SPCBIC 2024

22nd – 24th April,

Minna Nigeria

4th SCHOOL OF PHYSICAL SCIENCES BIENNIAL INTERNATIONAL CONFERENCE (SPSBIC 2024)

Conference Proceedings

THEME:

Innovative scientific research: A tool for socioeconomic development and environmental sustainability

Federal University of Technology Minna,
Niger State, Nigeria

THEME OF THE CONFERENCE

Innovative scientific research: A tool for socioeconomic development and environmental sustainability.

SUB-THEMES OF THE CONFERENCE

- Advancement in Materials Science and Technology for Sustainable Development
- Modeling, Theory and Applications
- Climate Sustainability and Sustainable Development Goals
- Science, Technology and Innovation, and the Journey to a Net Zero Energy Future for Africa

PRE-CONFERENCE WORKSHOP TITLE

Publication in Impact Factor Journal: Challenge and Breakthrough

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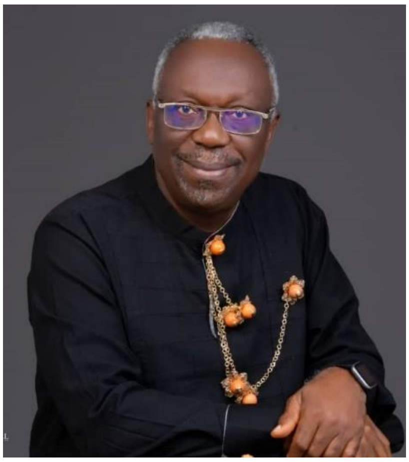

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Chairman's Remark

It is with great pleasure and a deep sense of responsibility that I welcome you all to this important conference, themed "Innovative scientific research: A tool for socioeconomic development and environmental sustainability." As Chairman of the Conference Planning Committee, I am truly honored to share a few remarks at this pivotal moment.

This gathering was not just a meeting of minds; it was a convergence of visionaries, scholars, industry experts, policymakers, and young professionals committed to shaping a better future through collaboration, research, and practical innovation. Our theme reflects the urgency of our times—recognizing that sustainable progress hinges on our willingness to challenge the status quo, embrace change, and work across disciplines.

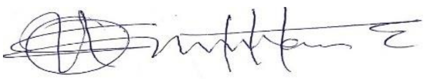
The planning and execution of this conference has been a journey of diligence and commitment. I would like to acknowledge the unwavering efforts of the organizing committee members, the Dean of our great school; Professor Jiya Mohammed, academic members of the school, and every stakeholder who contributed in various ways to make this event a reality. Special thanks go to our amiable Vice Chancellor and his management team, keynote speakers, presenters, and panelists who had travelled far and near to share their insights and experiences with us.

Over the course of this conference, we had explored a variety of sub-themes ranging from renewable energy and environmental sustainability, to technological innovations, policy frameworks, and inclusive economic growth. We believe that the sessions, workshops, and discussions lined up did not only spark intellectual curiosity but also inspire actionable solutions for local and global challenges.

It is also our hope that beyond the formal sessions, meaningful connections and collaborations would have been formed. Conferences like this serve as fertile ground for networking, mentorship, and the cross-pollination of ideas—elements that are crucial for long-term impact.

In conclusion, I encourage all participants who actively engaged in the conference, to have this carefully packaged pieces of academic presentations in the form of conference proceeding as a document for intellectual use. Let this conference be remembered not just for the ideas exchanged, but for the seeds of change it sows in our respective fields.

Thank you for your attention, and once again, welcome.



Professor Usman Shehu ONODUKU, PhD
Chairman, Conference Planning Committee
April 21-25th, 2024

CONTENT

Chemical Science

Earth Science

Mathematical/ICT

Physical/Climate Sciences

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Application of Queuing Theory to Optimize Waiting-Time in Hospital Operations

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ABSTRACT

Waiting time is inherent to the healthcare service sectors in Nigeria and a major challenge faced by almost every big hospital is queuing. Long waiting time can be a reflection of inefficiency in hospital operations. The out-patient department (OPD) has the biggest queue as compared to other departments in hospital operations. This study comprises of in-depth analysis of OPD from different dimensions. Like in many big hospitals across Nigeria, the OPD of General Hospital in Minna Niger State, Nigeria is managed using experience and rule of thumb rather than strategic research-based techniques such as queuing theory. The General Hospital in Minna Niger State, receives a large number of patients each day which results in longer waiting time for patients due to long queues. To address the challenge, queueing model was design to identify the bottlenecks in service operations and potential areas for improvement in the system, with the objective of optimizing patients waiting time, thereby allowing a higher flow of patients in OPD using queuing model. The result from the multi-server model (m/m/s) shows that the probability of having zero patients in the queue at the OPD unit in the clinic is 0.71 (71%). This infers that the clinic experience constant queue each day. The average time spent in the system (Wq) per patients is 30minute to 35 minute and the average service time in the system before leaving the clinic was estimated to be between 31minute to 40 minutes each day. The study recommends to the government authority to look into the factors that result in long queue and delay of patients at the OPD unit so as to resolve the increasing rate of queue and delay patients experience in the clinic before being attended to.

Keywords: queuing theory, OPD, arrival time, waiting time, service time, hospital operations

INTRODUCTION

Hospital services operations particularly, the outpatient department plays a crucial role in providing quality healthcare for multi-specialty hospitals (Carman, 1990). The outpatient department (OPD) often acts as a profit centre in hospital operations not only for investing in new technology but also to curb losses on inpatient services (Green, 2006). However, despite the importance of OPD, hospitals fail to address complaints regarding long waiting time caused majorly due to observable queues which result in patient dissatisfaction (Kim et al., 2009). Thus, hospital service operations should have a smooth flow to satisfy the patient's expectations by redesigning their systems and adapting to the best practices and tools with improved processes (Natrajan, 2006) which has a huge scope in developing economies such as India (Natchair et al., 1994).

The OPD of a hospital acts as a bridge between hospital and community, hence it is very important to plan the OPD with the idea of maximizing the utilization and quick turnover. (McQuarrie, 1983). It is imperative to have effective co-operation between the medical services and the support line services catering to the OPD requirements (Kritchanchai, 2012). The interpersonal skills of the medical personnel, availability of medicine, hospital infrastructure and medical information plays an important role in managing OPD and create a positive influence on patient satisfaction (Natarajan, 2006). Hence, it is necessary to focus on optimizing waiting time in hospital operations for the benefit and wellbeing of patients.

The hospital industry, like other service-oriented businesses, is becoming increasingly competitive. Providing quick service by a service provider improve patient's satisfaction. The fundamental issue confronting hospitals in Nigeria is that attendance has increased as a result of increase in population and awareness among Nigerians, hospital/clinic capacity has remained constant, and patients must wait a long time for service. Furthermore, multiple studies showing patient dissatisfaction with extended waiting periods have been found in the literature, indicating that this is a widespread problem in hospital practice and a common source of worry and unhappiness among patients. In addition, extra hands are required in order to increase the service rate, which implies cost to management. Furthermore, the obvious costs implications of patients waiting range from idle time spent when a queue forms, which results in man-hours to a loss of good will, which can occur when patients are dissatisfied with a system. This study seeks to determine amount of time a patient is likely to experience in a system at General Hospital Minna.

LITERATURE REVIEW

This paper summarizes the literature relevant to hospitals optimization of patients waiting time. The scope of the review is to exhibit an overview of various studies done so far in this field; and relevant literature on methodologies for solving queueing systems that are similar to OPD.

Conceptual Framework

There have been studies on waiting time in hospital operations focused on the doctor and patient consultations in general hospitals (Park, 2001) which found that the factors influencing waiting time were characteristics of healthcare providers, consultation and patient's characteristics (Hwang, 2006).

