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The Application of Operations Research Models in Nigerian Deposit Money Banks

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Abstract

This study examines the current level of application of Operations Research (OR) models in Nigerian Deposit Money Banks. The study empirically reveals which Operations Research model techniques are being applied on a wide variety of core banking problem areas and decisions in Nigeria. The study utilized a combination of questionnaire and structured oral interview to elicit information from the sampled respondents. The data collected was analyzed using simple percentages and relative frequencies. The investigations revealed a high frequency of use of OR techniques in solving the investment decision problems of Nigerian deposit money banks; a high extent of use of OR techniques in handling the liquidity management decision problems of Nigerian deposit money banks; a high level of usage of OR techniques in solving the loans and credit administration decision problems of Nigerian deposit money banks, and, a high level of application of OR techniques in solving the operations management decision problems of Nigerian deposit money banks. The study recommends the enhanced usage of OR in Nigerian deposit money banks and other related commercial banking institutions, the establishment of more OR departments in the nations citadel of higher education as well as the strengthening of the newly established Institute for Operations Research of Nigeria, to further enhance OR awareness and usage in Nigerian banks.

Keywords: Operations Research (OR), Deposit Money Banks, Investment, Liquidity, Management, Loans and Credits, Operations, Nigeria

JEL Classification: C610, C000

Paper Classification: Research Paper

Introduction

There currently seem to be a difficulty in ascertaining the level of application of Operations Research (OR) models/techniques in the core commercial banking functions of Nigerian deposit money banks. Previous research has tended to focus more on the application of OR in manufacturing organisations that are involved in the production of tangible goods, while very low emphasis have been placed on conducting research related to OR usage in banking related institutions; with specific emphasis on the four core commercial banking functions (or decisions). Many stakeholders who are interested in ascertaining the impact of OR on the core commercial banking functions (or decision) of commercial banks have to resort to position papers and

opinions of some practitioners and researchers in the field; without any form of empirical test to add validity to their opinions, findings and suggestions. These core banking functions (or decisions) are very vital for efficiency and profitability as they significantly impact the firm value and shareholders wealth (Idolor, 2012).

The core commercial banking functions or decisions from a Financial Management point of view include investment decision, liquidity management decision, loans and credit administration decision and operations management decision. The unique nature of banks as providers, mainly of financial services, have made it relatively difficult to determine, from the extant empirical literature, which banking decision problems are amenable to Operations Research (OR) applications. Indeed a vast majority of the limited studies are more descriptive in nature with little or no form of statistical test of significance conducted on specific problem areas in commercial banking operations where OR have been utilized (Idolor, 2012; Idolor & Okolie, 2015).

In addition, analysis indicating the possible effect of OR models on operating costs, client convenience, deposits and revenue growth in commercial banking halls is increasingly generating considerable interest from stakeholders (practitioners, regulatory authorities and researchers) in the commercial banking sector worldwide; as problems in these area have often led to major incidence of bank fraud, distress and involuntary liquidation of major commercial banks. Some challenges that specifically fall within the purview of these core commercial banking decisions (or functions) include challenges related to cash inventory management, determination of optimal cash reserve, liability management, interest rate management, asset management, and optimal timing of deposit withdrawals in commercial banking halls (McClure & Miller, 1979). This line of research is however still very limited and very much at the infancy stage in Nigeria at the moment (Idolor & Okolie, 2015).

Furthermore, in recent years, commercial banking institutions in Nigeria have had their own fair share of commercial banking challenges (like their counterpart abroad) which still pose a great threat to their corporate existence and profitability. Such challenges emanate from the quality of their investment decisions, liquidity management decisions, loans and credit administration decisions and operations management decisions. Wrong decisions in these areas in Nigerian commercial banks have continued to constitute a major cause of bank distress, bank fraud, reduced level of profitability and low levels of customer service delivery. Also, many Nigerian commercial banks are saddled with long and uncontrollable queues because neither the arrival times (or arrival rate) of customers or the service times (or service rate) of the facilities are predicted accurately. These have led to the existence of many idle facilities in Nigerian banks (especially during rush hours of the day), despite the significant sum of money invested in procuring and installing them.

To date, the sensitive nature of commercial banking operations, still continue to ensure a paucity of reliable operations data that could be used by researchers concerned with studies aimed at improving efficiency (through OR application) in Nigerian deposit money banks. For instance, data on the specific challenges faced by banks in the preparation of periodic plans, process selection, capacity planning and facility layout are often scarce or treated as classified documents in Nigerian deposit money banks. Yet such data if widely available could easily facilitate research studies which can help prevent stunted growth, inefficiency or possible financial distress in Nigerian banks. In cognizance of the potential problems that could arise as a result of low OR usage in Nigerian deposit money banks; it became expedient and even compelling to conduct a study of this nature to assess the impact of OR models in Nigerian deposit money banks.

Literature Review

Operations Research can be defined as the application of scientific methods to improve the effectiveness of operations, decisions and management, by means such as analysis of data, creating mathematical models and proposing innovative approaches that give insights and guides in decision making scenarios (Uwah, 2007; Agbadudu, 2006). Also, as the name implies Operations Research basically means "research on operations" (Ewurum, 2007). However, for the purpose of this study, the definition of Operations Research provided by Akingbade (1991) and adopted by Ighomereho (2006), and, Idolor (2012) will be adopted. They define Operations Research as a problem solving science-based activity using analysis and modeling as a basis for aiding decision makers in organisations to improve the performance of the operations under their control.

With respect to the commercial banking sector, the utilization of Operations Research (OR) models have been significantly due to the rapid improvements in information and communication technology and the available range of financial products and services rendered to clients. In addition, empirical analysis outlining the potential effect of Operations Research models in relation to cost reduction have also stimulated growing interests and propositions on its potential effects on commercial banks financial performance (Uwah, 2007). Presently in the empirical literature, Operations Research methods have been successfully applied in four core commercial banking functions: investments, liquidity management, loans and credit administration and operation management (McClure & Miller, 1979; Kusy & Ziemba, 1986; Idolor, 2012; Idolor & Okolie, 2015); and these core areas constitute the basic theoretical framework of the study.

According to McClure and Miller (1979), the following Operations Research methods have also been successfully applied in performing many of the core commercial banking functions in numerous developed and developing countries.

i. Linear Programming Model
ii. Integer Programming Models
iii. Non Linear Programming Models
iv. Dynamic Programming Models
v. Probabilistic Programming Models
vi. Simulation Modeling
vii. Inventory Models
viii. Queuing Models
ix. Forecasting Models
x. Decision Theory
xi. Goal Programming Models
xii. Network Models
xiii. Markovian Models

The above mentioned Operations Research models have been applied in the core functions of commercial banks (in numerous countries) in other to achieve higher efficiency irrespective of prevailing economic and political uncertainty in the local and international business environment.

The inherent uncertainty of commercial banks cash flow, cost of fund and return on investments have led banks to strive for higher efficiency in their assets and liabilities management activities (Kusy & Ziemba, 1986). In Nigeria, these OR models have been applied in commercial banking institutions with the broad aim of reducing cost and increasing profitability (Ighomereho, 2006; Idolor, 2012; Idolor & Okolie, 2015). A robust discussion of the four core commercial banking functions, and, the importance and limitations of Operations Research will form the basis of the next subsections.

