DOAJ DIRECTORY OF OPEN ACCESS JOURNALS
Научно-технический вестник Брянского государственного университета, 2026, №2
Nauchno-tekhnicheskiy vestnik Bryanskogo gosudarstvennogo universiteta, 2026, No.2
DOI: 10.22281/2413-9920-2026-12-02-160-167

МОДЕЛИРОВАНИЕ И ОПТИМИЗАЦИЯ СЕРВИСНЫХ ОПЕРАЦИЙ В БАНКОВСКОЙ СИСТЕМЕ НА ОСНОВЕ FLEXSIM

SIMULATION AND OPTIMIZATION OF SERVICE OPERATIONS IN A BANKING SYSTEM BASED ON FLEXSIM

Умека Б.Дж., Дагва И.М., Угеоке И.Б., Нурудин А.Х.
Julius Bettluwhobel Umeka, Dagwa Ishaya Musa, Iyenagbe Benjamin Ugheoke, Abdulhakeem Hassan Nurudeen

Университет Абуджи (Абуджа, Нигерия)
University of Abuja (Abuja, Nigeria)

Аннотация. В данном исследовании применяется метод моделирования для решения проблемы очередей с целью повышения качества обслуживания в банковской системе Нигерии. Для исследования использовались данные, полученные в банке с 8:00 до 16:00, которые были проанализированы с помощью симуляционного моделирования FlexSim©. Результаты моделирования показывают, что исходная модель отражает неэффективность работы банковских касс, поскольку сотрудники были перегружены, а большинство клиентов оставались недовольными. В исходной модели клиенты, обращающиеся к кассирам, находились в очереди около 3000 секунд (50 минут), а клиенты, обращающиеся в службу поддержки клиентов, - около 2541,6 секунд (42 минуты). За период моделирования обе кассы обслужили 271 клиента. Эффективность работы персонала на кассах составила 79,62% и 79,79% соответственно, а на кассах службы поддержки клиентов - 99,28%, что свидетельствует о перегрузке персонала. Однако оптимизированный процесс организации очередей продемонстрировал улучшение производительности персонала и высокую удовлетворенность клиентов. При добавлении еще одного сотрудника на рабочее место в отделе обслуживания клиентов пропускная способность увеличилась до 322 клиентов, а эффективность работы персонала составила 91,42% и 86,37% соответственно. Результаты оптимизированного процесса организации очередей показывают лучшие показатели и должны быть внедрены в банке для повышения удовлетворенности клиентов и эффективного управления персоналом.

Ключевые слова: *теория массового обслуживания, моделирование, оптимизация, FLEXSIM, банковское дело.*

Abstract. This study applies a simulation approach to the queueing problem to improve service delivery of a banking system in Nigeria. The study adopted data obtained at the bank from 8:00 am to 4:00 pm which was analysed using FlexSim© simulation. The results of the simulation analysis show the initial model signifies how the bank counters were designed, which was not efficient as workers were overworked, majority of customers were left unhappy and unsatisfied. The initial model had customers for teller services stay in queue for around 3000 seconds (50 minutes) while customers seeking the attention of customer service stayed around 2541.6 seconds (42 minutes) in queues both the counters had a throughput of 271 customers attended to over the simulation period. Staff efficiency for the teller counter was 79.62 and 79.79% each and 99.28% for customer service, this signifies worker overload. However, the optimized queuing process showed improved performance of staff and high customer satisfaction with the addition of another staff to the customer service workstation, the throughput capacity was increased to 322 and staff efficiency of 91.42 and 86.37%. The results of the optimized queueing process show better performance and should be adopted and implemented in the bank for increased customer satisfaction and proper staff management.

Keywords: *queueing theory, simulation, optimization, FLEXSIM, banking.*

Дата получения статьи: *04.04.2026*
Дата принятия к публикации: *10.05.2026*
Дата публикации: *25.06.2026*

Date of manuscript reception: *04.04.2026*
Date of acceptance for publication: *10.05.2026*
Date of publication: *25.06.2026*

Сведения об авторах:
Юлиус Беттлувобел Умека – магистр технических наук, кафедра машиностроения, инженерный факультет, Университет Абуджи, Нигерия,

Authors' information:
Julius Bettluwhobel Umeka – M. Eng, Department of Mechanical Engineering, Faculty of Engineering, University of Abuja, Nigeria,

DOI: 10.22281/2413-9920-2026-12-02-160-167

e-mail: juliusumeka@gmail.com.