Queueing theory was developed by A.K. Erlang in 1904 to help determine the capacity requirements of the Danish telephone system (see Brockmeyer et al. 1948). It has since been applied to a large range of service industries including banks, airlines, and telephone call centers (e.g. Brewton 1989, Stern and Hersh 1980, Holloran and Byrne 1986, Brusco et al 1995, and Brigandi et al 1994) as well as emergency systems such as police patrol, fire and ambulances (e.g. Larson 1972, Kolesar et al 1975, Chelst and Barlach 1981, Green and Kolesar 1984, Taylor and Huxley 1989). It has also been applied in various healthcare settings as we will discuss later in this chapter. Queueing models can be very useful in identifying appropriate levels of staff, equipment, and beds as well as in making decisions about resource allocation and the design of new services.

Queuing theory in health care

Works on the theory and applications of queuing systems have grown exponentially since the early 1950s (Green, 2006a). Queuing Theory (QT) is the mathematical study of waiting lines, or queues. QT can be applied in various fields, yet most of previous studies are well documented in the literature of Probability, Operations Research, and Management Science. Some of the applications are machine repair, tool booths, inventory control, the loading and unloading of ships, scheduling patients in hospital clinics and in computer fields. Queuing theory has been applied to computer simulation models to help with decision making of numbers of hospital server, resource utilization and to reduce waiting time. QT has been extensively utilized in industrial settings to analyze how resource-constrained systems respond to various demand levels, and thus is a natural fit for modeling patient flow in a health care setting (Boyd & Gupta, 2006), (Xia, Sean, & Bruce, 2018). The theory enables mathematical analysis of several related process, including arriving at the queue, waiting in the queue, and being served at the front of the queue. The theory permits the derivation and calculation of several performance measures including the average waiting time in the queue or the system, the expected number waiting or receiving service, and the probability of encountering the system in certain states, such as empty, full, having an available server or having to wait a certain time to be served (Boyce et al., 1991).

Empirical frame work

Kha skheli et al., (2020) used optimum number of receptionists and doctors to optimize the performance of existing queuing systems at the out-patient departments (OPDs). The most congested OPD i.e. medical OPD was selected for the study at the case hospital 1 and then same OPD was selected in another public sector hospital (case hospital 2) in Sindh Pakistan. The study collected data for two weeks. The data collection parameters were; arrival rate, service rate of patients, number of servers, salaries of the servers and associated waiting cost of patients. Arrival and service distribution of the patients were verified as per assumptions of the multi-server queuing model (M/M/c) by using input analyser of Rockwell Arena 14.5. Performance measures of the queuing system were calculated by using TORA optimization software. For cost calculation and graph plots MS excel was used. According to the results, one receptionist and doctor was suggested to be increased at both of the OPDs for the minimization of congestion of patients and their waiting times.

Segun (2020) conducted a research on the Performance Modelling of Health-care Service Delivery in Adekunle Ajasin University, Akungba-Akoko, Nigeria Using Queuing Theory. The purpose of this study was to determine the waiting, arrival and service times of patients at AAUA Health- setting and to model a suitable queuing system by using simulation technique to validate the model. This study was conducted at AAUA Health- Centre Akungba Akoko. It employed analytical and simulation methods to develop a suitable model. A stopwatch was used to calculate the number of minutes spent by each patient from the reception section where patients arrive and collect their hospital cards or register to the last section (the consulting room section). Data on the arrival time, waiting time and service time of each patient was collected on Weekdays (Mondays through Fridays) for three (3) weeks. The data was calculated and analyzed using Microsoft Excel. Based on the analyzed data, the queuing system of the patient current situation was modelled and simulated using the PYTHON software. The result obtained from the simulation model showed that the mean arrival rate of patients on Friday week1 was lesser than the mean service rate of patients (i.e. 5.33> 5.625 ($\lambda > \mu$). What this means is that the waiting line would be formed which would increase indefinitely; the service facility would always be busy. The analysis of the entire system of the AAUA health centre revealed that queue length increases when the system is very busy. The study recommends the need for the AAUA Health-Centre to improve the quality of service offered to the patients visiting this health centre.

Nor and Binti (2018) Applied Queuing Theory Model and Simulation to Patient Flow at the Outpatient Department. The objective of this study is to determine the waiting arrival time and service time of patients at the outpatient counter and to model suitable queuing system using simulation technique. This research was carried out at a Public Health Clinic in southern Malaysia. Descriptive analytical and simulation method were employed to develop suitable model. The collection of waiting time for this study is based on the arrival rate and service rate of patients at the outpatient counter. The data calculated and analyzed using Microsoft Excel. Using the ARENA, the patient's existing queuing system was modelled and simulated based on the analysed data. Descriptive analysis and observations study was used to determine the time taken of patients from the registration until seen by pharmacist at the outpatient clinic. The results obtained from the ARENA simulation stated that the average waiting time of patient have to wait before get the treatment is 54.295 minutes whereas the maximum waiting time is 144.48 minutes. Then, the average service time for patient get the treatment is 13.48 minutes whereas the maximum service time for several patients is 23.724 minutes. Therefore, the average total time spend by patients in outpatient department is 68.315 minutes and maximum total time in system is 156.718 minutes. Total average number of patients arrived at outpatient counter is 327 patients per day. Thus, based on the result average total number of patient gives the utilization of server at outpatient department is 78.84%.

Shastrakar and Pokley (2017) analyzed different parameters of queuing theory for the waiting time of patients in hospital, in their research parameters such as arrival rate, service rate, utilization factor, the average number of patient in the system, average number of patient in the queue, average time spent by the patient in the system, average time spent by the patient in the queue were analyzed. They concluded that the percentage of idle workstation is very less and utilization factor is very high so it needs some improvement in the service facility.

Rotich (2016) conducted a study on the effect of Queuing Theory on Emergency Medical Service Department in Moi Teaching and Referral Hospital (MTRH). The objective of this paper was to determine the optimum waiting and service cost in a hospital ICU emergency service. The study adopted Use of M/M/s queuing model to analyze ICU services using secondary data of MTRH emergency patient's arrival and service rates together with estimated service cost of available 6 beds. Waiting cost estimated using formulated Modified Normal Loss function. Modeling and simulation method were employed to develop suitable model. The results showed that the average individual tolerance of 0.083 hours and average response time of 0.083hrs, the present scenario of 6 ICU beds in MTRH is operating at a service cost of

Ksh 60 and patient queuing cost of Ksh 415.53 per hour. The length of the queue is 1.4 hour or approximately 34 patients per day. Increasing ICU beds to 18 minimizes the length of the queue to 6 patients per day and queuing cost by 76% and reduces the total cost by 65% thereby reducing the financial burden of the patients and increase the chances of saving lives during emergency cases. However, the management of the hospital need further work and inclusion of related services to give a bigger and better picture of the facility.

The analysis of waiting time in healthcare systems can be approached mathematically using queuing theory (Ozcan, 2006). It is being established that queuing theory can be used for improving patient waiting time in hospital operations by an extensive review of the literature (Green, 2006a; mcquarrie, 1983; Siddhartan *et al.*, 1996). There is already large publication involving the application of queuing theory to service operations in hospital settings (Adele and Barry, 2005; Ivalis and Millard, 2003; Vasanawala *et al.*, 2005). Unfortunately, this vital tool is underutilized in most hospital operations across India. There has also been extensive research on queuing analysis to enhance performance at various hospital departments (Green, 2002; Kim *et al.*, 1999) and emergency departments (Green *et al.*, 2006). Most hospital operations involve appointment system and the use of queuing is done in either of the two ways i.e. First-in-first out or different classes of patients solely based on priority for e.g. In case of an emergency which automatically gets first priority before others (Adele and Barry, 2005). It is indeed possible to optimize patient waiting time on a priority basis by addressing the issue of which patient requires shorter service time (mcquarrie, 1983).