Investment Decision

Commercial banks investment decisions often involve the allocation of their funds to profitable investment proposals that promises to yield future benefits that will guarantee high returns to clients and investors (Brealey & Myers, 2006). Investment decision or capital budgeting decision, as it is commonly referred to, involves the decision to commit investable funds to long-term assets that yield beneficial returns in the near or distant future (Olowe, 2000). Two key areas in analyzing investment decisions borders on the evaluation of potential profitability of new investment outlets as well as the cut-off rate against which the anticipated return of the proposed investment could be compared (Pandey, 2010). Investment decisions could in some instances also include decisions bordering on the re-commitment of funds when assets are unproductive or less-profitable (Fisher & Jordan, 2008). The future benefits of investment decisions made by banks are often not readily measurable and therefore may not be easily ascertained as funds are committed for which the future benefits are uncertain (McClure & Miller, 1979; Chandra, 2008). Two important aspects of any investment are time and risk. The sacrifice must take place now and is quite certain in nature, as far as the resources that must be given up, while the benefits expected in the future are uncertain (Fisher & Jordan, 2008).

In much of the extant literature, Operations Research models have been widely applied in various facets, or forms of investment decisions and activities of commercial banking institutions worldwide. This ranges from problems relating to securities investment such as efficient portfolio selection, statutory bond and corporate debenture analysis and pricing of financial instruments in competitive financial markets. Often, in the empirical literature, commercial banks indicate that numerous Operations Research models are applied individually or jointly in a particular problem area (McClure & Miller, 1979; White, 1990). For instance, it is common in the literature to see commercial banks combining forecasting techniques with simulation modeling, linear programming and decision theory (White, 1990). Also, these methods could also be used to a much larger extent in one bank than in others thus revealing significant differences in terms of application (or combinations) in the use of Operations Research models (McClure & Miller, 1979). Currently such analysis or problem solving using Operations Research models are no longer manually done in commercial banks as commercial banks can always avail themselves the use of computers in their investment planning. This has made it very easy for busy bank executives (who may have a weak mathematical background) to utilize already existing commercial or custom made Operations Research computer packages (Fisher & Jordan, 2008).

Liquidity Management Decision

The primary purpose of commercial bank liquidity management is to support other commercial banking functions by maintaining reserves to meet unanticipated deposit withdrawals and an inventory of near cash funds to meet or satisfy potential credit demands. Because of the substantial volume and the frequent turnover of assets and liabilities, liquidity management requires close attention to money market portfolio management as well as deposit and credit

activities. Thus, the numerous constraints on such activities in commercial banks suggest that liquidity management may best be accomplished with the aid of Operations Research models like linear programming, goal programming and probabilistic programming (Fielitz & Loeffler, 1997).

Current asset management should be efficiently done in order to safeguard the bank against possible illiquidity and insolvency (Pandey, 2010; White, 1990). In order to ensure that appropriate funds are invested in current assets by commercial banks, top management of commercial banks need to develop sound techniques of managing current assets which enable them to properly forecast their bank's current assets requirements on how sufficient funds will be made available when needed (Uwah, 2007; White, 1990).

In the empirical literature, Operations Research models have been very widely applied in various facets of a commercial banks liquidity management function. This ranges from problems dealing with deposit withdrawals, cash inventory management, and the determination of optimal bank cash reserves (McClure & Miller, 1979). Operations Research models have a wide application in these areas because commercial banks, as well as most other financial institutions, need to hold a certain amount of cash and other short assets as a buffer against adverse fluctuations in deposits. Given the probability distribution of deposit variability and given relevant interest rates, both for alternative means of placing funds and of raising funds, in commercial banks, it is therefore possible to derive a well-defined mathematical problem (using Operations Research methods) to determine the optimal cash-holding strategy (Agbadudu, 2006; Taha, 2010).

Loans and Credit Administration Decision

Commercial banks loan and credit administration decision involves the allocation (or extension) of funds to deficit segments or units of the society. These are usually individuals or institutions with needs in excess of their available funds and who therefore resort to borrowing in order to cover the shortfall. Credit basically means the provision by a creditor (in this instance the bank) of such items like, goods, services or money to another party or legal entity with the repayment coming at a later date. Generally, a creditor is any person or legal entity to whom a debt is owed. The debt might have arisen through many means, however for a commercial banking institution it is commonly as a result of loans extended to a client (White, 1990; Idolor & Okolie, 2015).

Commercial banks on a regular basis have to extend credit (either commercial or consumer) to business organisations to carry out productive activities, or to individuals to purchase certain domestic or household products which improve their living standards (White, 1990). In many economies of the world the extension of credits have made it possible for bank customers to have what they want, when they want it, and with a promise to pay for it in full in one payment or in installments out of future income. By doing so commercial banks through their loans and credit policies make significant contributions to the overall economy by facilitating mass production (Adekanye, 1986).

The loans and credit administration function in commercial banks usually involves sound management of commercial banks assets such as loans, advances and discounted bills. This is done in order to control credit facilities with a view to collect the debts (or loans advanced) within the shortest possible time; thereby minimizing the chances or occurrence of bad debts and thus increase profits and organisational growth in the long run. This poses a big challenge to numerous commercial banks as their loan policies and activities have a tremendous effect (positive or negative), not only on their survival alone but also on the orderly growth and development of the general economy of the country where the commercial banks are situated.

In the empirical literature, Operations Research models have been applied extensively in bank loans and credit administration decisions. These have usually been in the area of credit investigation and analysis, determining credit limits and simulating repayment plans and programmes for loans extended to clients. The methods have also been used to analyse information obtained from loan applicants with the aim of determining the probability or possibility of having defaults in payments, bad debts or slow repayments (White, 1990, Kusy & Ziemba, 1986). Widely applied Operations Research methods in the area of loans and credit administration are forecasting models, probabilistic programming, decision theory and simulation models (McClure & Miller, 1979).

Operations Management Decisions

Operations management decision focuses on carefully managing the entire production and service rendering system of an organisation. Major activities in operations management area include product creation, development, production and distribution. In all these areas, the organisation is actively also engaged in managing its value chain. Other specific areas of interest include purchases, reduction in facility waiting time and queue control, inventory control, quality control, storage, and logistics; and also clearly focused on efficiency and effectiveness of processes. Operations management activities also include adequate measurement, management and effective coordination of all internal organizational processes from the production stage to the final consumer of the product or services.

Operations management is the aspect of a business which encompasses the entire activity involved in the production of goods and rendering of organizational services to clients. It involves also the duty of ensuring that organizational business activities are running efficiently in terms of the usage of fewer resources to obtain higher quantity and quality of output, and that all customer requirements are met as far as the product or service is concerned. Operations management also covers management of the entire input, thru put and output process in manufacturing or service rendering facilities. In commercial banks, this function is traditionally used to refer to the creation of financial products and the rendering of requisite services to bank clients. To this end, decisions made in the aspect of organizational operations, is geared towards improving the entire activity in a commercial bank's service rendering process; and aligning it with the available market opportunity for optimal enterprise performance (Uwah, 2007; Kusy & Ziema, 1986; Idolor, 2012; Idolor & Okolie, 2015).

In the empirical literature, Operations Research models have been applied extensively in bank operations management decisions. These have usually traditionally been in the area of cash reserve management, bank liquidity management activities, allocation of funds to banks competing projects and profitable asset categories. Other areas include efficient allocation of tellers and cubicle or lock box arrangement and location problems. Others are in branch site selection and location problem and the determination of optimum customer account profitability (White, 1990). Widely applied Operations Research models in the area of operations management decision are forecasting models, probabilistic programming techniques, decision theory, queuing techniques, goal programming models as well as simulation techniques (White, 1990; McClure & Miller, 1979, Idolor & Okolie, 2015). Successful applications of numerous Operations Research

techniques in solving bank problems abound in the empirical literature (Uwah, 2007). Successful application of Operations Research technique requires the construction of a model that explains the actual phenomenon. A model is a simplification of real world reality (Taha, 2010). This system as previously stated may already be in existence or a conceived idea awaiting execution. The importance and limitations of Operations Research models are presented in the next subsections.