Ишая Муса Дагва – доктор философии, профессор, кафедра машиностроения, инженерный факультет, Университет Абуджи, Нигерия,
e-mail: dagwa.ishaya@uniabuja.edu.ng.

Иенагбе Бенджамин Угеоке – доктор философии, профессор, кафедра машиностроения, инженерный факультет, Университет Абуджи, Нигерия,
e-mail: ben.ugheoke@uniabuja.edu.ng.

Абдулхаким Хассан Нурудин – доктор философии, преподаватель, кафедра машиностроения, инженерный факультет, Университет Абуджи, Нигерия, *e-mail: hassan.abdulhakeem@uniabuja.edu.ng.*
ORCID: https://orcid.org/0000-0002-9624-8224

e-mail: juliusumeka@gmail.com.

Ishaya Musa Dagwa – PhD, Professor, Department of Mechanical Engineering, Faculty of Engineering, University of Abuja, Nigeria,
e-mail: dagwa.ishaya@uniabuja.edu.ng.

Iyenagbe Benjamin Ugheoke – PhD, Professor, Department of Mechanical Engineering, Faculty of Engineering, University of Abuja, Nigeria,
e-mail: ben.ugheoke@uniabuja.edu.ng.

Abdulhakeem Hassan Nurudeen – PhD, Lecturer, Department of Mechanical Engineering, Faculty of Engineering, University of Abuja, Nigeria,
e-mail: hassan.abdulhakeem@uniabuja.edu.ng.
ORCID: https://orcid.org/0000-0002-9624-8224

1. Introduction

Banks are regarded as service facilities that provide financial and make contributions to the economy, they also play a crucial role on the mobilization of idle funds, aid in the implementation of Government monitoring funds [1]. There are many challenges faced by this system, in Nigeria with many related to service delivery, human resource management, inadequate technology innovation in operation services, poor corporate governance practices, reliance on public sector funds [2]. In most banks in Nigeria, customers spend huge amounts of time in queues, and congestion in most bank branches which leads to customer dissatisfaction as well as loss of business opportunities [3].

Queues are lines of people or objects waiting for services which operation managers use it as a tool to assess and manage waiting times through strategic approaches to reduce the time waiting line length, average waiting times [4]. Queueing theory models are vital to service and manufacturing industries; the service industry regards queues as customers waiting to be attended to, the formation of queues is largely affected by the speed of service delivery, fast queues do not easily form, but when services are slow queues are formed [5].

Queuing theory is essential in evaluating system performance, customer volume within the system, customers in line, service utilization, response time, customer waiting time and system idle time [6].

The expense of delivery and the expenses incurred when service is not provided are regarded as queuing concepts, therefore, management must provide services to attract and retain customers by prioritising effective and efficiency service that will guarantee customer satisfaction, reduced queues, waiting time costs etc. [7, 8].

2. Literature Review

A study was performed on queue analysis of public healthcare system to reduce waiting time using Flexsim 6.0 software, the research realized that the long queues make patient's waiting time large and service delivery to be very slow and stressful for patients. Therefore, a simulation experiment was performed to develop an alternative solution. Before the simulation, the registration counter and other points were almost busy all the time, with utilization of 96.56%, then the simulation results showed a decrease in waiting time of around 80% through the addition of resource personnel in the registration counter [9].

Meanwhile, another study optimized queue system using line balancing method and Flexsim software. The results show that the initial path efficiency of 64.69% and 31 patients queueing, while the simulation results show that having an additional doctor also reduces queuing of patients from 31 to 14 and an average path efficiency of 78.80% [10].