METHODOLOGY

Sources of Data Collection

In this study, primary data were collected through observation and direct interview from the respondents.

Data were collected randomly among the patients without any specific patient classification of treatment. This is because the study focuses on determining the waiting time of patients at outpatient counter. Data was collected via record the waiting time of patients in the pre-planned form at the outpatient clinic. The data required to develop the patient flow as follows:

i. Patients arrival times
ii. Service time at the registration counter (new patient registration counter and appointed patient registration counter). Service time is the time taken at the beginning of the service until the end of the service for each patient.
iii. Service time at the pre-consultation room.
iv. Service time at the consultation room.
v. Service time at the pharmacy counter.
vi. The number of patients (at each phase)
vii. The number of doctors, staffs involved at each phase.

Population and sample size

General Hospital Minna, clinic was considered in this study with a population size of 7,298 registered patients at OPD units per week. According to Raasoft sample size calculator, a minimum of 400 sample size should be considered. A sample size of 400 of registered patients was considered in this study.

Sampling technique

The hospital used in this study was selected using convenience sampling technique. A sample of registered patients in this hospital was selected using simple random sampling technique.

Data Analysis

Data obtained through observation and direct interview were analyzed using percentages and frequencies. Similarly, exponential queuing models were developed using the data obtained through observation.

Descriptive analysis and observations study will be used to determine the time taken of patients from the registration until seen by pharmacist at the outpatient clinic. In order to get better results, this study reconfirmed the patient's process flow with the clinic management together with on-site observation few times to get the correct flow. The collected date was the arrival time (λ) which was the number of patients entered to the outpatient counter during standard study time (30-munites intervals) and the service time (μ) which was the time period of giving services to each patient per 30 minutes.

Exponential Queuing Model

Certain assumptions that will be made during the research are:

i. Queue discipline will assume to be first-come-first-serve (FCFS) type.
ii. Reneging, balking and jockeying of the patients will not be taken into consideration in the study.
iii. The population source is going to be infinity.
iv. Infinite number of patients is allowed in the system.

According to Kendall's notation, the model for the system could be represented as m/m/i: FCFS/∞/∞. The following parameters would be analysed for the model:

Mean patient's arrival rate = λ

Mean service rate = μ

Utilization factor, $P = \frac{\lambda}{\mu}$

Probability of zero patients in the system $P_0 = 1 - P$

Probability of having n patients $P_n = P_0 P^n = (1 - P)\, P^n$

Average number of patients in the system, $Ls = \frac{\lambda}{\mu - \lambda}$

Average number of patients in the queue, $Lq = Ls - \frac{\lambda}{\mu}$

Average time spent in the system, $Ws = \frac{1}{\mu - \lambda}$

Average time spent in the queue, $Wq = \frac{P}{\mu - \lambda}$

Descriptive Data Analysis

The study utilized a graphical descriptive analysis to evaluate the arrival rates in minute for patients in General Hospital Minna. Based on the descriptive analytical data, the total number of patient sampled at OPD unit in seven days at the hospital was 304 patients in a week (Monday to Sunday).

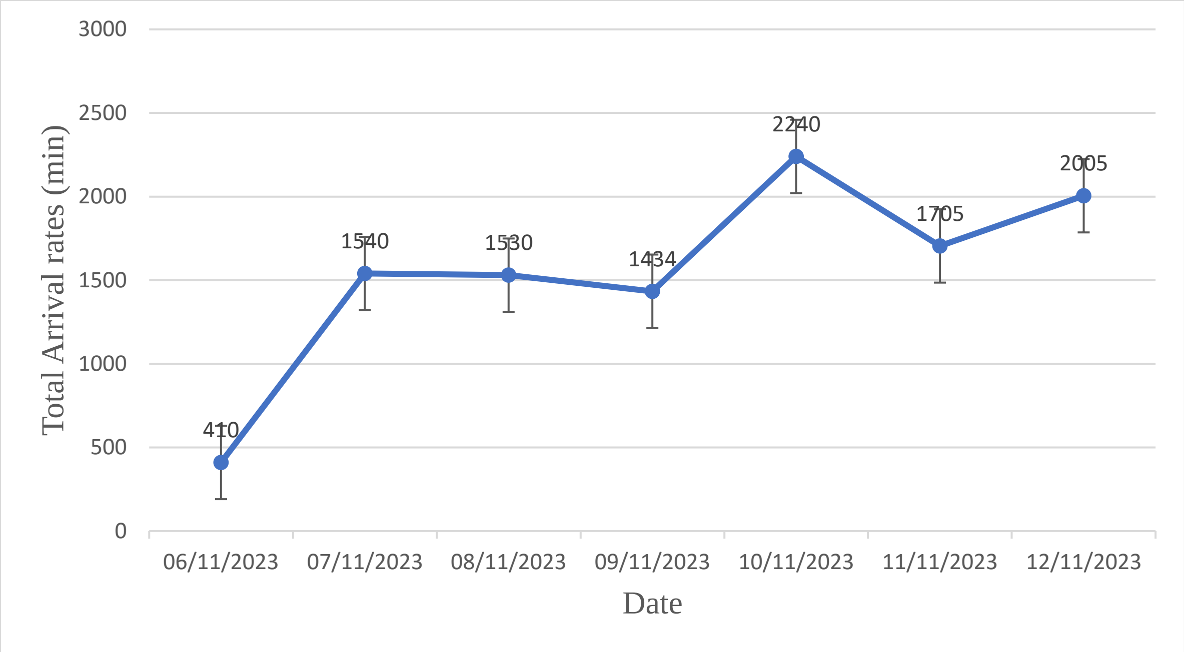

Figure 1 Time graph showing total arrival rate in minute of patients to the clinic

The result in figure 1 shows the time graph of patient's arrival rate. From the graph, we observed that the distribution of the OPD patient's attendance was busiest on Friday, Saturday and Sunday. The result shows that the total arrival rate in minute, of patients on Monday is minimal as compared to the other days of the week.

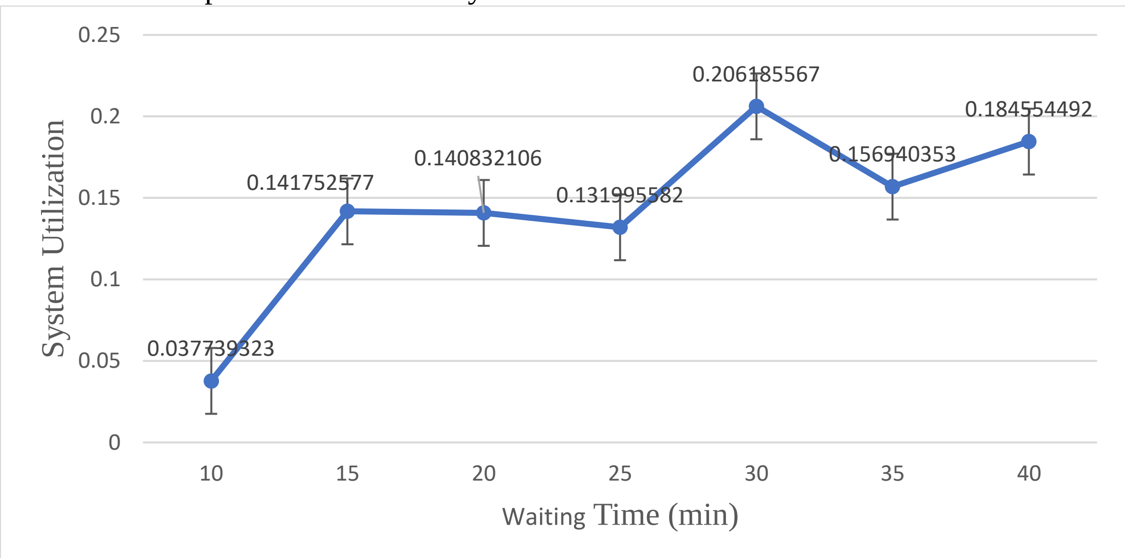

Figure 2: Time plot showing the probability of patients waiting time on the queue

The result from figure 4.2 evaluate the time plot to evaluate the probability of patients waiting time on the queue before he or she is attended to. The result from the figure shows that the patients have to wait in the queue for about 30 minutes, 35 minute and 40 minutes before they are attended to. The probability of waiting for 30 minutes, 35 minute and 40 minutes is given as 0.21, 0.16 and 00.18 respectively.