The Importance and Limitations of Operations Research

Decisions, especially business decisions, can be characterised by many interrelated factors. The combined impact of the interrelated factors is rarely obvious, so that intuition and common sense alone do not necessarily on its own lead to good decision making. This is not to suggest that common sense, intuition, executive judgment and experience are irrelevant to decision making, but purely subjective decision making might not be sufficient in the ever changing business environment (Anderson, 1997). For managers with vast experience, heavy emphasis may be placed upon a qualitative analysis (rather than a quantitative analysis) for simple organizational challenges. Since the business environment is constantly changing in the real world, it is often observed that once old problems or challenges are solved, newer problems or challenges arise almost immediately with new structures and relations and this has effect on decision making; thus, managers need help and Operations Research techniques have the potential capability to support this need (INFORMS 2010). Quantitative analysis is important under the following conditions:

- When challenges are complex and the manager cannot resolve the issues arising without the use of quantitative techniques.
- Management is confronted with numerous decision factors than can readily be coped with, thereby making the use of operations research model techniques pertinent, with the goal of improving or optimizing performance.
- The problem is very important and deserves thorough analysis before decisions involving the commitment of funds are made.
- The emerging challenges are new and for which managers have no previous experience. Operations Research experts in this regard, can model various scenario and sensitivity analysis to help grapple with emerging issues, threats and opportunities as they arise.
- Management is worried with regards to adequate assessment of project risk.
- The organisation is not efficiently utilizing the data available. Many business organisations typically try to keep track of the information at their disposal. This activity often involves amassing huge data on the different functional areas of the organization; with the aim of making astute business decisions. Operations Research readily lends itself to such analysis that could involve the use of high intensity data for an extended period of time.

Operations Research helps organisations to make the best use of their resources, increase productivity and optimise profits (Murphy, 2000). Figure 1 depicts the role of Operations Research (OR) in operations management system which is aimed at achieving increased productivity and profit.

Fig. 1: Operations Management System

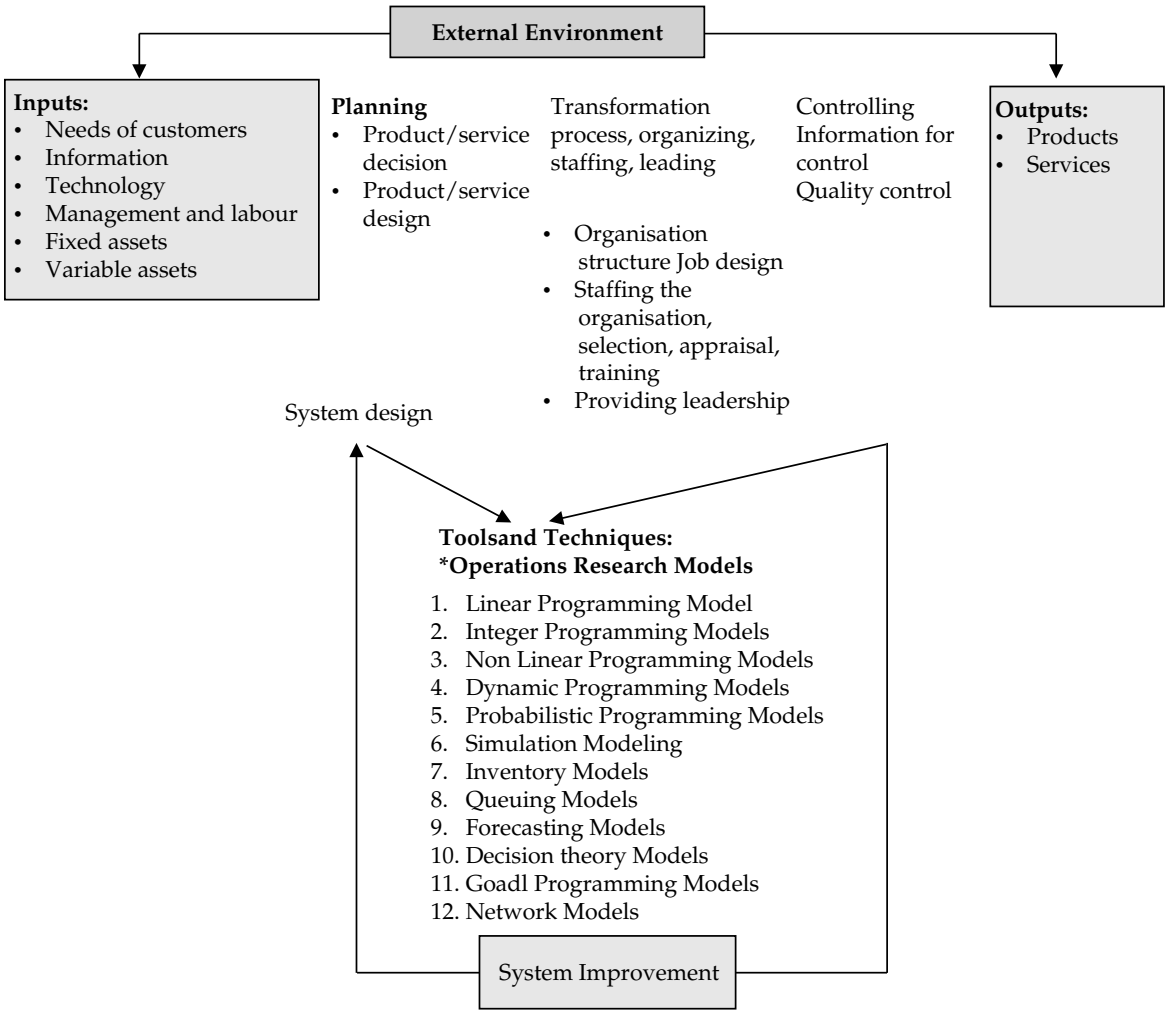


Figure 1 indicates that OR techniques can be used for improving manufacturing and service operations which can in turn lead to increased productivity. This implies that if OR activities are well coordinated, it will have a positive effect on performance and overall success of the organisation. Despite the relevance of Operations Research to organisations, Griffen (2010) stated that quantitative techniques cannot fully account for intangible or qualitative factors in decision making. Qualitative or intangible factors are factors that are difficult to measure numerically. For example, individual behaviour and attitudes, employee morale, and, image of the organization are major factors in managerial decisions, but they cannot be quantified.

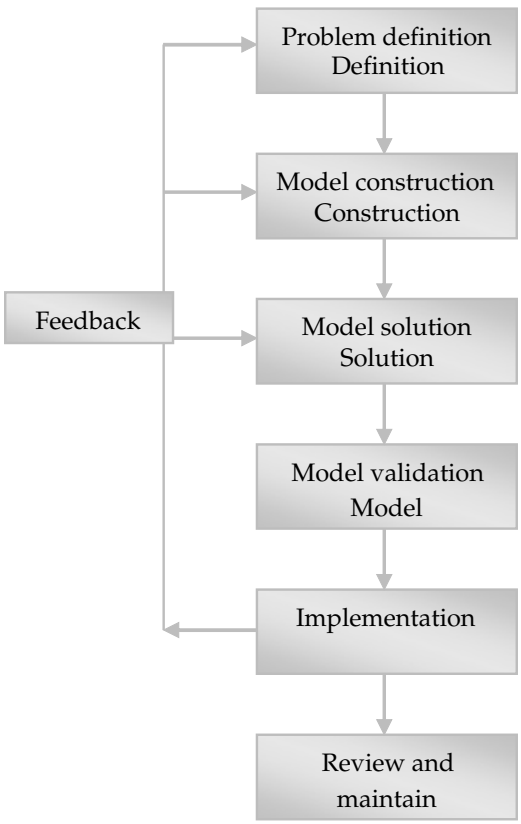
Another weakness of quantitative aids is that, they may not always be realistic. Also, for most techniques, the managers must identify and characterise all variables to be considered and must also recognise that, when the solution is subsequently implemented, a variable that has gone unaccounted for may influence it in some way than was initially expected. According to Agbadudu (2006) the limitations of OR are:

- Much time and effort can be wasted in finding solutions for rather irrelevant problems which are so far remote from reality and their solutions have little meanings to the prevailing problem.
- At times, a manager's practical experience and initiative would be a better judgment than unnecessary rigorous mathematical analysis,
- Costly in both time and resources.