Madaline et al [1] applied queuing theory to improve service of a banking system in Laguna, Philippines. The bank had 2 operational counters which had a significant difference between the waiting and service time when serving senior citizens in the system. However, the system's waiting, service and total time were determined

DOI: 10.22281/2413-9920-2026-12-02-160-167

using ProModel 2016. The study recommended an additional counter for all transactions, reducing waiting time. Another study was also performed on the optimization of foreground support facilities for commercial banks based on queuing theory, the scholars argued that the addition of ATM variables in the two banks as support facilities reduces the bank's total costs and customer waiting costs [5].

The aim of the study was to perform simulation and optimization of a queue process in a service organization to increase service delivery and reduced worker overload using FlexSim.

3. Methodology

In this research work, data was gathered through the following ways:

Physical counting of customers coming into the bank was collected for four weeks in one bank (i.e., one month) between 8:00 am to 4:00 pm. Questionnaires were used. 200 questionnaires were administered and 180 respondents were received.

3.1.|Simulation Modelling using FlexSim

Flexsim software has distinguished itself from other simulation software companies as having an object-oriented environment that enables the design of models, visualization and monitoring of flow processes with animation in 2D and 3D [11].

3.2. Building the Simulation Model

Simulation elements were added to the Flexsim© environment and parameters were set as shown in Table 1 and according to [12].

Table 1

Summary of Model and System Elements used in the Simulation Environment

Model Element	System Element	Description
Source	Customer entry point	Arrival of customers at the banking hall.
Queue	Customers waiting point	Point where customers queue in lines to be attended to
Workers	Staff	Attending to customer needs
Fixed Resources	Workstations	Customer service desks or tellers
Task Executor	Sets the queueing process	Executes how the queues move within the bank
Sink	Exit point	Customer exit from the bank

4. Results and Discussions

4.1. Simulation Results Analysis

The simulation model was set, objects were connected and the simulation time was set to 28800 seconds, during the simulation period, staff, and workstations are connected as shown in Figure 1.

The system throughput is shown in Figure 2, a careful observation could be seen that the customer service agent could only process 79 customer complaints, while Teller Services were able to process 190 requests and around 272 customers were unattended to in a day. Out of 541 people that entered the bank for various issues.

Customer stay times on queue were measured, on average, customers that were for transactions other than complaints spent around 3000 seconds each with a maximum staytime period of 304.46 seconds while customers having complaints on average spent 360.06 seconds with a maximum time of 364.07 seconds however the longest stay time for customers requiring the attention of customer service agent as recorded as 2541.6 seconds (42 minutes) with a maximum of 4883.74 seconds (81.5 minutes).

The state of each workstation showed the percentage utilization of staff as shown in Figure 3.

Научно-технический вестник Брянского государственного университета, 2026, №2
Nauchno-tekhnicheskiy vestnik Bryanskogo gosudarstvennogo universiteta, 2026, No.2
DOI: 10.22281/2413-9920-2026-12-02-160-167

