# A SURVEY OF DATABASE MANAGEMENT SYSTEMS CHOICE BY FIRMS QUOTED AT THE NAIROBI STOCK EXCHANGE

BY

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## DECLARATION

This management project is my own original work and has not been presented for award of a degree in any other University

Signed.....Date.....30/11/2005

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This management project has been submitted for examination with my approval as the university supervisor

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## DEDICATION

I dedicate this Research Project to

My wife, Daughter, Sons and

**Family**

## ACKNOWLEDGEMENT

I thank the Almighty **God** for the many blessings received throughout the period of my postgraduate studies. It is by his grace that I was able to complete the course and this research project.

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**THANKS A LOT AND GOD BLESS YOU.**

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| | | |
|---|---|---|
| CDS | - | Central Depository System |
| CDSC | - | Central Depository and Settlement Corporation |
| CEO | - | Chief Executive Officer |
| DBMS | - | Data Base Management Systems |
| DDL | - | Data Definition Language |
| DML | - | Data Manipulation Language |
| IBM | - | International Business Machine |
| ICT | - | Information Communication and Technology |
| IDS | - | Integrated Data Store |
| IMD | - | Information Management System |
| IT | - | Information Technology |
| MIS | - | Management Information System |
| NSE | - | Nairobi Stock Exchange |
| OMG | - | Object Management Group |
| OODMS | - | Object Oriented Database Management System |
| PC | - | Personal Computer |
| RFP | - | Request for Proposals |
| SQL | - | Structured Query Language |
| 3GLS | - | Third Generation Languages |
| VSAT | - | very Small Aperture Technology |

## ABSTRACT

The need for better data storage methods and trend towards more database technology has received expert attention. Several data storage techniques have been devised in the past but none of them can match DBMS technology. Increasingly, it appears that organizations have no choice but to adopt use of DBMS in order to cope with the complexities of data generated that need to be stored, manipulated and to produce information for the benefit of the organizations.

The need for the study arises from the fact that it is not clear as to whether the aspects of DBMS selection processes that have been documented are ideal or not, it is similarly difficult to single out the selection process that is prevalent in the organizations. It is also not clear which factors should be considered as relatively important in the choice of DBMS to the rest of the factors. Furthermore no one has carried out a research on DBMS choice in Kenya. Specifically no one has carried out a study on the factors neither considered in choice of DBMS nor documented the selection processes that are in use in Kenya.

This research effort, therefore, had two objectives. The first objective was to establish the relative importance of factors that firms quoted at the NSE consider in their choice of DBMS and secondly to document aspects of the DBMS selection process that is used by firms quoted at the NSE.

Primary data was the main form of data used in this research and it was collected using structured questionnaire. The questionnaire had both open and closed ended questions that heads of information systems/technology in the firms had to answer. The drop and pick later method was used to administer the questionnaire. The data was analyzed using frequency tables, bar charts percentages, pie charts and descriptive statistics and factor analysis.

The findings of the research indicate that the factors that were brought out by various researchers and scholars in the literature review as relatively important in the selection of DBMS appears to be the same as those that were identified by the research findings. These factors are compatibility with the existing hardware, minimum data redundancy, cost of DBMS maintenance, database administration support, and systems availability in the market and vendor support among others in order of

importance. It can then be concluded that whether a firm is operating in a developed or developing country, the firms must and ought to consider the factors identified in these study in their selection of DBMS.

The study also confirmed that organizations consider various aspects of DBMS selection process in their choice of the winning DBMS to be purchased. No particular selection aspect, method or procedure stood as the favorite of the firms quoted at the NSE. Literature on the same is consistent with this finding. The most popular aspects of selecting DBMS were cited as explicitly set terms of reference, use of selection service, influence by other firms, short listing of DBMS and vendor demonstrations.

There were no serous limitations to the study. However it would be interesting to carry out a research on organizations not quoted at The NSE as this research was confined to firms quoted at the NSE. Some respondents did not return the questionnaires. This may be attributed to the fact that respondents are busy people. All these shortcomings reduced the researchers attaining a 100%responds rate, however data collected was considered sufficient and a fair representation of the population for the purpose and scope of the research.

Because this study concentrated on the factors and the process of choosing a DBMS, it is suggested that future research be directed towards the challenges that firms face in implementing the DBMS and that the same research study could be done after five years.

