system. Comparison of simulation results with those of available as data , for example, from the company's database is another way of validation of model (Marsudi and Firda 2018).

Furthermore, Tau et al. (2022) validated simulation results by carrying out simplified mathematical calculations of a despatch product line. Similarly, simplified calculations can be conducted in order to quantify total number of bus ticket buyers sieved or that got admitted on teller 1 and teller 2 which contributed to overall number of tickets that can be potential sold in 8 hours operations as follows:

For teller 1 at counter one:

Total number of bus ticket buyers that can be sieved for ticket sales at least waiting times per operational processes= $\frac{Available\ ticket\ sales\ hours}{\text{Total time required to process one ticket sale}}$

Total time required to process one ticket sale = Ticket buyer arrival time + Queuing time for the next available counter + time for ticket purchase on counter 1 + queuing time to exit

Total time required to process one ticket sale = 9 + 4 + 4 + 1

Total time required to process one ticket sale = 18

Total number of bus ticket buyers that can be sieved for ticket sales at least waiting times per operational processes= $\frac{8 \times 60\ minutes}{18}$

Total number of bus ticket buyers that can be sieved for ticket sales at least waiting times per operational processes by teller 1= 26.67 ~ 27 tickets

For teller 2 at counter one:

Total number of bus ticket buyers that can be sieved for ticket sales at least waiting times per operational processes= $\frac{Available\ ticket\ sales\ hours}{\text{Total time required to process one ticket sale}}$

Total time required to process one ticket sale = Ticket buyer arrival time + Queuing time for the next available counter + time for ticket purchase on counter 2 + queuing time to exit

Total time required to process one ticket sale = 9 + 4 + 2 + 1

Total time required to process one ticket sale = 16

Total number of bus ticket buyers that can be sieved for ticket sales at least waiting times per operational processes= $\frac{8 \times 60\ minutes}{16}$

Total number of bus ticket buyers that can be sieved for ticket sales at least waiting times per operational processes by teller 2= 30 tickets
∴ Total number of ticket buyers that can be potentially assisted in 8 hours shift = Total number of bus ticket buyers that can be sieved for ticket sales at least waiting times per operational processes by teller 1 + Total number of bus ticket buyers that can be sieved for ticket sales at least waiting times per operational processes by teller 2.
Total number of ticket buyers that can be potentially assisted in 8 hours shift = 27 + 30
Total number of ticket buyers that can be potentially assisted in 8 hours shift = 57
Furthermore, according to the community bus service company ticket sales data record, 44 number of tickets are sold on average in an 8 hour shift.

Results and discussion

Results

Structured questionnaire

Figure 4, 5 and 6 shows results based on structured questionnaires to bus ticket purchasers at the by ticket sales operations.

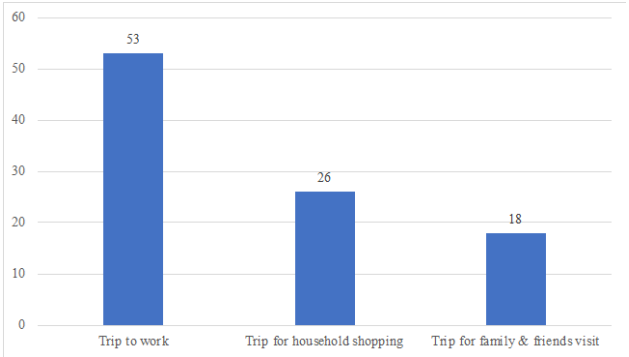


Figure 4. Responses from ticket buyers on reasons for bus ticket purchase

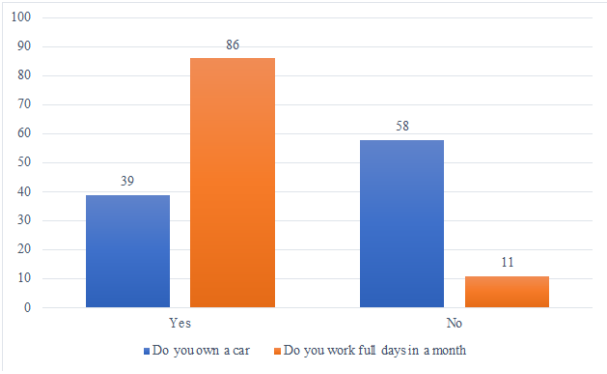


Figure 5. Responses from ticket buyers on question regarding owning a car and if they work full month.