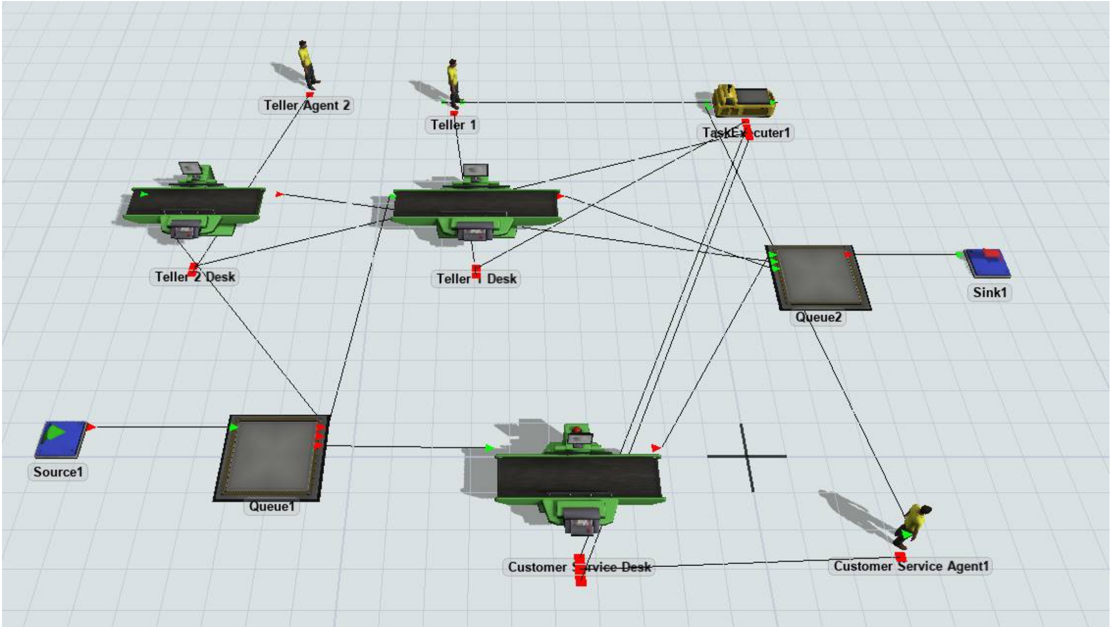

Figure 1. Simulation model layout

Throughput

Object	Throughput
Customer Service Desk	79
Teller 1 Desk	95
Teller 2 Desk	95
Queue1	272
Queue2	269
Sink1	269

Figure 2. Throughput capacity of customer service agents

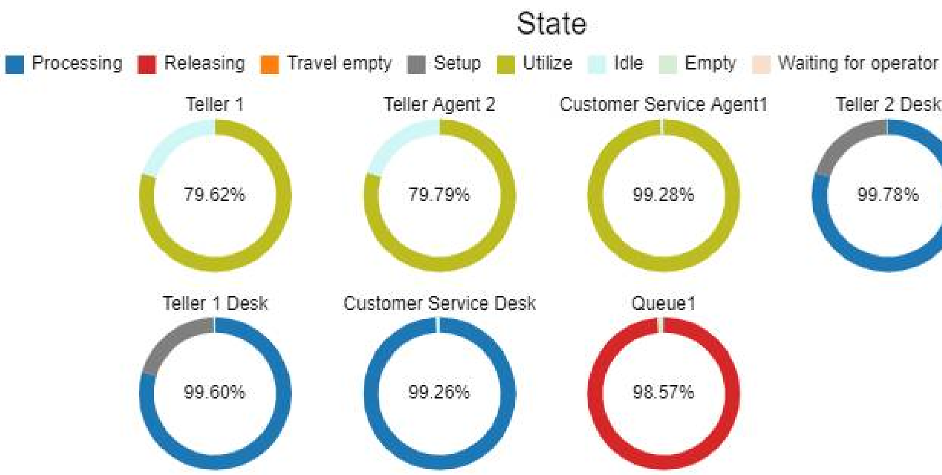

Figure 3. System state of each agent

From Figure 3, Teller1 had 79.62%, Teller Agent2 with 79.79%, Customer Service Agent1 had 99.28% utilization which is too high for an employee to have such efficiency this will result in fatigue and employee demoralization as the work seems too tedious and unfavourable.

The State Gantt Chart showed the worker activity from the opening hours to closing hours

DOI: 10.22281/2413-9920-2026-12-02-160-167

shown in Figure 4, the system shows it is being fully utilized.

The Stay time by the hour for the model shown in Figure 5 peak period from 10:00 AM to till closing period with so many customers in the queue.