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background

The need for better data storage and trend towards more database technology has received expert attention. Several data storage techniques have been devised in the past. As Bercich (2003) observe that before the advent of modern database technology, computerized data was primarily stored in flat files of varying formats. Examples include indexed access methods and virtual storage access methods. The problems experienced in using flat files included data redundancy and data inconsistencies among others. The search for a solution for data redundancy, inconsistency and access problems led to the development of the various data models used today. Bercich (2003) points out that the underlying implementation data model categorizes the DBMSs. An implementation data model describes the structure of a database. It describes the manner in which a database stores and links data together. There are several distinct database models adhered to by the common DBMSs commercially available today. These include: Network, hierarchical, relational, object oriented and object relational models.

Connolly and Begg (2002) define a database system as just a computerized record keeping system. The database itself can be regarded as a kind of electronic filing cabinet. It is a container for a collection of computerized data files. Users of the system can perform a variety of operations on such files for example, adding new, empty files to the database, inserting data into existing files, deleting data from existing files or removing existing files from the database.

DBMS on the other hand is an interface between the database and the users and is highly complex and sophisticated piece of software that aims to provide services such as data

storage, retrieval, and update among others. It is partitioned into several Software components (or Modules) each of which is assigned a specific operation. Some of the functions of DBMS are supported by the underlying operation system. However, the operating system provides only basic services and the DBMS must be built on top of it. Thus, the Design of DBMS must therefore take into account the interface between the DBMS and the operating system (Connolly and Begg, 2002).

Zwass (1998) defines DBMS as system software that provides assistance in managing databases shared by many users. It makes it possible to create access, maintain and control databases. DBMSs have been available for many years, primarily only for use in large mainframe computers. Universities, large companies and hospitals have used DBMS successfully provided they could afford the DBMS software and the mainframe. Nowadays, one can buy commercial off-the-shelf DBMS software packages for smaller computers with essentially the same functionality as mainframe DBMS systems.

A database system is a fundamental component of the larger organization-wide information system; consequently the database application life cycle is inherently associated with the life cycle of the organizational information system needed in developing information systems. Choice of DBMS may be infrequent, however as firms need to expand, or as existing systems are replaced, it may become necessary at times to choose new DBMS products in the market. There are several ways in which firms can select DBMS.

The first simple documented selection process in which firms can choose DBMS is to check off DBMS features against requirements. O'Brien (1994) notes that DBMS are sometimes compared in matrices where each column is a product and each row one of the hundreds of possible features a product may have, but this makes it difficult to see which DBMS is better than the other. However, a better way would be to group the features according to a common characteristic and make useful generalization possible.

O'Brien (1994) is of the opinion that it would be easier if we group our list of 300 so possible features under only ten headings from kind of data through to control. O'Brien (1994) argues that where one is faced with a situation where a decision is to be made to adopt a conceptual schema in relational form, this will lead inevitably to the choice of DBMS software based on relational as opposed to hierarchical, network or object oriented principle. He contemplates whether this was not bad practice because non-technical database design for example should be ideally defined in a way that leaves DBMS software choice open. The counter argument is that however desirable that may be in theory, it is not realistic in this particular area of technology any more than it would be possible to put on shoes before wearing socks.

The second documented typical approach to selecting the best DBMS according to Connolly and Begg, (2002) would involve the following main steps: Define terms of reference of study, Short list two or three products, Evaluate products, Recommend selection and produce report.

The third documented selection process is one where all object attributes (factors) of DBMS are presented in a tree diagram horizontally where the factors are assigned weights on each branch. It is then that the tips of the tree branches are scored with values ranging from 1 to 8 for example. The weights and scores are then multiplied and added together and the DBMS with highest sum is the winner (Zwass, 1998).

The fourth documented selection process is one where the main activities are required to be carried out are read, read, read; talk, talk, talk; and consider, consider, consider. This means that after reading all relevant literature on the subject and talking to peers in the industry, one must analyze, weigh, and consider the information gathered and come up with alternatives by making personal judgments and using a committee in carrying out the exercise. It is then that the winning DBMS product is chosen (Perez, 1999).

The fifth documented selection process is one where a selection service is contracted to use an automated software tool to match vendor capabilities against user requirements. A short list of two or three vendor would be let to conduct orchestrated demos of their DBMS strength in meeting user requirements and from this, the winning DBMS is picked (Strub, 2003).