As a result of these limitations, when using operations research, it is advisable to focus on pertinent quantitative information embedded in the decision problem, understand the mathematical assumptions and relationships embedded in the problem, clearly articulate the goals and objectives to be achieved once the challenge is resolved, clearly understand the unique challenges and constraints to be surmounted and other implicit and explicit interrelationships that exist in the problem situation being analysed. Once these issues are clearly resolved with the aid of one or more combination of techniques, recommendations based on the quantitative aspects of the decision problem can then be made in order to make the best possible decision. It should be noted that OR may be useful in some situations but not in others that may call for a more intuitive approach and that OR does not result in decisions, but it generates enough quantified data to point the manager to the most plausible decision.

Operations Research encompasses a logical and systematic approach to problem solving. This approach follows a generally recognized and ordered set of steps as shown in Figure 2.

Fig. 2: The Operations Research Approach



Problem Definition

This phase focuses on clearly articulating the scope of the decision challenge or problem that is being investigated. It is an important function which requires the full time attention and effort of the entire Operations Research group within the organisation. Outcomes of the investigation is mainly to resolve the three major issues of the decision problem which include a clear description of the possible alternatives available to the organisation, the goals and objectives of the study, as well as the possible limitations of the modeled system in question. The first step in this regard is to define the organisation's problems. Problems are not always the result of a crisis that must be reacted to, they can also be anticipated. Once it has been determined that a problem exists, the problem must be clearly and concisely defined (Gass, 1990).

Model Construction

After formulating the problems, there is a need to formulate models that best capture essential features of the challenges under consideration. Taylor (2006) defines a model as a simplified representation of an existing problem situation. Operations Research models usually consist of mental models, verbal models, diagrams and mathematical models (Akingbade, 1991). However, the most widely used Operations Research models are the mathematical models which comprise a set of mathematical relationships. Effective modeling processes aims at capturing only basic aspects or features of a typical problem scenario. It should be able to identify both possible and significant interactions existing among the various activities or sections of the organisation. The focus of model construction phase is to reveal major elements and interrelationships. How reliably a model captures the reality of the situation at hand is often determined by the validity of its assumptions.

Model Solution

This phase is often perceived as the simplest phase as it entails the usage of well-defined mathematical model techniques which could be iterative or algorithmic in nature. Equally important in the model solution phase is practical sensitivity analysis aimed at obtaining additional vital information on the possible behaviour of the "optimum" solution under differing scenarios and varying circumstances. Sensitivity analysis is often required if the model parameters are difficult to estimate with accuracy. Given such a scenario, it becomes vital to study the optimum solution of the initial estimates of the model's parameters for differing circumstances (Taha, 2010). Model solution phase basically involves manipulating the model to arrive at the feasible optimal solutions to the problem. In many instances, trial and error methods are utilised, and all that is required is to finally pick the one that best serves as an optimal and feasible solution. To record success in the model solution phase, there is need to always ensure the accuracy of the input data utilised.

Model Validation

Model validation concerns the efforts that are made to demonstrate that the model and the solution are sufficiently realistic to serve as a solid foundation for subsequent management action. The validation process includes careful consideration of assumptions, a review of data that were used in the model, and, checks to detect mathematical or arithmetic errors.

Model Implementation

This is the application of the information generated from Operations Research models. After careful interpretation of the results of the operation research model, modifications are made where appropriate and the final solution is approved by the decision maker, after which it is then implemented or incorporated into the company. It is the effectiveness of Operations Research in solving the problem it is expected to solve that determines its integration into the organisation. Sometimes, the solution may not be implemented because, although technically valid; management may consider that it should not be implemented.

Review and Maintenance

After implementation, the performance of the model should be carefully and constantly monitored to ensure that it actually does work and fulfill its objectives. The review process should be at regular intervals so that appropriate adjustments can be made to meet changes in conditions which can render the implemented solution inappropriate (Lucey, 2002).

Research Gap

Nigerian banks are currently facing service rendering and production challenges for which the application of operations research models may turn out to be beneficial to them in managing the challenges and problems they encounter. In the extant literature, a number of foreign researchers in time past including Fielitz and Loeffler (1997), Kusy and Ziemba (1986), and McClure and Miller (1979) have advocated for the application of operations research model techniques in commercial banking institutions operating in developed and developing countries as a veritable tool in enhancing organizational efficiency and profitability. However, to the best knowledge of the researcher, no attempt has been made to specify the level of application of the numerous operations research models in Nigerian commercial banking institutions in recent time. These gaps in the Nigerian extant literature therefore pose the following pertinent questions: What is the frequency of use of operations research techniques in (a) Investment decisions of Nigerian deposit money banks? (b) Liquidity management decisions of Nigerian deposit money banks? (c) Loans and credit administration of Nigerian deposit money banks? (d) Operations management decisions of Nigerian deposit money banks?

Methodology

Type of Study

This is a survey of deposit money banks in Nigeria to collect data for the research.

Research Sample

In January 2017, 544 questionnaires were distributed to the employees of three large old generation and three large new generation banks operating in the Southern part of Nigeria. The banks are namely: First Bank Plc, Union Bank Plc, United Bank for Africa (UBA) Plc, Guaranty Trust Bank (GTB) Plc, Zenith Bank Plc and Access Bank Plc. The sampling technique adopted is a non-probability, purposive or convenience sampling technique (Agbadudu & Ogunrin, 2006; Idolor, 2011). For a non-probability sampling technique, potential respondents or population

elements are not given equal probabilistic chance of inclusion in a sample. Therefore non-probability sampling does not indicate or guarantee randomness of a sample (Nachmias & Nachmias, 2009). This sampling technique can therefore be said to simply describe the process of selecting elements of a sample from a target population, bearing in mind typical assumptions of what elements are in the target population of study; and which elements or respondents are more likely to provide the pertinent information required by the researcher conducting the study (Asika, 1991; Idolor, 2011).

Justification for choice of Sample and Data Collection Methods

For our study, our objective is to provide answers to questions with regards to the application of Operations Research Models in Nigerian Deposit money banks. To this end questionnaire developed for the study was administered to respondents in the Southern parts of Nigeria. This region of Nigeria was selected for two basic reasons. Firstly, it constitutes the most ethnically heterogeneous region in Nigeria and clearly reflects the multi-ethnicity of Nigeria. Basically a vast number of all the major ethnic groups that make up Nigeria are also found in the southern region. The region therefore is representative of the vast ethnic diversity of Nigeria which makes it very much intuitively appealing to the researcher for a study of this nature. Secondly, the southern region is a very significant gateway in and out of the country as the major developmental facilities like good road networks, railway infrastructure including domestic and international airports are majorly located in the southern parts of Nigeria. Moreover, the region houses the major commercial nerve centres of Nigeria; and also boasts of the presence of numerous reputable federal institutions (Universities, Polytechnic, Colleges of Education, Ministries, Departments, and Agencies amongst numerous others) which increases the chances of employing citizens from within and outside the southern region of Nigeria, apart from the indigenous people domiciled in the region. This has given the region a highly advanced, educated and heterogeneous metropolitan population; many of whom (just like in other climes of the world) are possibly actual or potential operations research and banking specialists.