Analysis of data using M/M/3 queuing model

The type of queuing system that we take under consideration is the multiple server queuing system with three consulting rooms and three medical doctors attending to patients. The assumptions made for this queuing system are:

a) It consists of a single queue with three identical servers.
b) The input process is Poisson arrival rate of λ patients per minute.
c) Service times follow an exponential distribution with the mean service rate of μ patients per minute.
d) Patients receive services from each server on a first-in, first-out basis.
e) The queue size is unlimited.

Table 4.1 shows the average arrival and service rates of three doctors for 7 days.

Days	Total Arrival rate (min)	Inter Arrival (λ)	Total Service Time/patients (Min)	Mean Service tine (μ)
1	410	0.037739	943	0.202404
2	1540	0.141753	393	0.084353
3	1530	0.140832	242	0.051942
4	1434	0.131996	755	0.162052
5	2240	0.206186	982	0.210775
6	1705	0.15694	382	0.081992
7	2005	0.184554	962	0.206482
Total	**10864**	**1**	**4659**	**1**
Average	**1552**	**0.142857143**	**665.5714286**	**0.142857143**

$$\text{Mean service rate } \mu = \frac{4695}{305} = 15.39 \; minutes\ per\ Patents$$

$$Mean\ arrival\ rate\ \lambda = \frac{1595}{305} = 5.23 \; minutes\ per\ Patients$$

Number of server's k = 3 (three doctor attending to patients at a time)
Mean combined rate of all servers = $K\mu$ = 3(15.39) = 46

$$Utilization\ factor\ of\ the\ entire\ system = \rho = \frac{\lambda}{k\mu} = \frac{5.2}{3 \times 15.4} = 0.11\ or 11\%$$

The probability that there are no patients in the system (all servers are idle) is

$$P_0 = \left[\left\{\sum_{n=0}^{k-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right\} + \frac{1}{k!}\left(\frac{\lambda}{\mu}\right)^k \left(\frac{k\mu}{k(\mu-\lambda)}\right)\right]^{-1}$$

$$P_0 = \left[1 \times \left(\frac{5.2}{15.4}\right)^0 + 1 \times \left(\frac{5.2}{15.4}\right)^1 + \frac{1}{2!} \times \left(\frac{5.2}{15.4}\right)^2 + \frac{1}{3!} \times \left(\frac{5.2}{15.4}\right)^3 \times \frac{3(15.4)}{3(15.4-5.2)}\right]^{-1}$$

$$P_0 = [1 \times 1 + 1 \times (0.3377)^1 + 0.5 \times (0.3377)^2 + 0.17 \times (0.3377)^3 \times 1.5098]^{-1}$$

$$P_0 = (1.3377 + 0.0570 + 0.0065 \times 1.5098)^{-1}$$

$$P_0 = (1.4046)^{-1}$$

$$P_0 = 0.7120$$

Hence, the Probability of zero patients in the system= 0.71
The expected number of patients in the waiting line

$$L_q = \frac{\left(\frac{\lambda}{\mu}\right)^k}{k!\,(1-\rho^2)} P_0$$

$$L_q = \frac{\left(\frac{5.2}{15.4}\right)^3}{3!\,(1-0.11^2)} \times 0.71$$

$$L_q = \left[\frac{0.038}{5.9274}\right]^{-1} \times 0.71$$

$$L_q = 0.006410905287^{-1} \times 0.71$$

$$L_q = 155.9842$$

$$L_q = 156$$

The expected number of patients in the system,

$$L_s = L_q + \frac{\lambda}{\mu}$$

$$L_s = 156 + \frac{5.2}{15.4}$$

$$L_s = 156.3377$$

$$L_s = 157$$

The expected waiting time in the queue

$$W_q = \frac{L_s}{\lambda} = \frac{157}{5.2} = 30.1923\, minutes$$

$$W_q = 30\, minutes$$

= 30 minutes' average time a patient spends in the queue waiting

$$W_s = W_q + \frac{1}{\lambda}$$

$$W_s = 30 + \frac{1}{5.2}$$

$$W_s = 30.1923$$

$$W_s = 31\, minutes$$

$W_s = 31$ minutes average time a patient spends in the system

Table 4.2 Summary result from seven days M/M/3 Queueing model

Queue model	**M/M/3**
Arrival rate(λ)	5.2
Service rate (μ)	15.4
P_0	0.71
L_q	156
L_s	157

W_q	30
W_s	31
ρ	0.11

The result in table 4.2 shows the summary result from seven days M/M/3 Queueing model. From the analysis the arrival rate follows a Poisson distribution with mean (λ) = 5.2 and the Service rate, follows an exponential distribution with mean (μ) = 15.4. We observed from the table that the Probability of having zero patients in the system (P_0) is 0.71 that is 71% which is very high. The Average number of patients in the queue (Lq) is given as 156 and the average expected number of patients in the system (Ls) is 157. It was observed that the average time spent in the system (Ws) = 31 whereas the average time spent in the queue(Wq) is 30.

Conclusion
In the quest to evaluate and solve queuing problems on service operations to patients waiting time at General Hospital Minna. We observe that the probability of having zero patients in the queue at the clinic is not zero. This infers that the clinic experience constant queue each day. The study was able to evaluate the average waiting time in the queue and the average service time in the system before leaving the clinic was estimated to be between 30minute to 40 minutes each day.

Recommendation
Prior to the result obtained in the analysis from this study on queuing problems associated with service operations to patients waiting time at General Hospital Minna. The study recommends to the University authority to look into the factors that result in long queue and delay of students and patients in this clinic so as to resolve the increasing rate of queue and delay patients experience in the clinic before being attended to.

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Effect of Cashless Policy on Gross Domestic Products in Nigeria: A Vector Autoregressive Model (VAR) Approach

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ABSTRACT

The study undertakes an econometric research to analyze the cashless policy and its effectiveness on Gross Domestic Products in Nigeria using quarterly data of 2019 to 2022. The vector Autoregressive model (VAR) was adopted to examine how automated teller machine (ATM), Point of sale (POS) and Internet banking (IB) had impacted on Nigeria GDP. Unit root test was carried out on each of the variables to determine their level of stationarity. They were however found stationary after first difference with the p-values less than 0.05 and then used for the regression analysis. And a Johanso test of cointigration was used to examine the short or long term influence of the cashless policies on GDP. In the VAR model result, the activities on automated teller machine (ATM) and point of sales (POS) has significant influence on Nigeria economic growth with their respective p-values less than 0.05 and R-Squares = 0.99. The result from the Johanson test of cointigration show that there is on cointigrating factor which infers a short-term influence. The study recommends that the use of ATM and POS should be much more encouraged in Nigeria, with proper awareness on its benefit. Also effective policy needs to be developed by the government through the CBN to ensure the effectiveness and efficiency of ATM and POS.

Keywords: Automated teller machine (ATM), Point of sale (POS), Internet banking (IB), Vector Autoregressive model (VAR)

1.0 INTRODUCTION

Cashless economy is not the complete absence of cash, it is an economic setting in which goods and services are bought and paid for through electronic media. According to Woodford (2003), Cashless economy is defined as one in which there are assumed to be no transactions frictions that can be reduced through the use of money balances, and that accordingly provide a reason for holding such balances even when they earn rate of return. In a cashless economy, how much cash in your wallet is practically irrelevant. You can pay for your purchases by any one of a plethora of credit cards or bank transfer (Roth, 2010).