In theory, different approaches suit different real life cases when choosing a new DBMS. (O'Brien, 1994) observes that in one case, a DBMS may be superior to another if used with skill. In another case, it is entirely possible that a DBMS may turn out to have superior features to another under all circumstances if it was designed by a small group of very bright people while, the other was developed within some bureaucratic corporation. Therefore choosing the most appropriate DBMS achieves little unless you also have competent people to make use of the options it offers.

Ogbuji (2001) notes that the study of databases is a battleground of ideas. According to him, database community has diversity of ideas and is sharp on the debate between its gurus. Increasingly, developers find themselves lately choosing between DBMS. This task is not only daunting considering the many available DBMS, both open and closed source but a broad spectrum of differences between one DBMS and the other. Consultants' guidance through the maze of available DBMS features and methodologies is not only refreshing but also helpful to both developers and other interested parties, to quickly narrow the choices to the best candidate.

Ogbuji (2001) observes that the first and most fundamental aspect of choice to make in DBMS purchase is the model used to store, manage and query databases. The model affects the choice of DBMS one needs to acquire as it affects the way one will think about the data and can be a surprisingly hard choice to undo later.

Ogbuji (2001) alludes that the second most important aspect (factor) to consider in choosing a DBMS is the language. The DBMS of choice should probably have a natural

and efficient language and preferably more than one and should be a language one is comfortable with.

The third aspect (factor) of DBMS to consider is the platform the DBMS must work on and to be used by the rest of the application, but there might be other platform needs as well. The DBMS should be in position to communicate with other devices such as mobile phones etc. The forth and probably the most important general aspects to consider in DBMS choice are security features.

Connolly and Begg, (2002) lists the following factors as the most important in the choice of DBMS: strength of integrity controls, multi-user access, constant data independence, support for many concurrent users, network or distributed systems, systems support, adequacy of backups and recovery routines upon crashes, availability of multi level security features, and scalability among others.

Gordon and Gordon (1996) suggests that, the most important factors to consider when an organization is making a choice of the DBMS that will be suitable for implementation are: compatibility with hardware, compatibility with operating system, Availability of term license agreement with the DBMS software vendor, Frequency of updates and revision, Performance on transactions benchmarks/throughput, availability of documentation among others.

According to Inmon and Bird (1986) ease of use, Cost of DBMS software acquisition and Organization –wide philosophy among others are the factors that are important in selecting the best DBMS and should therefore be considered. The findings of a study carried out by Kannangara, Fraser, and Radicalism (2002) in New Zealand were that factors such as suitability of the DBMS to the user needs, Popularity of DBMS and compatibility with existing hardware and software seem to be most important in deciding new DBMS for organizations.

From the foregoing discussions, it is not clear which of the documented selection process organizations prefer to use in their choice of DBMS. It is also not clear which factors are considered as important in the selection process. This is because organizations differ in their choice of DBMS. There is need therefore to establish the factors that are considered important in the choice of DBMS and document the selection processes that firms quoted at the NSE use in their choice of DBMS.

### 1.2 Nairobi Stock Exchange

Nairobi Stock Exchange was started in 1954 and by April 2005, it had in its listing 47 companies. According to Karina (2003) the role of the Nairobi stock exchange is to allocate resources to the most productive sectors of the economy, establish asset values through efficient price discovery and enable the public to know how much organizations in different sectors are worth according to the latest news and the most recent economic outlook.

In order for the NSE to meet its mandate, it has embraced the use of ICT in respond to the changing needs of consumers. It has introduced a clearing, settlement, depository and registry system and an automated trading system. This system will be part of a wider Virtual East African Stock Exchange linked through the use of VSAT technology. VSAT technology stands for "Very Small Aperture Terminal" and refers to receive/transmit terminals installed at dispersed sites connecting to a central hub via satellite using small diameter antenna dishes (0.6 to 3.8 meter).

VSAT technology represents a cost effective solution for users seeking an independent communications network connecting a large number of geographically dispersed sites. VSAT networks offer value-added satellite-based services capable of supporting the Internet, data; LAN, voice/fax communications, and can provide powerful, dependable private and public network communications solutions.