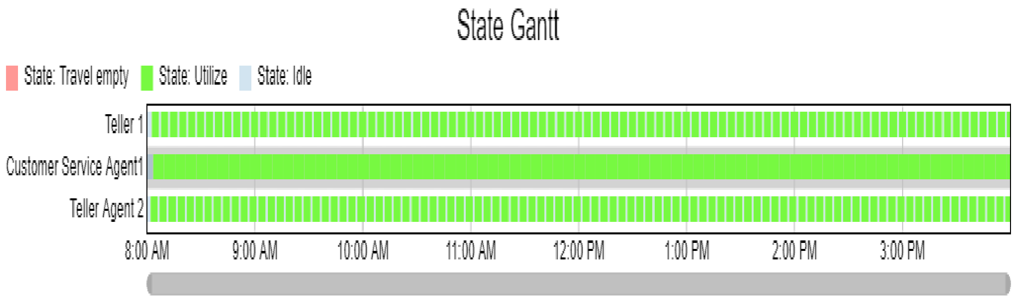

Figure 4. Employee Gantt chart

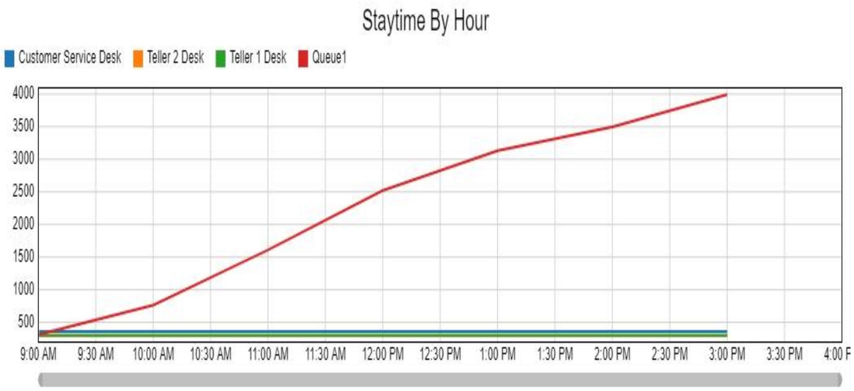

Figure 5. Staytime by hour of customers

4.2. Optimization of the Queuing Process

The initial simulation results were not very effective as customers requiring attention were left mostly stranded, hence the need for optimization of the customer service section as shown in Figure 6.

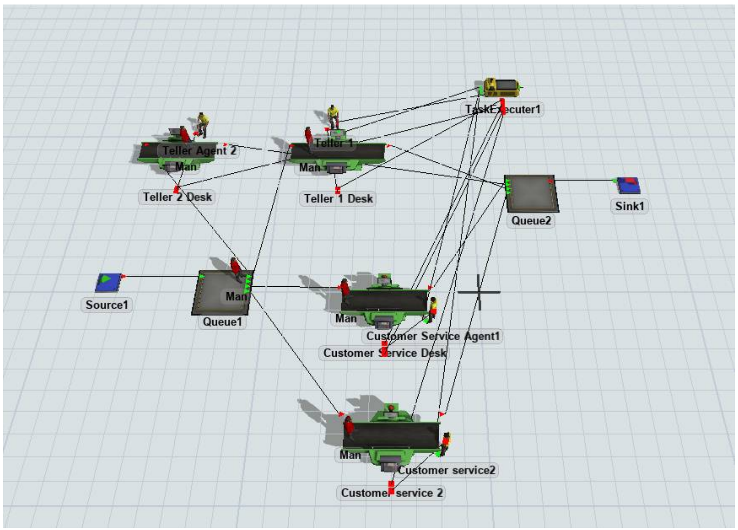

Figure 6. Optimized simulation model layout

DOI: 10.22281/2413-9920-2026-12-02-160-167

Figure 6 shows the improvement in the queueing process with the addition of another workstation (Customer Service 2 and staff), then the simulation clock was reset and set to 28800 seconds. The results obtained show the stay time on average for customers at the workstations was recorded as 300 seconds and a maximum of 305.59 seconds while customers needing the attention of customer service agents spent on average 360.07 and 340.06 seconds. The maximum stay time for customers being attended to by the customer service agent was 364.00 seconds. The maximum staytime period for customers in queue was 573.00 seconds while on average of 108.83 seconds was observed. This showed a great improvement in the waiting period of customers from the initial model that on average a customer spent around 2541.6 seconds with a maximum waiting period of 4883.74 seconds from the initial process.

Staytime

Object	Avg Staytime	Min Staytime	Max Staytime
Teller 2 Desk	300.05	300	304.46
Teller 1 Desk	300.04	300	303.53
Customer Service Desk	360.06	360	364.74
Queue1	108.83	0	573.00
Customer service 2	340.06	340	344.52

Figure 7. Customer staytime

The throughput of staff also improved in the optimized process, with an increase in the number of treated customers from 72 customers in the initial model to 146 customers per day as shown in Figure 8.