The questionnaire was tested for content or face validity before administration. Two senior staff of managerial status in their respective banks was required to analyse the questionnaire for adequate coverage of relevant dimensions of the research objectives with regards to possible problem areas and applied Operation Research (OR) models in Nigerian deposit money banks. The result of their useful comments and suggestions facilitated the development of the final questionnaire utilised for the current study. The final questionnaire therefore consists of questions that are not categorized explicitly into sections. It is hoped that by deliberately refusing to categorize the questions, the necessary informality required in the data gathering exercise can be readily achieved, thereby facilitating a higher completion rate. The questions do not follow any rigid formal logical sequence either. It is hoped that the absence of such sequence would greatly diminish the challenging problem of response set; which is basically an innate tendency to answer questions administered in a questionnaire in a specific general direction irrespective of the nature or content of the questions (Agbadudu & Ogunrin, 2006; Agbonifoh & Yomere, 2009; Idolor, 2011). Also, the questions regarding personal details like age, gender, educational qualification and religion appears at the end of the questionnaire so as to reduce any discomfort that such disclosure could induce in our selected respondents. It is assumed that for as long as respondents are not unnerved after filling or ticking a few questions, which is likely if personal details are sought first, then the odds in favour of a high response rate could be favourable. Qualitative analysis was

conducted when required, and, the questions in the questionnaire were analysed using percentage analysis presented in tabular form. This resolved and simplified the problem of comparison, thereby showing the required qualitative characteristics in numerical form.

Data Analysis Tool

The research applied frequency count and percentage analysis.

Results and Discussions

Response Rate

Out of the 544 questionnaire distributed to the respondents, 535 was successfully retrieved, and out of which 515 was deemed suitable for use, giving a questionnaire retrieval completion rate of 94.85 percent, which is approximately 95 percent. The data generated from the questionnaire was analysed, discussed and presented in the study.

Demographic Characteristics of Respondents

Our analysis revealed that our respondents comprised 301 males and 214 females. A total of 202 respondents are within the highest age bracket 'above 40 years' while 20 respondents are within the lowest age bracket – "less than 30 years". The modal age bracket is ">40 years" with a corresponding frequency of 202. Amongst the respondents, 403 had postgraduate degree/ qualification, 95 had HND/B.Sc. and the remaining 17 had ND/Diploma degrees. Amongst the 515 respondents 37 had less than five years' experience in the banking industry, 50 had between "5-10 years" experience, 95 had between "11-15 years" experience, 177 had between "16-20 years" experience and the remaining 156 had above twenty years' experience in the banking industry. Amongst the respondents 19.22% are in the customer service unit, 23.30% are in cash management unit, 22.14% are in funds transfer unit, 18.84% are in clearing unit, 12.42% are in the domestic treasury operations unit while the remaining 4.08% are in the international operations unit of the respective sampled deposit money banks. The frequency count and percentage analysis indicated that the respondents of the sampled Nigerian deposit money banks cuts across the major commercial banking operations units of their respective banks. This is shown in Table 1, 2 and 3 respectively.

Table 1: Respondents' Sex, Age distribution and level of Education

	Age distribution (years)							Level of Education			
Sex		**<30**	**30-35**	**36-40**	**>40**	**Nil response**	**Total**	**Nil response**	**ND/ Diploma**	**HND/B. Sc.**	**Postgraduate Degree**
Male	301	20	39	40	202	0	301	0	10	75	216
Female	214	10	55	34	115	0	214	0	7	20	187
Total	515	30	94	74	317	0	515	0	17	95	403

Source: Data from Fieldwork, 2017

Table 2: Years of Service in the Banking Industry

	Length of Service (years)					
Sex		<5	5-10	11-15	16-20	>20
Male	301	18	17	25	130	111
Female	214	19	33	70	47	45
Total	515	37	50	95	177	156

Source: Data from Fieldwork, 2017

Table 3: Units or Aspect of Banking Operations of Respondents

Unit	Percentage (%)
Customer Service Unit	19.22
Cash Management Unit	23.30
Funds Transfer Unit	22.14
Clearing Unit	18.84
Domestic Treasury Operations Unit	12.42
International Operations Unit	4.08
Total	100.00

Source: Data from Fieldwork, 2017

Findings on Operations Research Applications

The findings from the field survey are presented in Tables 4 – 8 respectively. Also, the result shows that numerous methods are associated with a particular problem area; thus indicating that commercial banks solved each problem area using more than one method or even a combination of methods. The Operations Research techniques with larger frequencies or percentages, indicates the models which have a higher frequency of use in the Nigerian commercial banking industry.

Table 4: Respondents Views on the types of Operations Research Models that is currently being used by Decision Makers in Nigerian Commercial banks in tackling their Investment Decision Problems

Investment Functions OR Techniques	Investment portfolio selection	Percentage %	Security pricing and bidding	Percentage %	Asset acquisition	Percentage %	Bond/ debenture trade analysis	Percentage %	Bond/ debenture pricing and bidding	Percentage %	Equity analysis and investment	Percentage %
Linear programming models	57	11.10	65	12.62	95	18.45	78	15.15	71	13.79	90	17.48
Integer programming models	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Nonlinear programming models	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Dynamic programming models	0	0.00	11	2.14	6	1.17	18	3.49	11	2.13	25	4.85
Probabilistic programming models	11	2.13	26	5.05	19	3.69	24	4.66	26	5.05	32	6.21
Simulation modeling	124	24.10	68	13.20	117	22.72	104	20.19	96	18.64	88	17.08
Inventory models	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Queuing models	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Forecasting models	127	24.66	148	28.74	138	26.80	122	23.69	110	21.36	118	22.91
Decision theory models	107	21.00	79	15.34	63	12.23	84	16.31	95	18.45	52	10.10
Goal programming models	71	13.80	92	17.86	77	14.94	71	13.79	65	12.62	81	15.74
Network models	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Markovian Models	18	3.21	26	5.05	0	0.00	14	2.72	41	7.96	29	5.63
No OR method in use	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	515	100.00	515	100.00	515	100.00	515	100.00	515	100.00	515	100.00

Source: Data from Fieldwork 2017

Table 4 shows the frequency of use of numerous Operations Research (OR) model techniques for six different designated areas of challenge bordering on investment decisions in the Nigerian banking industry. The results indicate differences in the usage of Operations Research (OR) techniques for the designated areas of challenge suggested. The responses of the respondents are shown in absolute numbers and percentages. The result obtained from the respondent indicates that linear programming models (11.10%), probabilistic programming models (2.13%), simulation models (24.10%), forecasting models (24.66%), decision theory models (21.00%), goal programming models (13.80) and Markovian models (3.21%) are used in solving the investment portfolio selection problems of Nigerian commercial banks. For security pricing and bidding investment decision problems, the responses of the respondents showed that linear programming models (12.62%), dynamic programming models (2.14%), probabilistic programming models (5.05%), simulation models (13.20%), forecasting models (28.74%), decision theory models (15.34%), goal programming models (17.86%) and Markovian models with 5.05% are utilized with respect to the problem. For asset acquisition investment decision problem, the results from the responses of respondents showed that linear programming models (18.45%), dynamic programming models (1.17%), probabilistic programming models (3.69%), simulation models (22.72%), forecasting models (26.80%), decision theory models (12.23%) and goal programming models with 14.94% are utilized with respect to the problem.