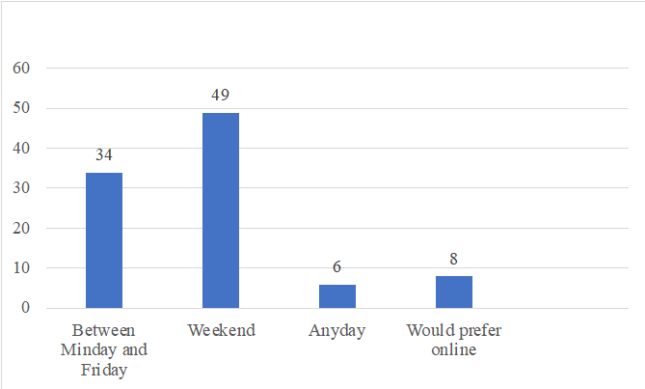


Figure 6. Responses from ticket buyers on question regarding when they prefer purchasing ticket.

Simulation modeling using Arena.

Simulation of the current 8 hours ticket sales operations

Simulation of 8 hours ticket sales operations in Arena was conducted and Figure 7, 8, 9,10,11,12,13,14, 15 and 16 indicates the model results.

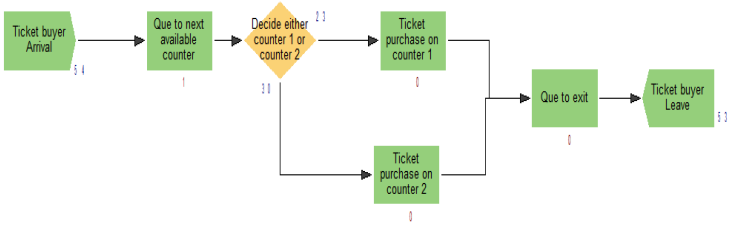
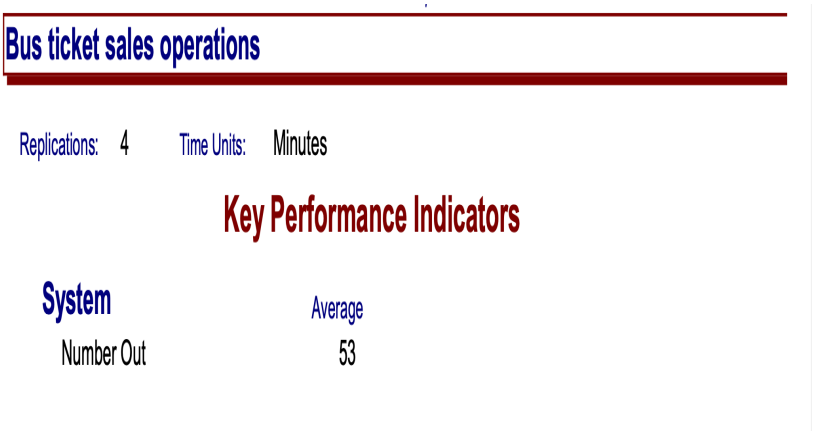


Figure 7. Simulation of the current 8 hours ticket sales operations



Bus ticket sales operations

Replications: 4 Time Units: Minutes

Key Performance Indicators

System	Average
Number Out	53

Figure 8. Number of ticket buyer serviced in current 8-hour shift

Replications: 4 Time Units: Minutes

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	10.4357	0,33	10.1522	10.6430	7.3514	13.6551

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0,00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0,00	0.00	0.00	0.00	0.00

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0,00	0.00	0.00	0.00	0.00

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0,00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	10.4357	0,33	10.1522	10.6430	7.3514	13.6551

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	54.0000	0,00	54.0000	54.0000

Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	53.0000	0,00	53.0000	53.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	1.1585	0,04	1.1272	1.1814	0.00	2.0000

Figure 9. Valued added time, none value added time for ticket buyer serviced in current 8-hour shift

Replications: 4 Time Units: Minutes

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Ticket purchase on counter 1.Queue	0.00	0,00	0.00	0.00	0.00	0.00
Ticket purchase on counter 2.Queue	0.00	0,00	0.00	0.00	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Ticket purchase on counter 1.Queue	0.00	0,00	0.00	0.00	0.00	0.00
Ticket purchase on counter 2.Queue	0.00	0,00	0.00	0.00	0.00	0.00