Throughput

Object	Throughput
Customer Service Desk	73
Teller 1 Desk	88
Teller 2 Desk	88
Queue1	326
Queue2	322
Sink1	322
Customer service 2	73

Figure 8. Throughput capacity

The state of the system was also recorded in terms of the staff utilization efficiency and shown in Figure 9, from the Figure, it could be observed that the teller section remained unchanged while the section requiring much attention was customer service which had an efficiency of 91.42% and 86.37% respectively which is a decrease from the initial model that was 99.26%.

The system staytime by hour showed the graph of peak periods of customers in the banking hall shown in Figure 10.

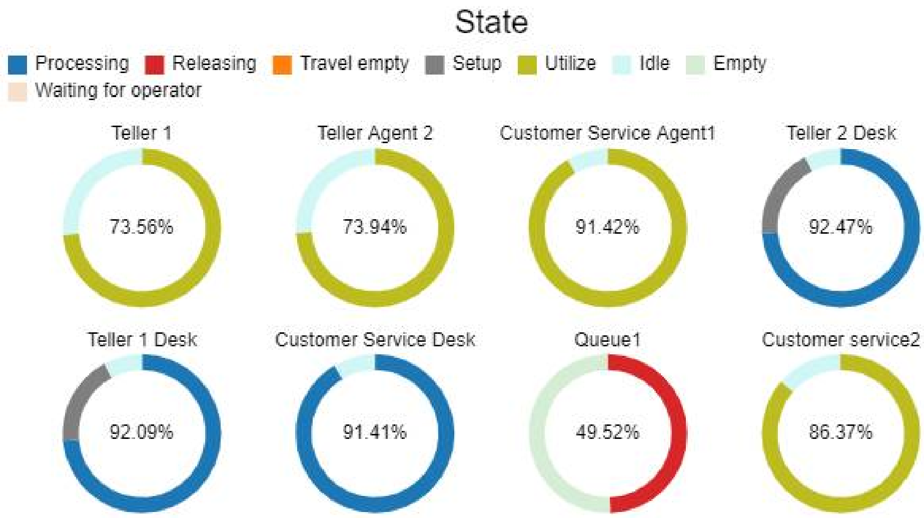

Figure 9. State of customer service agents

DOI: 10.22281/2413-9920-2026-12-02-160-167

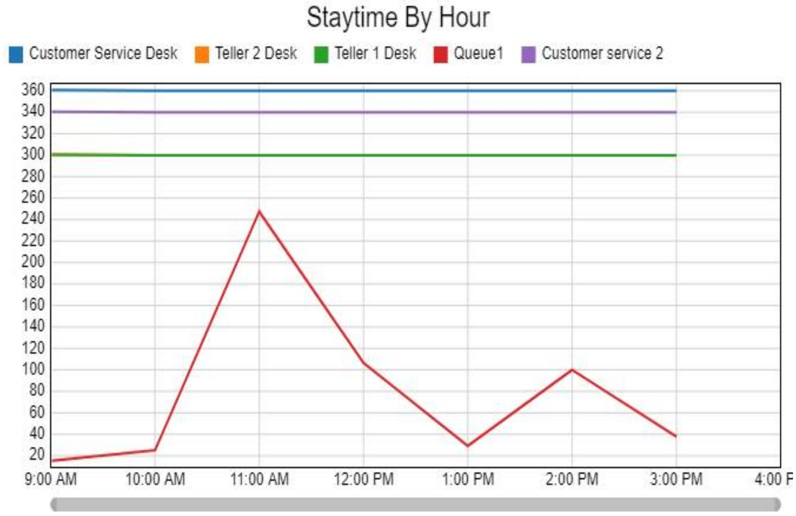

Figure 10. Customer staytime by hour

Figure 10, highlights the peak period showing that from 10:00 AM to 1:00 PM is where customers are trooping into the bank and queues are formed in the system each with different desired service to be delivered.