Furthermore, with respect to bond/debenture trade analysis investment problems, the responses of the respondents revealed that the Operations Research model(s) in use are linear programming model (15.15%), dynamic programming models (3.49%), probabilistic programming models (4.66%), simulation models (20.19%), forecasting models (23.69%), decision theory (16.31%) goal programming models (13.79%) and Markovian models (2.72%) are utilized respectively in regards to the question. With regards to bond/debenture pricing and bidding investment problem, the responses of the respondents indicated that the Operations Research model in use are linear programming (13.79%), dynamic programming models (2.13%), probabilistic programming models (5.05%), simulation models (18.64%), forecasting models (21.36%), decision theory (18.45%), goal programming models (12.62%) and Markovian models with 7.96% respectively.

With respect to equity analysis and investment decision problems, the responses of the respondents revealed that the Operations Research (OR) models in use were linear programming models (17.48%), dynamic programming models (4.85%), probabilistic programming models (6.21%), simulation modeling (17.08%), forecasting models (22.91%), decision theory models (10.10%), goal programming models (15.74%) and Markovian models with 5.63% respectively. The findings from the percentage analysis and frequency count further revealed that the predominant models in use are forecasting models, simulation models, linear programming models, goal programming models and decision theory models. There was no application of integer programming models, nonlinear programming models, inventory models, queuing models and network models (from the responses of respondents) in solving the investment decision problems inherent in Nigerian banking operations. Also, the findings reveal that numerous OR methods are associated with a problem area; thus indicating that commercial banks solved each problems area using more than one method or even a combination of methods. The Operations Research techniques with larger frequencies or percentages, indicates the models which have a higher frequency of use in the Nigerian banking industry.

Table 5: Respondents Views on the types of Operations Research Models that is currently being used by Decision Makers in Nigerian Commercial banks in tackling their Liquidity Management Decision Problems

Liquidity Management Function OR Techniques	Cash Inventory Management	Percentage %	Determination of Optimal Cash Reserve	Percentage %	Liability Management	Percentage %	Interest Rate Management	Percentage %	Optimal Timing/ Management of Deposit Withdrawals	Percentage %	Asset Management	Percentage %
Linear programming models	54	10.48	65	12.62	77	14.95	57	11.06	95	45	60	11.65
Integer programming models	0	0.00	0	0.00	0	0.00	0	0.00	13	2.52	0	0.00
Nonlinear programming models	7	1.36	18	3.50	10	1.94	8	1.55	15	2.91	21	4.01
Dynamic programming models	0	0.00	10	1.94	0	0.00	11	2.13	18	3.50	0	0.00
Probabilistic programming models	14	2.72	24	4.66	11	2.14	22	4.27	60	11.65	29	5.63
Simulation modeling	127	24.66	111	21.55	65	12.62	95	18.45	99	19.22	138	26.79
Inventory models	11	2.14	8	1.55	72	14.00	0	0.00	71	12.42	25	4.86
Queuing models	0	0.00	0	0.00	0	0.00	0	0.00	64	12.43	0	0.00
Forecasting models	122	23.69	125	24.27	110	21.36	143	27.77	77	16.32	86	16.70
Decision theory models	97	18.83	88	17.09	31	6.02	100	19.42	3	0.58	102	19.81
Goal programming models	56	10.87	38	7.39	95	18.45	61	11.86	0	0.00	45	8.74
Network models	14	2.73	28	5.43	44	8.52	11	213	0	0.00	9	1.81
Markovian Models	13	2.52	0	0.00	0	0.00	7	1.36	0	0.00	0	0.00
No OR method in use	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	515	100.00	515	100.00	515	100.00	515	100.00	515	100.00	515	100.00

Source: Data from Fieldwork 2017

Table 5 shows how frequently used are the various Operations Research (OR) models for six different types of bank problem areas, bordering on liquidity management decisions of Nigerian commercial banks. The results naturally show the differences in the utilisation of Operations Research (OR) techniques for the designated problem areas suggested. The responses of the respondents are shown both in absolute numbers as well as in percentages. The responses of the respondents indicate that linear programming models 10.48%, nonlinear programming models 1.36%, probabilistic programming models 2.72%, simulation modeling 24.66%, inventory models 2.14%, forecasting models 23.69%, decision theory models 18.83%, goal programming models 10.87%, network models 2.73%, and Markovian models 2.52%, are used in solving the cash inventory management problems of Nigerian commercial banks. The remaining Operations Research models yielded no response from the respondents.

For the question bordering on the determination of optimal cash reserve, the responses are linear programming models 12.62%, nonlinear programming models 3.50% dynamic programming models 1.94%, probabilistic programming 4.66%, simulation modeling 21.55%, inventory models 1.55%, forecasting models 24.27%, decision theory models 17.09%, goal programming models 7.39% and network models with 5.43%. The results posted zero responses with regards to integer programming models, queuing models and Markovian models. Concerning the question on liability management, the responses are linear programming models with 14.95%, nonlinear programming models 1.94%, probabilistic programming 2.14%, simulation modeling 12.62%, inventory models 14.00%, forecasting models 21.36%, decision theory models 6.02%, goal programming models 18.45% and network models with 8.52%.

With respect to interest rate management problems, the responses yielded 11.06% for linear programming model, 1.55% for nonlinear programming models, 2.13% for dynamic programming models, 4.27% for probabilistic programming models, 18.45% for simulation modeling, 27.77%for forecasting models, 19.42% for decision theory models, 11.86% for goal programming models, 2.13% for network models and 1.36% for Markovian models. While integer programming, inventory models and queuing models yielded zero response from the respondents. Optimal timing and management of deposit withdrawals yielded 18.45% for linear programming models, 2.52% for integer programming models, 2.91% for nonlinear programming models, 3.50% for dynamic programming models, 11.65% for probabilistic programming models, 19.22% for simulation modeling, 12.42% for inventory models, 12.43% for queuing models, 16.32% for forecasting models and 0.58% for decision theory models; with the other remaining OR models yielding zero responses from the respondents. Asset management yielded 11.65% for linear programming models, 4.01% for nonlinear programming models, 5.63% for probabilistic programming models, 26.79%for simulation modeling, 4.86% for inventory models, 16.70% for forecasting models, 19.81% for decision theory models, 8.74% for goal programming models and 1.81% for network models. Integer programming model, dynamic programming models, queuing models and Markovian models all yielded zero responses from the respondents.

Furthermore, the results revealed that a combination of methods was related with a problem area; thus indicating that Nigerian commercial banks solve each problem area using more than one method or even a combination of methods. Also, the Operations Research techniques with the higher frequency counts or percentages indicate the models which have higher frequency of use in the Nigerian commercial banking industry.