Figure 10. Que for ticket buyer serviced in current 8-hour shift

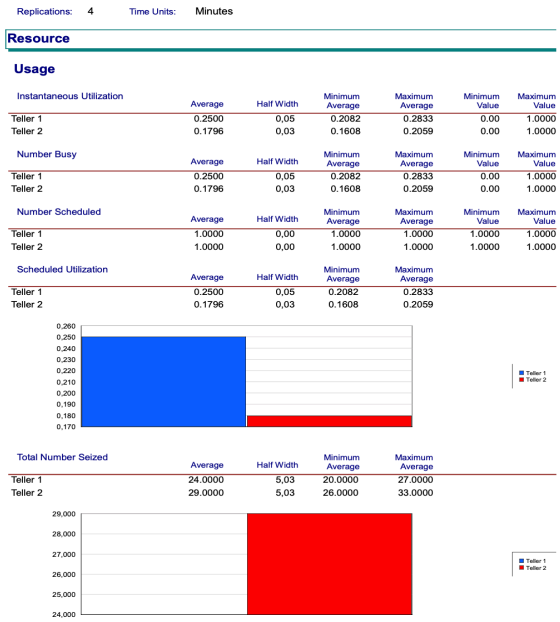


Figure 11. Resource utilization for buyers serviced in current 8-hour shift

1.1.1.5. Simulation of 13.5 hours ticket sales operations as an improvement scenario

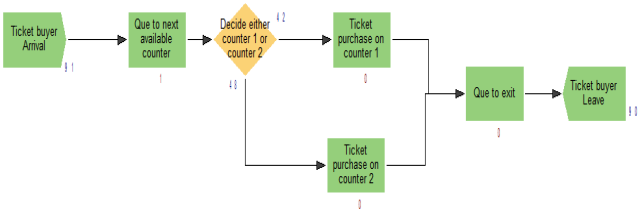


Figure 12. Ticket sales operations at 13.5 hours as an improvement scenario

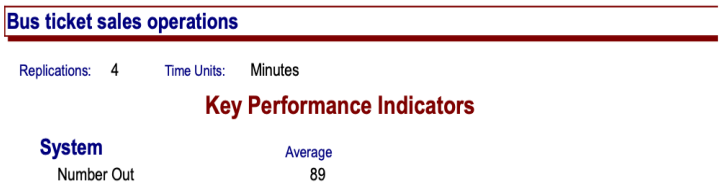


Figure 13. Number of ticket buyer serviced in 13.5 hours as an improvement scenario.

Replications: 4 Time Units: Minutes

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	10.4940	0,24	10.3057	10.6809	7.3141	13.6551

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0,00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0,00	0.00	0.00	0.00	0.00

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0,00	0.00	0.00	0.00	0.00

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	0.00	0,00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	10.4940	0,24	10.3057	10.6809	7.3141	13.6551

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Entity 1	91.0000	0,00	91.0000	91.0000

Number Out	Average	Half Width	Minimum Average	Maximum Average
Entity 1	89.2500	0,80	89.0000	90.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Entity 1	1.1646	0,03	1.1435	1.1847	0.00	2.0000

Figure 14. Valued added time, none value added time for ticket buyer serviced in 13.5 hours as an improvement scenario

Replications: 4 Time Units: Minutes

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Ticket purchase on counter 1.Queue	0.00	0,00	0.00	0.00	0.00	0.00
Ticket purchase on counter 2.Queue	0.00	0,00	0.00	0.00	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Ticket purchase on counter 1.Queue	0.00	0,00	0.00	0.00	0.00	0.00
Ticket purchase on counter 2.Queue	0.00	0,00	0.00	0.00	0.00	0.00

Figure 15. Que for ticket buyer serviced in 13.5 hours as an improvement scenario

Resource

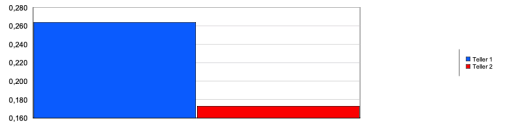
Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Teller 1	0.2636	0,03	0.2331	0.2809	0.00	1.0000
Teller 2	0.1727	0,02	0.1593	0.1896	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Teller 1	0.2636	0,03	0.2331	0.2809	0.00	1.0000
Teller 2	0.1727	0,02	0.1593	0.1896	0.00	1.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Teller 1	1.0000	0,00	1.0000	1.0000	1.0000	1.0000
Teller 2	1.0000	0,00	1.0000	1.0000	1.0000	1.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Teller 1	0.2636	0,03	0.2331	0.2809
Teller 2	0.1727	0,02	0.1593	0.1896



Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Teller 1	43.0000	6,23	38.0000	47.0000
Teller 2	47.0000	6,23	43.0000	52.0000

Figure 16. Resource utilization for buyers serviced in 13.5 hours as an improvement scenario

Discussion

Structured interviews

From the interviews conducted with a total of 97 ticket buyers over two days period at the bus ticket sales office, it was noted that 54.64% of the travelers purchase tickets to travel to work, followed by 26.80% travelling to purchase for household items shopping and with 18.56% visiting families and friends being one the least reasons as indicated by Figure . 59.79% of the travelers who bought tickets did not own cars thus relying on public transport such as the community buy for traveling daily to the workplace, meanwhile 88.66% worked full time at their place of employment as indicated on Figure. It is evident that the travelers relied on the bus to reach work places including 41.49% who owns cars but opted to use bus to travel to work in order to save on monthly costs associated with fuel for travelling over 60 km as shown on Figure.