Cashless economy is also viewed as an economy where transaction can be done without necessarily carrying physical cash as a means of exchange of transaction but rather with the use of credit or debit card payment for goods and services. The cashless economy policy initiative of the Central Bank of Nigeria (CBN) is a move to improve the financial terrain but in the long run sustainability of the policy will be a function of endorsement and compliance by end-users (Ejiro, 2012). The CBN cash policy stipulates a daily cumulative limit of N150, 000 and N1, 000,000 on free cash withdrawals and lodgements by individual and corporate customers respectively in the Lagos State with effect from March 30, 2012. Individuals and corporate organizations that make cash transactions above the limits will be charged a service fee for amounts above the cumulative limits. Furthermore, 3rd party cheques above N150, 000 shall not be eligible for encashment over the counter with effect from January 1, 2012. Value for such cheques shall be received through the clearing house. All Nigerian banks were expected to cease cash in transit lodgement services rendered to merchant-customers from January 1, 2012.

The policy through the advanced use of information technology facilitates fund transfer, thereby reducing time wasted in Bank(s). Wizzit, a fast growing mobile banking company in South Africa has over three hundred thousand customers across South Africa. Likewise, M-PESA was introduced in Kenya as a small value electronic system that is accessible from ordinary mobile phones. It has experienced exceptional growth since its introduction by mobile phone operator (Safaricom) in Kenya in March, 2007 and has already been adopted by nine million customers, which is about 40% of Kenya's adult population. Wizzit and other mobile financial services including MPESA in Kenya are helping low income Africans make financial transaction across long distance with their cell phones, thereby reducing their travel cost and eliminating the risks of carrying cash and also avoiding most banking charges (Akintaro, 2012). It is assumed that the proper implementation of mobile phones and other technologies can aid the implementation of cashless policy and hence, the growth of cashless economy in Nigeria.

The initiative of cashless policy by government is to minimize the quantity of physical cash in circulation by dissuading the use of cash while persuading the adoption of electronic payment system. This policy is not aimed at eliminating the use of cash in consummating transaction, rather, it is meant to reduce physical cash handling and the quantity of cash in circulation (Gbanador MA, 2021). This study aimed to evaluate the impact of cashless policies on Nigeria economic growth.

2.0 LITERATURE REVIEW

The literature review constituted the basis of variable, method and model preferences for the econometric analysis. When the economics literature is reviewed, one can spot many empirical studies that prove a negative relation between the cashless policies and economic growth.

2.2 Conceptual Framework

2.2.1 The Cashless Policy Concept

Cashless payment

A cashless transaction refers to an economic setting whereby goods and services are transacted without cash (Paul and Friday 2014), either through electronic transfer or cheque payment. The effect of cashless payment on an economy can be analysed by the Diffusion of Innovation Theory (DOI). The concept was first introduced by Roger in 2016 where he explained how innovation is diffused to members of a social system over time (Rogers, 2015). According to DOI, the adoption of a new idea or innovations is caused by interaction between individuals through interpersonal networks. In this context, diffusion is the spread of cashless payment where consumers seek improved and convenient transaction, while businesses seek new profit opportunities.

2.3 Theoretical Review

Bank focused theory

Kapoor S, (2015) propounded the Bank focused theory. The theory is built on the foundation that banks utilized non-traditional though conventional but minimal cost delivery channels to offer financial services to its clients. These channels are online banking, point of sales, mobile pay, etc. Thus, banks provide arrays of financial services without recourse to the customers' account domiciled branch via the electronic payment channels. This theory is pertinent to this study because it hinges on the electronic payment channels which is the hallmark of the CBN cashless policy.

The Theory of Money

Money plays an important role in facilitating business transactions in a modern economy. Various theories of money have been propounded to examine the all-round effect of money towards economic transactions. The quantity theory of money is hinged on the Irvin Fisher equation of exchange that states that the quantum of money multiplied by the velocity of money is equal to the price level multiplied by the amount of goods sold. It is often replicated as

$$MV = PQ$$

Where

M = defined as the quantity of money,

V = the velocity of money (the number of times in a year that a currency goes around to generate a currency worth of income),

P = represents the price level and

Q = the quantity of real goods sold (real output). By definition, this equation is true. It becomes a theory based on the assumptions surrounding it.

The first assumption is that velocity of money is constant. This is because the factors, often technical, habitual and institutional, that would necessitate a faster movement in the velocity of money evolve slowly. Such factors include population density, mode of payment (weekly, monthly), availability of credit sources and nearness of stores to individuals.

2.4 Empirical Review

Taiwo, *et al*. (2016) assessed the adoption of the cashless policy in the Nigerian financial system from 2012 to 2016. The survey research design was employed for the study while the descriptive statistics and one-sample t-test were adopted for the data analysis.

One sample t-test formula utilized is given as: $t = \frac{(\bar{X}-\mu)}{S/\sqrt{n}}$ given that samples are independent.

Where $\bar{X}$ = is the sample mean

μ = is the hypothesized population mean

S = is the sample standard deviation and

n= is the sample size

The study concluded that cashless policy will earn the needed result only if much is done to implement its policies.

Akhalumeh and Ohioka (2017) observed some challenges with the introduction of cashless policy.

The study utilized $Gross\ profit\ percentage = \frac{Tpotal\ sale - Cost\ sale}{Tpotal\ sale} \times 100$

$$Net\ profit\ percentage = \frac{Net\ profit}{Tpotal\ sale} \times 100$$

$$Operation\ profit\ percentage = \frac{Operation\ profit}{Tpotal\ sale} \times 100$$

Their findings show that 34.0% of the respondents cited problem of internet fraud, 15.5% cited problem of limited POS/ATM, 19.6% cited problem of illiteracy and 30.9% stayed neutral - the respondent not been sure of problem been expected or experienced. While in some quarters there was fear of unemployment, some believe it will create more jobs especially when companies manufacturing POS machine are cited in Nigeria.

Echekoba and Ezu (2017), carried out research in Nigeria using descriptive statistics of frequency and percentage count.,

The study utilized:

$$Gross\ profit\ percentage = \frac{Tpotal\ sale - Cost\ sale}{Tpotal\ sale} \times 100$$

They observed that 68.2% of the respondent complained about long queues in the bank, 28.9% complained of bad attitude of teller officers (cashiers) while 2.89% complained of long distance of bank locations to their home or work places. Likewise, in her 24th NCS national conference in December 2015, CBN data shows that 51% of withdrawal done in Nigeria was through automated teller machine (ATM), while 33.6% was through over the counter (OTC) cash withdrawals and 13.6% through Cheques. Payment was also done through point of sales machine (POS) which accounted for 0.5% and web 1.3%. Therefore, if the introduction of ATM in Nigeria cash withdrawals system reduced OTC withdrawal; then it will imply that introduction of cashless policy supported by application of information technology can achieve more to reduce over dependent on cash payment in Nigeria economy system.

Ewa and Inah (2016) did a study to examine the Nigeria Cashless Policy Implementation. The study used the survey research design while Simple percentages and Relative Important Index (R.I.I) were employed in analyzing the collated data. The study's findings revealed that social infrastructures in power and telecommunications requires improvement and thereby create the need for more awareness to encourage the unbanked to access banking services.

Okafor (2020) carried out a study to assess the influence of cashless policy on Deposit Money Banks' performance in Nigeria (2009-2019). Internet banking, ATM, mobile banking and POS were used as proxies for the independent variable while return on assets was adopted to represent the dependent variable. The econometric techniques used for the study were descriptive statistics, augmented dickey fuller tests for unit roots, and the regression analysis.