Table 6: Respondents Views on the types of Operations Research Model that is currently being used by Decision Makers in Nigerian Commercial banks in tackling their Loans and Credit Administration Decision Problems

Loans and Credit Administration Decision/Function OR Techniques	Commercial loans Portfolio Selection	Percentage %	Installment Loan Portfolio Selection	Percentage %	Commercial Customer Credit Analysis	Percentage %	Installment Customer Credit Analysis	Percentage %	Determination of Optimum Credit Limits	Percentage %	Determination of Optimum Repayments Periods	Percentage %
Linear programming models	54	10.48	71	13.79	65	12.62	53	10.29	123	23.88	99	19.22
Integer programming models	6	1.17	7	1.36	10	1.94	0	0.00	6	1.17	15	2.91
Nonlinear programming models	13	2.50	18	49	8	1.55	6	1.17	7	1.36	0	0.00
Dynamic programming models	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Probabilistic programming models	65	12.62	74	14.37	82	15.92	50	9.71	85	16.50	32	6.21
Simulation modeling	138	26.79	168	32.62	157	30.5	124	24.08	134	26.01	166	32.23
Inventory models	8	1.55	15	2.91	14	2.72	18	3.50	28	5.44	7	1.36
Queuing models	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Forecasting models	122	69	110	21.36	86	16.70	135	26.21	116	22.52	96	18.64
Decision theory models	38	7.40	14	2.72	42	8.16	52	10.09	6	1.71	29	5.63
Goal programming models	65	12.63	27	5.24	36	6.98	67	13.01	4	0.80	58	26
Network models	6	1.17	11	2.14	15	2.91	10	1.94	6	1.17	13	2.54
Markovian Models	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
No OR method in use	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	515	100.00	515	100.00	515	100.00	515	100	515	100.00	515	100.00

Source: Data from Fieldwork 2017

Table 6 shows how frequently used are the various Operations Research (OR) techniques for six different designated problem areas (isolated from the empirical literature) bordering on loans and credit administration decisions of Nigerian commercial banks. The results reveal differences in the utilisation of Operations Research (OR) techniques for the stipulated bank problems. The responses of respondents are shown both in absolute numbers as well as in percentages. The results indicate that linear programming model (10.48%), integer programming model (1.17%), non linear programming model (2.50%), probabilistic programming models (12.62%), simulation modeling (26.79%), inventory models (1.55%), forecasting models (23.69%), decision theory models (7.40%), goal programming model (12.63%) and network models (1.17%) are used in solving the commercial loan portfolio selection problems of Nigerian commercial banks. The remaining Operations Research models yielded no response from the respondents.

For the question bordering on installment portfolio selection, the responses were linear programming model (13.79%), integer programming model (1.36%), non linear programming model (3.49%), probabilistic programming model (14.37%), simulation modeling (32.62%), inventory models (2.91%), forecasting models (21.36%), decision theory models (2.72%), goal programming models (5.24%) and network models (2.14%) respectively, used in tackling the problem. The remaining models, dynamic programming models, queuing models and Markovian models yielded negative responses from respondents.

With respect to commercial customer credit analysis, the responses were; linear programming model (12.62%), integer programming models (1.94%), non linear programming models (1.55%), probabilistic programming models (15.92%), simulation modeling (30.50%), inventory models (2.72%), forecasting models (16.70%), decision theory models (8.16%), goal programming models (6.98%) and network models (2.91%) are used. The remaining Operations Research models yielded no response from the respondents.

For installment customer credit analysis, the response of respondents were linear programming (10.29%), non linear programming models (1.17%), probabilistic programming models (9.71%), simulation modeling (24.08%), inventory models (3.50%), forecasting models (26.21%), decision theory models (10.09%), goal programming models (13.01%) and network models with (1.94%) respectively are used. The remaining OR models yielded zero response from the respondents. Determination of optimum credit limits problem yielded linear programming (23.88%), integer programming models (1.17%), nonlinear programming models (1.36%), probabilistic programming models (16.50%), simulation modeling (25.01%), inventory models (5.44%), forecasting models (22.52%), decision theory (1.17%), goal programming models (0.80%) and network models (1.17%) respectively. The remaining OR models yielded zero response from the respondents.

With respect to determination of optimum repayment periods, the responses of respondents were; linear programming model (19.22%), integer programming (2.91%), probabilistic programming model (6.21%), simulation modeling (32.23%), inventory models (1.36%), forecasting models (18.64%), decision theory models (5.63%), goal programming models (11.26%) and network models (2.54%) respectively are used. The remaining Operations Research models yielded zero response from the respondent.

Table 7: Respondents Views on the types of Operations Research Method or Methods that is currently being used by Decision Makers in Nigerian Commercial banks in tackling their Operations Management Decision Problems

Operations Management Decisions/ Function OR Techniques	Management or Reserve and Liquidity Requirements	Percentage %	Allocation of funds of Bank Asset Categories	Percentage %	Teller Staffing or Allocation Problems	Percentage %	Lock Box/ Cubicle Location	Percentage %	Branch Site Selection and Location Problem	Percentage %	Determination of Optimum Customer Account Profitability	Percentage %
Linear programming models	65	12.62	42	8.15	47	9.13	81	15.73	61	11.84	77	14.95
Integer programming models	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Nonlinear programming models	0	0.00	0	0.00	0	0.00	0	0.00	14	2.72	0	0.00
Dynamic programming models	28	5.44	0	0.00	0	0.00	0	0.00	21	4.08	14	2.72
Probabilistic programming models	56	10.87	15	2.91	0	0.00	0	0.00	8	1.55	46	8.93
Simulation modeling	127	24.66	121	23.50	113	21.94	143	27.77	161	31.26	150	29.12
Inventory models	42	8.16	67	13.01	0	0.00	0	0.00	7	1.36	0	0.00
Queuing models	0	0.00	0	0.00	121	23.50	110	21.36	30	5.83	0	0.00
Forecasting models	84	16.31	68	13.20	115	22.33	15	2.91	104	20.19	92	17.86
Decision theory models	54	1049	71	13.78	67	13.00	79	15.34	44	8.54	58	11.26
Goal programming models	59	11.45	79	15.36	52	10.10	47	9.13	51	10.00	78	15.16
Network models	0	0.00	52	10.09	0	0.00	40	7.79	14	2.63	0	0.00
Markovian Models	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
No OR method in use	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	515	100.00	515	100.00	515	100.00	515	100.00	515	100.00	515	100.00

Source: Data from Fieldwork 2017

Table 7 shows the frequency of use of the various Operations Research (OR) techniques for six different designated problem areas (isolated from the empirical literature) bordering on operations management decision problems of Nigerian commercial banks. The result shows the differing usage of Operations Research (OR) techniques for the stipulated bank problems. The responses of the respondents, shown in both absolute numbers and percentages, show that for management of reserve and liquidity requirements linear programming model had a frequency of 65 (12.62%), dynamic programming models had a frequency of 28 (5.44%), probabilistic programming model had 56 (10.87%), simulation modeling had 127 (24.66%), inventory models had 42 (8.16%), forecasting models 84 (16.31%), decision theory models 54 (10.49%), and goal programming model 59 (11.45%). The remaining OR models had zero response from the respondents.

For allocation of funds to bank asset categories, the results was linear programming models 42 (8.15%), probabilistic programming models 15 (2.91%), simulation modeling 121 (23.50%), inventory models 67 (13.01%), forecasting models 68 (13.20%), decision theory model 71 (13.78%), goal programming models 79 (15.36%) and network models 52 (10.09%). Teller staffing or allocation problem had linear programming model 47 (9.13%), simulation modeling 113 (21.94%), queuing models 121 (23.50%), forecasting models 115 (22.33%), decision theory models 67 (13.00%) and goal programming models 52 (10.10%). All the remaining models yielded zero responses from the respondents.

With respect to lock box/cubicle location, the responses were, linear programming model 81 (15.73%), simulation modeling 143 (27.77%), queuing models 110 (21.36%), forecasting models 15 (2.91), decision theory models 79 (15.34%), goal programming model 47 (9.13%) and network models 40 (7.76%). The remaining OR methods yielded zero response from the respondents. Branch site selection and location problems yielded, linear programming models 61 (11.84%), non linear programming models 14 (2.72%), dynamic programming models 21 (4.08%) probabilistic programming models 8 (1.55%), simulation modeling 161 (31.26%), inventory models 7 (1.36%), queuing models 30 (5.83%), forecasting models 104 (20.19%), decision theory models 44 (8.54%), goal programming models 51 (10.00%) and network models 14 (2.63%).