Figure indicates that 50.52% of 97 travelers preferred purchasing bus tickets on weekends as most of them are not going to work on weekends also due to issues with purchasing system taking time to reboot after downtime due issues such as load-shedding, however on weekends the weekend operates Saturday only and still operates 8 hours only which might be time constraint to cover all travelers. Thus, not ideal to purchase on the same day on travelling. Furthermore, 35.05% preferred to purchase between Monday and Friday as shown on Figure depending on ques at the ticket offices. Purchasing of bus tickets online was preferred by only 8.25% of the 97 travelers as they believed it would save time and they can purchase while at home thus without traveling to the ticket sales office which they get inconvenienced if they cannot be serviced immediately due to load-shedding or other reasons thereof. The remaining 91.75% preferred onsite at the ticket sales office through purchasing on weekend or between Monday and Friday and or any day if the sales office is open.

Simulation using Arena.

The validity of the simulation model results can be compared to manual calculations performed in section 3.3.2.2, where the number of ticket buyers in current company's 8 hours shift that can be serviced as ticket per buyer amounted to 57. According to modeling results, 53 number of ticket buyers can potentially be serviced in the 8 hours shift. Thus, the manual calculations were not comparable by a margin of 7.55% ahead of the 53 buyers predicted by the model, thus valid on 92.45% of account.

Simulation modelling for the potential number of total ticket sales operations in an 8 hour operation indicated 53 tickets as outlined on Figure 3 for counter.1 and 2. The sequence of activities followed by bus ticket buyers as shown on Figure 3 and Figure indicated that 54 buyers accessed the sales operations and 53 buyers are potentially serviced, This further indicated an efficiency of 98.12% in converting the purchasing intent to sale. Figure 3 further indicated that counter number 2 had 30 buyers compared to counter 1 who had 23 buyers being serviced, thus counter 2 was efficient by 30.43% of counter 1 and further contributed 56.60% of ticket sales output while counter 1 contributed 43.40% of ticket sales output in the current 8-hour operating time. This was further indicated by high number of ticket buyers seized by teller 2 compared to teller 1, teller 2 number sieved of buyers was high by 5 buyers. At this service efficiency, there are no ques on all counters as shown on Figure . This is further indicated by Figure which shows that counter 2 teller had capacity to be utilized more in the 8-hour shift due indication on less instant utilization of 0.1796 minutes compared to counter 1 teller 1 which were high at 0.2500 minutes.

The adjustment of ticket sales operations by increasing to 13.5 hours operated by two shifts has the potential of increasing ticket sales output by 69.81% from current 8 hours operations. This meant additional 5.5 hours of ticket sales operating times as shown on Figure . This 13.5 hours operations also had similar operations efficiency as 91 potential ticket buyers accessed the ticket sales operations and only 89 were serviced, thus indicated 97.80% efficiency as shown on Figure and Figure and no ques are potentially experienced as shown by Figure .
Teller 2 on counter 2 line continued to process more ticket purchases by 14.29% higher based on teller 1 on counter 1 sales output of 42. Furthermore, this indicated that teller 2 sieved more ticket buyers that teller 1 as shown on Figure . This has also been further indicated by teller 1's full ticket purchase processing potential being

realized as it was high at 0.2636 minutes compared to teller 2 which was low at 0.1727 minutes as shown on Figure 16.

Conclusion

Based on the structured interviews had with ticket buyers onsite, it was noted that most travelers through bus are used it to go travel to work daily. This was noted by 54.64% reported purchasing bus ticket for trips to travel to work, while a low of 18.56% only purchased bus ticket to visit family and friends. Furthermore, 59.79% did not own cars meanwhile 40.21% did own cars, however resorting to using bus to travel to work and 88.66% worked full month.

The current 8-hour shift had a potential of selling 53 bus tickets compared to actual average sale of 44 tickets. The actual 44 ticket sale indicated 83.02% utilization of the available potential. Extension of operating times 5.5 hours has a potential to increase ticket sales output from 53 to 89 which is 67.92% increase. Although there were no ques in both 8 hours and 13.5 hours operations, teller 2 on counter 2 was not fully utilized as there was an opportunity to sell more tickets compared to teller 1 on counter 1 which was fully utilized though sold less tickets than teller 2.

Recommendations

Proposed improvement initiatives

- The bus service company can opt to maximize bus ticket sales through addition of 5.5 hours to cater the demand as there is increase in ticket of 67.92% of the current 8-hour shift.
- Intense return on investment of the additional 5.5-hour additional operating hours needs to be correlated with the anticipated revenue versus the cost associated with the extra hours. This is because either current resources will interchange on working hours or a whole new crew of tellers will have to be hired to meet the 5.5 hours resources requirement.

1.2. Future research study

- This study can be extended to model the bus capacity planning to identify if the current truck capacity for the company they have so they can proactively check if will meet the demand.
- Return on investment scenario simulation modelling scenario analysis is required to assess risk associated the investment. Monte Carlo simulation modelling is one of the commonly used tools for finance forecasting.

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