Ejoh, *et al*. (2014) carried out a study that examined the cashless economy in other to evaluate the relationship between ICT and implementation of cashless policy. They administered 120 questionnaires and tested the data using chi-square.

The row by column Chai-Square formula utilized: $\chi^2 = \sum\sum\frac{(O-E)^2}{O}$

Where O= Observed frequency and

E= Expected frequency

The results showed that there exists a significant level of relationship between ICT and cashless policy implementation in the Nigerian financial environment. Moreover, public awareness should be done to encourage cashless economy in Nigeria.

Latifat and Alhassan (2015) embarked on a research to examine the pre-and post-implementation period of cashless policy tools in Nigeria. They focused the relationships between the cashless policy tools and currency outside deposit money banks (DMBs) in the Nigerian economy between 2009-2012. The study employed ordinary least squared regression technic to test the effects of this tool on the level of currency in circulation.

The ordinary least square model utilized is: $Y = \alpha + \beta_i X_i + \varepsilon$.

Where X are independent random variables and Y is the dependent variable. ε is a random variable normally distributed with mean 0 and variance

Their findings show that not a single cashless policy tool has a significant relationship with currency in circulation outside banks mainly due to high collinearity between the tools of cashless policy.

Marco and Bandiera (2014) argued that increased usage of cashless banking instruments strengthens monetary policy effectiveness and that the current level of e-money usage does not pose a threat to the stability of the financial system. However, it does conclude that central banks can lose control over monetary policy if the government does not run a responsible fiscal policy.

Mbutor and Uba (2013) while investigating the impact of financial inclusion on monetary policy in Nigeria between 1980 and 2012, adopted unrestricted cointegration and Ordinary Least Square (OLS) techniques reported that growing financial inclusion would improve the effectiveness of monetary policy and that country with higher degree of financial inclusion tends to achieve higher economic growth.

The cointegration equation utilized in the study is given as:

$$X_t = \gamma_0 + \gamma_1 Z_t + \varepsilon_t \sim I(1), \qquad Y_t = \delta_0 + \delta_1 Z_t + \eta_t \sim I(1), \qquad Z_t \sim I(0), \varepsilon_t . \eta_t \sim I(0)$$

Where η, ε are stationary process $I(0)$ with zero mean, but they can be serially correlated. In a nutshell, cointegration assumes a common stochastic non-stationary (i.e. I ((1)) process underlying two or more processes X and Y.

The study show that the cashless variables are cointegrated.

Mawejje and Lakuma (2017) examined the macroeconomic effects of mobile money in Uganda using both vector error correction mechanism (VECM) (to examine the effect of mobile money on money demand) and Structural Vector Autoregressive Model (SVAR) (to examine the effectiveness of monetary policy on mobile money)

The VECM utilized in the study is given as:

$$\Delta Y_t = \alpha \beta' y_{t-1} + \sum_{i=1}^{p-1} \tau \Delta y_{t-i} + \mu_t$$

where $\beta' y_{t-1} = ECM_{\ t-1}$(Error Correction Term), τ is the short-run coefficients, Δ is the symbol of difference operator, p is the lag order, and μ_t is the residuals.

And the structural VAR model in their work is:

$$y_{kt} = -\sum_{\substack{i=1 \\ i\neq k}}^{k} a_{ki} y_{it} + a_k^* Y_{t-1} + \omega_{kt}$$

Where:

a_k^* Shows the kth row of AA.

To ensure identifying properties of matrix A and estimating its consistency, the constraints should be imposed on this matrix, which are called the A-model by [Lütkepohl, H. 2005].

Their result shows that mobile money balances are sensitive to monetary policy shocks and thus have the potential to improve the conduct of monetary policy.

Kamukama and Tumwine's (2016) adopted correlation matrix and multiple regression model to unravel the liquidity threat of mobile money to commercial banks in Uganda showed that mobile money was negatively related to the liquidity position of commercial banks.

The multiple linear regression model utilized in the study is:

$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_k X_{ik} + \varepsilon_i$ I = 1, 2, … , n

The study also reported that mobile money service accounts for 36.7% of liquidity variance in Ugandan commercial banks and that this may present a serious problem to the effectiveness of monetary policy in the country. Given the unclear impact of mobile money on monetary policy and the inconclusive debate of its effect on the conduct of monetary policy, this study therefore seeks to fill the gap by empirically examining the influence of mobile money on the conduct of monetary policy in Nigeria.

Kehinde and Adelowo (2016) carried out a study to assess the level of Nigerians preparedness for e-commerce and cashless policy using the level of Information Communication Technology (ICT) adoption, usage and infrastructure available covering a space of 13 years. The study utilized ordinary least squared regression and concluded that ICT policy needs to be fully implemented and private and public sectors collaborations or partnership should be supported to facilitate the ecommerce and cashless policy.

3.0 METHODOLOGY

The study utilizes linear vector autoregressive model (VAR) to investigate the effects of cashles policy on economic growth in Nigeria, using quarterly data from 2019-2022. These data were sourced from the CBN data bank, and data will be analyzed using EVIEW statistical software.

3.1 Data Description

3.1.1 Gross Domestic Product (GDP)

Gross Domestic Product is the monetary value of goods and services produced in an economy during a period of time irrespective of the nationality of the people who produced the goods and services. It is calculated without making deductions for depreciation. This is GDP valued at the market prices which purchasers pay for the goods and services they acquire or use. It is collected from World Bank, 2019.

3.1.2 Variables of cashless policy

In the cost of this study we shall consider the following variables for cashless policy in Nigeria. These are Cheques, Automated Teller Machine, Point of Sale (POS) Terminal and Internet banking

3.2 Data Collection Procedure

This study employs the use of secondary data obtained from the website of Central Bank of Nigeria, a publication of Data and Statistics department of Central Bank of Nigeria titled "Real Growth Domestic Product (Billion Naira)". The data was grouped on *Quality bases.*

3.3.1 VAR Model

The Vector Autoregression (VAR) model, proposed by Sims (1980), is one of the most successful, flexible, and easy to use models for analysis of multivariate time series. It is applied to grasp the mutual influence among multiple time series. VAR models extend the univariate autoregressive (AR) model to dynamic multivariate time series by allowing for more than one evolving variable. All variables in a VAR model are treated symmetrically in a structural sense; each variable has an equation explaining its evolution based on its own lags and the lags of the other model variables (Enders, 2003).

Let $Y_t = (y_{it}, y_{2t}, \cdots\cdots, y_{nt})'$ denote an $(n \times 1)$ vestor of time series variable $(cheque_{-t}, POS_{-t}, ATM_{-t}, Internet\ banking_{-t}\ and\ GDP_{-t})$. A VAR model with p lags can be expressed as follows;

$$Y_t = c + \Psi_1 Y_{t-1} + \Psi_2 Y_{t-2} + \cdots + \Psi_p Y_{t-p} + \epsilon_{t,} \qquad t = 1, \cdots, T$$

Where:

Ψ_i = is a $(n \times n)$ coeeficient matrix,

$\epsilon_{t,}$ = is an $(n \times 1)$ unobservable zero mean white noise vector process, and

c = is an $(n \times 1)$ vector of constants (intercept).

Estimates Ψ_i of contain information on short run adjustments while c contain information on long run adjustments in changes in Y_t.

3.3.2 Model specification for VAR

The VAR model can be specify in econometric form as given below:

$$(cheque_{-t}, POS_{-t}, ATM_{-t}, Internet\ banking_{-t}) = f(GDP_{-t})$$

$$GDP = \beta_0 + \beta_1 cheque_{-t} + \beta_2 POS_{-t} + \beta_3 ATM_{-t} + \beta_4 Internet\ banking_{-t} + \varepsilon_t$$

A VAR model checks for the interaction between all the variables used in the analysis and thus treating them as an endogenous variable and a function of all variables in lags.