For the determination of optimum customer account profitability, the responses of respondents were, linear programming models 77 (14.95%), dynamic programming 14 (2.72%), probabilistic programming models 46 (8.93%), simulation modeling 150 (29.12%), forecasting models 92 (17.86%), decision theory models 58 (11.26%) and goal programming model 78 (15.16%) respectively were in use. The remaining Operations Research models yielded zero responses from the respondents. Furthermore, the Operations Research models with the higher frequency counts or percentages indicate the models which have higher frequency of use in the Nigerian commercial banking industry. Also, the results indicate that numerous Operations Research method are associated with a particular problem area; thus indicating that Nigerian commercial banks solve their operations management decision problems using more than one method or even a combination of methods.

Table 8: Cumulative Frequency of Use in Banking Problem Areas

OR TECHNIQUE	FREQUENCY OF USE IN PROBLEM AREA					
	Investment Decision Problems[1]	Liquidity Management Decision Problem[2]	Loans and Credit Administration Decision Problems[3]	Operations Management Decision Problems[4]	Total Frequency Of Use of the method	Rank
Linear programming models	456	408	465	373	1702	3
Integer Programming Models	0	13	44	0	57	13
Nonlinear programming models	0	79	52	14	145	12
Dynamic programming models	71	39	0	63	173	10
Probabilistic programming models	138	160	388	125	811	6
Simulation modeling	597	635	887	815	2934	1
Inventory models	0	187	90	116	393	7
Queuing models	0	64	0	261	325	8
Forecasting models	763	663	665	478	2569	2
Decision theory models	483	421	181	373	1455	4
Goal programming models	457	295	257	366	1375	5
Network models	0	106	61	106	273	9
Markovian models	128	20	0	0	148	11
No OR method used5	0	0	0	0	0	-

Source: Data from Fieldwork.2017

Foot Notes:

1. Investment portfolio selection, Security Pricing and Bidding, Asset Acquisition, Bond/ Debenture Trade Analysis, bond/Debenture Pricing and Bidding, Equity Analysis and Investment.
2. Cash inventory management, determination of optimum cash reserve, Liability Management, Interest Rate Management, Optimal Timing/Management of Deposit Withdrawals, Asset Management.
3. Commercial Loans Portfolio Selection, Installment Loan Portfolio Selection, Commercial Customer Credit Analysis, Installment Customer Credit Analysis, Determination of Optimum Credit Limits, Determination of Optimum Repayment Periods.
4. Management of Reserve and Liquidity Requirements, Allocation of Funds to Bank Asset Categories, Teller Staffing or Allocation Problem; Lock Box/Cubicle Location, Branch Site Selection and Location Problems, Determination of Optimum Customer Account Profitability.
5. Includes Respondents who checked the category "None" as well as those who did not check any method category.

Table 8 shows the findings which reveal differences in the use of operations research (OR) models. This is presented on a cumulative basis for the various bank problem areas analysed in the study. This is visibly portrayed by the number and relative differences in complexity of the methods used. Table 8 also reveals values on the frequency of utilisation of each Operations Research (OR) method; derived on a cumulative basis, from the responses of the respondents

previously indicated in Tables 4 - 7. The total result of how frequently the OR models are used are also shown in Table 8; and it portrays the tendency for users of Operations Research (OR) models to apply same methods in multiple problem areas.

The magnitude of the frequency is significantly influenced by the applicability of the OR methods, and how conversant the respondents are in the utilization and integration of Operations Research and other related quantitative techniques for resolving challenges facing business organisations within competitive internal and external organizational business environments. Further estimates dwelling upon potential applicability could readily be obtained by observing the number of problem areas where various OR methods are used in Nigerian deposit money banks. For instance queuing models and networks which involve the project evaluation and review technique (PERT) and the critical path method (CPM) are in limited use by most users. However, an in-depth analysis of the two methods (in the previous Tables) reveals differences in their pattern of use compared to the results shown in Table 8. Queuing model techniques are utilised for basically operations management decision problems (Teller, Staffing, Cubicle Location, Site Selection and Location), whereas network models (though in limited use per problem area) are utilized for a variety of problem areas compared to queuing.

The ranks (based on the cumulative frequencies) show that the Operations Research (OR) model with the highest frequency of use in the Nigerian commercial banking industry is simulation models which have a rank of 1. This is followed by forecasting models (2), linear programming models (3), decision theory models (4), goal programming models (5), probabilistic programming model (6), inventory model (7), queuing models (8), network models (9), dynamic programming models (10), Markovian models (11), nonlinear programming models (12) and integer programming models (13). The rankings are consistent with expectations on the more frequently and less frequently utilised OR models. Possible reasons for the empirically derived rankings can quite easily be deduced.

Firstly, it is logical to assume that simpler models will be more frequently utilised. Simplicity in this regards refer to ease of understanding of how to manipulate, utilize and deduce results from OR models by the seemingly non-technical but busy commercial bank manager. Simplicity could also be extended to refer to the ease of deriving feasible and practical optimal solutions from the applied OR models. To this end, simulation modeling techniques, forecasting modeling techniques and linear programming modeling techniques could readily be described as simple models when compared to decision theory models, goal programming models and probabilistic programming models.

Secondly, models with easier applicability are most frequently utilised. This may be the reason for the relatively high ranking of simulation modeling techniques. It may also be the reason for the high ranking of forecasting and linear programming models, most especially with regards to complex organizational real life problems. In classifying extent of applicability of OR models, it is pertinent to focus on the creativity of OR users, their level of sophistication, resources required to implement OR solutions and the unique set of needs of the user. Furthermore, some of the set of OR models with lower rankings may eventually be quite useful to sophisticated decision makers operating in complex decision scenarios; most especially if they have access to the required input data and logically efficient algorithms.

Conclusion

Before conducting the study on the application of Operations Research (OR) models in Nigerian Deposit Money Banks, the researcher suspected that the extent of use of OR in decision

making in Nigerian banking institutions will be very low, mainly due to low level of education as well as the anticipated conservative nature of the commercial banking industry nationwide. Neither of these opinions was supported by the study findings. Our findings imply that Nigerian commercial bank managers and employees are increasingly beginning to combine executive judgment and experience with the use of rational Operations Research models. This change in perception and approach may be due to increasing levels of information available to Nigerian deposit money bank employees, increase in the use of consultants and the ever increasing desire of Nigerian commercial banks to survive in the ever changing and tumultuous local and global commercial banking environment.

These benefits can easily be achieved by facilitating access of deposit money bank staff to specialized in-house training, workshops and seminars where resource persons drawn from the academia can provide lectures on relatively simple OR techniques that can aid Nigerian deposit money banks in achieving competitive advantage over competitors. We further recommend the enhanced usage of OR in Nigerian commercial banks and other related commercial banking institutions, the establishment of more OR departments in the nations citadel of higher education as well as the strengthening of the newly established Institute for Operations Research of Nigeria, to further enhance OR awareness and usage in Nigerian commercial banks. To date OR has proven to be an indispensable tool for the successful operation of a diverse range of business organizations in advanced countries like the United States of America and Britain. However, its use in Nigerian deposit money banks, though increasing very rapidly, still leaves much to be desired when compared to developed foreign countries. It is therefore pertinent for Nigerian banks to be abreast with new trends in the application of OR models. As new applications are developed they will benefit more if they readily adopt, utilise and integrate them into their commercial banking operations.

Area for Further Studies

The findings of this research study could be further enhanced by investigating the utilization of operations research in simulating risk exposure and profile of Nigerian deposit money banks under conditions of uncertainty. Moreover, the study could be enlarged to cover other developing countries within or outside Africa with possibly similar economic models and conditions like Nigeria or perhaps further utilized as added experience for them.

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