5. Conclusions

At the end of the study, the results obtained from the simulation exercise of the improvement of a queue process in the banking hall in Nigeria were based on the objectives of the study to use simulation analysis to improve the queuing problem in a banking hall, the simulation analysis results from the initial model showed worker overload with utilization of customer service reaching 99.26% and only 79 customers were responded to. However, the optimization layout was done with an introduction of another customer service agent which further improved the state of the system recorded in terms of the staff utilization efficiency of the customer service agent which had an efficiency of 91.42% and 86.37% respectively and over 322 customers were attended to, therefore, the optimized queuing process layout should be adopted and implemented to improve customer satisfaction and staff management.

References

1. M. Sy, F.L.S. Malabuyoc, M.D.M. Sobrevilla, R.D. Estember. A Queuing Theory Approach to Improve Service Quality of Banking Systems: A Case Study of a Bank in Laguna, Philippines. In: *Proceedings of the International Conference on Industrial Engineering and Operations Management Monterrey, Mexico (2021)*, 2021, pp. 2703–2714.

2. A. Afolalu, K.O. Babaremu, S.O. Ongbali, A.A. Abioye, A. Abdulkareem, S.B. Adejuyigbe. Overview impact of application of queuing theory model on productivity performance in a banking sector. *Journal of Physics: Conference Series*, IOP Publishing, 2019, p. 032033.

3. C. Aronu, J. Okoh, E. Onyeka, S.A. Ikemefuna. The assessment of bank service performance in delta state, Nigeria: A queuing theory approach. *Further Applied Mathematics*, vol. 1, no. 1, pp. 10–25, 2021.

4. R. Dhar, A. Chakraborty, J. Sarkar. Queuing Theory and Optimization in Banking Models. In: *Cybernetics, Cognition and Machine Learning Applications: Proceedings of ICCCMLA 2019*, Springer, 2020, pp. 205–213.

5. J. Shi Jianxin, Wang. Optimization of Foreground Support Facilities for Commercial Banks Based on Queuing Theory. In: *The 19th International Conference on Industrial Engineering and Engineering Management*, Berlin, Heidelberg: Springer Berlin Heidelberg, 2013, pp. 913–924.

DOI: 10.22281/2413-9920-2026-12-02-160-167

6. D.J.Li Liang, Wu. Analysis of Bank Queueing Based on Operations Research. In: *The 19th International Conference on Industrial Engineering and Engineering Management*, Berlin, Heidelberg: Springer Berlin Heidelberg, 2013, pp. 777–787.

7. K.W.G. Cowdrey, J. de Lange, R. Malekian, J. Wanneburg, A.C. Jose. Applying Queueing Theory for the Optimization of a Banking Model. *Journal of Internet Technology*, vol. 19, pp. 381–389, 2018, [Online]. Available: https://api.semanticscholar.org/CorpusID:64679929

8. R. Dhar, A. Chakraborty, J. Sarkar. Queuing Theory and Optimization in Banking Models, 2020. [Online]. Available: https://api.semanticscholar.org/CorpusID:219093774

9. P. Amalia, N. Cahyati. Queue analysis of public healthcare system to reduce waiting time using flexsim 6.0. *International Journal of Industrial Optimization*, vol. 1, no. 2, p. 101, Aug. 2020, doi: 10.12928/ijio.v1i2.2428.

10. H. Karunianto, F. Agusti, R.I. Buwono. Optimization of the Queu System using Line Balancing Methods and Flexsim Software Simulation at the Siaga Medika Banyumas Hospital. In: *Proceeding of International Conference on Science, Health, And Technology*, 2023, pp. 473–481.

11. I.B. Ugheoke, A.H. Nurudeen, I.M. Dagwa, I.D. Muhammad. Facility Layout Design, Simulation, and Optimization for Kaolin Beneficiation Plant Using Flexsim. *Mechanical Technology and Engineering Insights*, vol. 1, no. 1, pp. 15–28, 2024.

12. N. Hassan, A. Arogundade, U. Iyenagbe, D. Musa. Simulation and analyses of shea nuts (vitallaria paradoxa) processing plant using FlexSim©. *Journal of Future Sustainability*, vol. 3, no. 2, pp. 67–74, 2023.