3.3.3 **Data Validation**

We first check for stationarity for all the data sets. If the data is stationary, then we have an unrestricted VAR, if it's not stationary then the data needs to be modified to allow consistency in estimation of the relationships among the series. This can be done through log or differencing which then prompts for a cointegration test to check relationships among the variables. If the results show that there is cointegration then we have to use Vector Error Correction Model (VECM). VEC model is a special case of VAR for variables that are stationary in their differences. If there is no cointegration then we use unrestricted VAR. Before estimating VAR/VECM we determine the VAR/VECM model. We should also conduct the impulse function and variance decomposition to analyze the dynamic property of the model before conducting stability test on the model.

3.3.5 Cointegration Test

Macroeconomic time series are typically non-stationary, as established by Nelson & Plosser, (1982). When traditional regression analysis is used on two non-stationary time series, a spurious regression may result Granger & Newbold (1974). Testing for cointegration is necessary step to check if you are modeling empirically meaningful relationships. If variables have different trends processes, they cannot stay in fixed long-run relation to each other, implying that you cannot model the long-run, and there is usually no valid base for inference based on standard distributions. If you do not find cointegration it is necessary to continue to work with variables in differences instead. In a nutshell, cointegration assumes a common stochastic non-stationary (i.e. I ((1)) process underlying two or more processes X and Y.

$X_t = \gamma_0 + \gamma_1 Z_t + \varepsilon_t \sim I(1),\qquad Y_t = \delta_0 + \delta_1 Z_t + \eta_t \sim I(1)\,,\qquad Z_t \sim I(0)\,, \varepsilon_t . \eta_t \sim I(0)$
η, ε are stationary process $I(0)$ with zero mean, but they can be serially correlated.

Although X_t and Y_t are both non-stationary$I(1)$, there exists a linear combination of them, which is stationary; $\delta_1 X \sim \gamma_1 Y_t(0)$. In other words, the regression of Y and X yields stationary residuals $\{\varepsilon\}$.

In general, given a set of non-stationary (of type I(1)) time series variables ,$\{X_{1,t}, X_{2,t} \cdots \cdots, X_{k,t}\}$ there exists a linear combination consisting of all variables with a vector β, such that:

$$\beta_1 X_{1,t} + \beta_2 X_{2,t} + \cdots \cdots + \beta_k X_{k,t} \sim I(0)$$

Where $\beta_j \neq 0, j = 1,2, \cdots \cdots, k$ .If this is the case, then the X's are cointegrated to the order of . $C, I(1,1)$. The Johansen test has two forms: the trace test and the maximum Eigen value test. Both forms/tests address the cointegration presence hypothesis, but each asks very different questions.

Trace Test

The trace test examines the number of linear combinations (i.e. K) to be equal to a given value (K_0), and the alternative hypothesis for K to be greater than K_0

$$H_0: K = K_0 \;\; Vs\; H_1: K > K_0$$

To test for the existence of cointegration using the trace test, we set $K_0 = 0$ (no cointegration), and examine whether the null hypothesis can be rejected. If this is the case, then we conclude that there is at least one cointegration relationship. In this case, we need to reject the null hypothesis to establish the presence of cointegration between the variables.

Maximum Eigen value Test

With the maximum Eigen value test, we ask the same central question as the Johansen test. The difference, however, is an alternate hypothesis:

$$H_0: K = K_0 \;\; Vs\; H_1: K = K_0 + 1$$

So, starting with $K_0 = 0$ and rejecting the null hypothesis implies that there is only one possible combination of the non-stationary variables to yield a stationary process. If we have more than one, the test may be less powerful than the trace test for the same K_0 values. A special case for using the maximum Eigen value test is when $K_0 = m - 1$,where rejecting the null hypothesis implies the existence of m possible linear combinations. This is impossible, unless all input time series variables are stationary $I(0)$ to start with.

4.0 Results

Table 4.1 Summary Statistics of the endogenous and exogenous variables of cashless policy from 2019 to 2022

Variable	Mean	Median	Std. Dev.	Minimum	Maximum
Cheque	5879.44	1761.92	6925.89	17.0522	21625.4
Internet Banking	7771.65	2948.67	9092.90	68.7957	27187.9
ATM usage	779.713	142.001	1079.66	6.09814	3606.56
Point of sales	4525.09	1131.83	5749.63	12.4939	20675.9
Nominal GDP	12188.6	3136.82	16420.0	104.585	58618.9
Actual GDP	25993.8	7515.81	31760.4	144.831	101489.
Real GDP	21620.9	6102.42	29834.9	144.831	101489.

The result from Table 4.1 shows the summary statistics of the cashless policies and three type of GDP in Nigeria from 2019 to 2022 at quarterly bases. From the table, the result based on the GDP's shows that actual GDP has average of 25993.8 million naira, greater than the average of Nominal GDP and real GDP. And for the cashless policies it is observed that internet banking has the highest average mean of 7771.65 million naira, followed by the mean of cheque 5879.44 million naira.

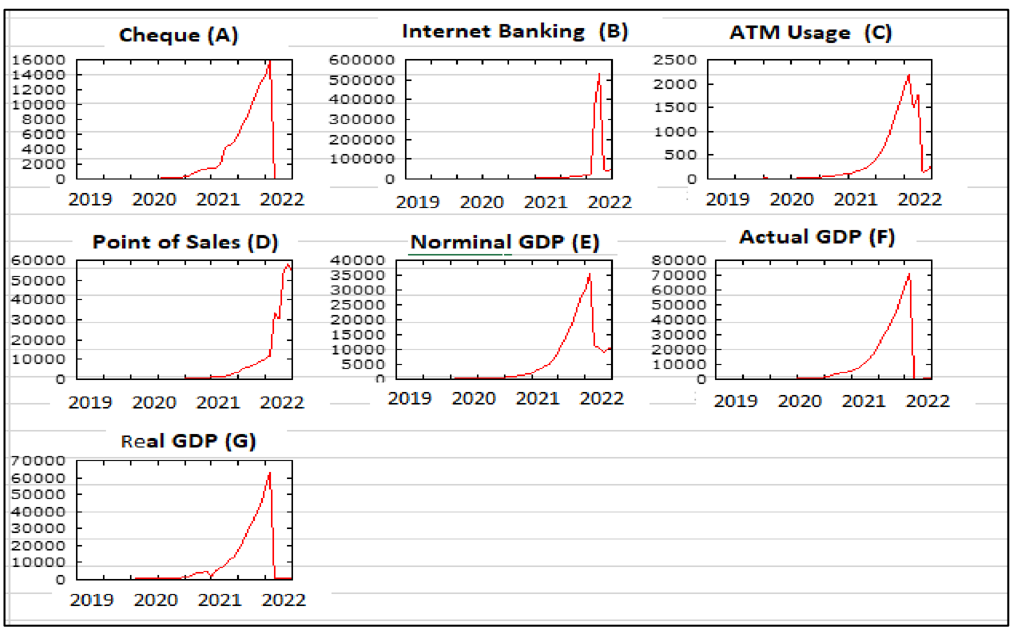

Figure 4.1: Time series plot representing the endogenous and the exogenous econometric variables and cashless variables used

Table 4.1: Unit Root Test using KPSS

T = 40 Lag truncation parameter = 3

Variables	Test statistic	10%	5%	1%	P-value
Cheque	0.954218	0.352	0.462	0.719	0.031
Internet Banking	0.957844	0.352	0.462	0.719	0.015
ATM	0.81846	0.352	0.462	0.719	0.012
Point of sales	0.87806	0.352	0.462	0.719	0.016
Nominal GDP	0.864408	0.352	0.462	0.719	0.051
Actual GDP	0.905999	0.352	0.462	0.719	0.017
Real GDP	0.654408	0.352	0.462	0.719	0.041

Null Hypothesis for KPSS state that the series is stationary.

A pre-condition for VAR modelling is to carry out a unit root test to ensure the time series is stationary. For this purpose, the study uses Kwiatkowski-Phillips-SchmidtShin test (KPSS) method to conduct the test for unit roots. The stationarity test reported in Table 4.2 showed that the time series variables studied did not attain stationarity at levels since the p-values = 0.001 are all less than 0.05, we reject the null hypothesis. The variables become stationary after first difference.

Table 4.3: VAR system, lag order 4

Equation 1: Effect on Nominal GDP

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	9.05004	80.9737	0.1118	0.9122	
NorminalGDP_1	0.289705	0.0869433	3.3321	0.0035	***
NorminalGDP_2	−0.310696	0.132983	−2.3364	0.0306	**
NorminalGDP_3	0.468293	0.119221	3.9279	0.0009	***
NorminalGDP_4	−0.554491	0.139786	−3.9667	0.0008	***
ActualGDP_1	−0.205672	0.0632496	−3.2517	0.0042	***
ActualGDP_2	0.438162	0.123317	3.5531	0.0021	***
ActualGDP_3	−0.0125034	0.133995	−0.0933	0.9266	
ActualGDP_4	0.255768	0.181214	1.4114	0.1743	
RealGDP_1	−0.155503	0.0913169	−1.7029	0.1049	
RealGDP_2	−0.191285	0.0862918	−2.2167	0.0390	**
RealGDP_3	−0.0543185	0.106966	−0.5078	0.6174	
RealGDP_4	−0.150157	0.0677109	−2.2176	0.0390	**
Cheque in Niara	0.228683	0.120035	1.9051	0.0520	*
Internet Banking	0.00352336	0.0554587	0.0635	0.9500	

ATM	9.34952	0.563481	16.5924	<0.0001	***
Point of sales	1.20455	0.171832	7.0100	<0.0001	***

Mean dependent var	13529.92	S.D. dependent var	16790.61
Sum squared resid	1446755	S.E. of regression	275.9438
R-squared	0.999853	Adjusted R-squared	0.999730
F(16, 19)	8097.969	P-value(F)	5.68e-33
rho	−0.480437	Durbin-Watson	2.958682

The result from table 4.3 shows the influence of cashless policy based cheque, internet banking, ATM and point of sale on nominal GDP and its lagged values. From the table the result shows that point of sale, ATM, Cheque as cashless variables and real GDP at lag 4, real GDP at lag 4 and nominal GDP at lag 1, 2, 3 and 4 have significant influence on nominal GDP. The value of Adjusted R-squared = 0.999730 shows that the good.

Table 4.4: VAR system, lag order 4

Equation 2: Effects on Actual GDP

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−208.588	86.9671	−2.3985	0.0269	**
NorminalGDP_1	0.0839555	0.0933785	0.8991	0.3799	
NorminalGDP_2	−0.0254471	0.142826	−0.1782	0.8605	
NorminalGDP_3	0.343282	0.128046	2.6809	0.0148	**
NorminalGDP_4	−0.399917	0.150132	−2.6638	0.0153	**
ActualGDP_1	−0.13917	0.0679311	−2.0487	0.0546	*
ActualGDP_2	0.204745	0.132445	1.5459	0.1386	
ActualGDP_3	0.134693	0.143913	0.9359	0.3611	
ActualGDP_4	0.132959	0.194627	0.6831	0.5028	
RealGDP_1	−0.163107	0.0980759	−1.6631	0.1127	
RealGDP_2	−0.141879	0.0926789	−1.5309	0.1423	
RealGDP_3	0.0151315	0.114883	0.1317	0.8966	
RealGDP_4	−0.0871024	0.0727226	−1.1977	0.2457	
Cheques	1.23569	0.128919	9.5850	<0.0001	***
Internet Banking	1.02954	0.0595636	17.2847	<0.0001	***
ATM	3.83165	0.605188	6.3313	<0.0001	***
Point of sales	1.87482	0.18455	10.1589	<0.0001	***

Mean dependent var	28864.47	S.D. dependent var	32237.31
Sum squared resid	1668849	S.E. of regression	296.3683
R-squared	0.999954	Adjusted R-squared	0.999915
F(16, 19)	25881.07	P-value(F)	9.15e-38
rho	0.405740	Durbin-Watson	1.162480

The result from table 4.4 shows the influence of cashless policy based cheque, internet banking, ATM and point of sale on Real GDP and its lagged values. From the table the result shows that point of sale, ATM, Internet Banking and Cheques as cashless variables and nominal GDP at lag 3 and 4 have significant influence on Real GDP since its P-values < 0.05. The value of Adjusted R-squared = 0.99915 shows that the good.

Table 4.5: VAR system, lag order 4

Equation 3: Effects on Real GDP

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	398.601	203.119	1.9624	0.0645	*
NorminalGDP_1	0.524982	0.218093	2.4071	0.0264	**
NorminalGDP_2	0.137416	0.333581	0.4119	0.6850	
NorminalGDP_3	0.405308	0.299061	1.3553	0.1912	
NorminalGDP_4	−0.135596	0.350646	−0.3867	0.7033	
ActualGDP_1	1.02421	0.158659	6.4554	<0.0001	***
ActualGDP_2	0.05678	0.309336	0.1836	0.8563	
ActualGDP_3	−0.196676	0.33612	−0.5851	0.5653	
ActualGDP_4	0.213313	0.454567	0.4693	0.6442	
RealGDP_1	−0.0740135	0.229064	−0.3231	0.7501	
RealGDP_2	0.00622989	0.216459	0.0288	0.9773	
RealGDP_3	−0.373442	0.268319	−1.3918	0.1801	
RealGDP_4	−0.338739	0.16985	−1.9943	0.0507	*
Cheques	−0.518198	0.301101	−1.7210	0.1015	
Internet Banking	0.0521483	0.139116	0.3749	0.7119	
ATM	−0.693009	1.41347	−0.4903	0.6295	
Point of sales	0.602489	0.431032	1.3978	0.1783	

Mean dependent var	24005.67	S.D. dependent var	30550.85
Sum squared resid	9103474	S.E. of regression	692.1923
R-squared	0.999721	Adjusted R-squared	0.999487
F(16, 19)	4260.103	P-value(F)	2.53e-30
rho	−0.038059	Durbin-Watson	2.060090

The result from table 4.5 shows the influence of cashless policy based cheque, internet banking, ATM and point of sale on Real GDP and its lagged values. From the table the result shows that

only Real GDP at lag 4 and Actual GDP at lag 1 have significant influence on Real GDP since its P-values < 0.05. The value of Adjusted R-squared = 0.99915 shows that the good.

Table 4.7 Johansen test:

Exogenous regressor(s): Cheque Internet Banking ATM usage Point of sales

						Corrected for sample size (df = 15)	
Rank	**Eigenvalue**	**Trace test**	**p-value**	**Max test**	**p-value**	**Trace test**	**p-value**
0	0.99673	219.03	0.0000	200.35	0.0000	219.03	0.0000
1	0.38992	18.677	0.0145	17.296	0.1450	18.677	0.2810
2	0.038679	1.3806	0.2400	1.3806	0.4970	1.3806	0.2835

The result Table 4.8 shows the output result of Johansson test of cointigration. From the table the result shows zero rank of cointigration since the P-value = 0.000 from the Trace test and Max test is less than 0.05 significant level This infers that the cashless variables have short run influence on the economic growths in Nigeria for the period studied.

5.0 Conclusion

In the expedition to evaluate influence of cashless variables on Nigeria GDP from 2019 to 2022 using multivariate VAR time series model. We observe that the activities of the cashless variable (automated teller machine (ATM), cheque withdrawal, internet bank and point of sales) contributed to Nigeria economic variable at short run.

Lastly the study reveal that that the economic variables and the cashless variables have an upward trend and a shock during the cashless period.

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