The Central Depository system (CDS) under the management of the Central and Settlement Corporation (CDSC) will operate the computerized ledger system for securities as banks do for cash with the assistance of DBMS. This will enable listed companies to hold or transfer their securities without need for physical movement, hence ownership of securities will be via book entry, rather than by physical movement.

On the other hand the Automated Trading System (ATS) will manage its data by making use of a DBMS. This system is designed to match, buy and sell orders placed by members of listed companies, enter quoted prices into a central electronic order book and match orders during trading according to fixed rules and set execution prices. Similarly most of the listed companies are able to manage their data by making use of DBMS. Given the prominence of DBMS in NSE information system and operations, its choice is critical. Consequently, the choice of DBMS by the firms quoted at the NSE is necessary.

### 1.3 Statement of the Problem

There is a tendency to go towards DBMS because organizations all over the world are implementing them. Perez (1999) pointed out that, to decide upon the DBMS product that one is going to commit to using is easier said than done. Perez (1999) asserts that it is not possible to find much natural advice on how to choose the exact software product to use. It is hard to find anything on how you actually choose the specific product, let alone choose between general categories of commercial products, shareware and freeware.

In a study on whether SQL server, DB2 and Oracle are really relational, Michiko (2003) found out that the choice of DBMS software vendor is not easy because DBMS software consists of several components, is a large and complex and it is always not clear which DBMS software is better than the other. Michiko (2003) also observes that there are thousands of documented selection processes, criteria and benchmarks to support the choice of DBMS, which pose a challenge to firms that would like to acquire DBMS.

In regard to the factors considered in the choice of DBMS, Connolly and Begg (2002) suggest that technical factors should be considered as more important. However, other researchers such as Elmasri and Navathe (2003) suggest that, non-technical factors are equally important in the choice of DBMS. In a study carried out by Kannangara, Fraser, and Radicevic (2002) to find out the DBMS that are used in education institutions and industrial establishments in New Zealand, they found out that factors such as suitability of the DBMS to the user needs, wide local usage, and compatibility with existing hardware and software seem to be most important in deciding new DBMS for organizations.

In addition to the factors considered, what further complicates the choice of DBMS is the selection process. The selection processes that have been documented as those that should be used in choosing DBMS are diverse. For example Perez (1999) observed that a good choice of DBMS is one that will satisfy the specifications required. However, in the current DBMS market place, he asserts that the specifications may only narrow the choice down to some 500 or 600 DBMS packages. There is then the additional task of deciding the best among the many quality products available in the commercial market.

Furthermore, the final decision on a particular DBMS is going to be the basis for a significant investment that will cost the organization enormous amounts of money and mistakes should therefore not be entertained. Perez (1999) pointed out that there is lack of published counsel in the area of DBMS selection process. He believes that, there are only three major activities that one needs to carry out, they are: one read, read, read; two, talk, talk, talk and three consider, consider, consider.

Deveau (2000) on the other hand asserts that one should think long term when choosing a DBMS and that the choice involve more than making a tactical decision to solve an immediate need, and that the wrong DBMS choice can lock the user into a technology that does not serve the enterprise well and is expensive to change. According to him the consideration for each type of database and reviews of the technical issues provide a roadmap for making DBMS decision. Deveau (2000) however, does not suggest the

selection process and the importance of factors that should be considered in making DBMS choice.

A typical approach in selecting the best DBMS according to Connolly and Begg, (2002) would involve the following main steps: Define terms of reference of study, Short list two or three products, Evaluate products, Recommend selection and produce report.

Zwass (1998) suggests a selection process where tree diagram of object attributes (usually shown horizontally) should be obtained. The major attributes (aspects) that would form the branches could be DBMS specification, access capabilities, output, file merge capability, protection, error recovery, documentation, and vendor support among others. Weights and scores would then be used in the evaluation process to zero in on the winner DBMS.

From the foregoing it is not clear whether the aspects of DBMS selection processes that have been documented are ideal or not, it is similarly difficult to single out the selection process that is prevalent in the organizations. It is also not clear which factors should be considered as relatively important in the choice of DBMS to the rest of the factors. Furthermore no one has carried out a research on DBMS choice in Kenya. Specifically no one has carried out a study on the factors that are considered in the choice of DBMS or documented the DBMS selection processes that are by organizations in use in Kenya.

Evidently, the issues of the DBMS selection process like the factors for choice is unresolved. Thus the two questions arise: What is the relative importance of the factors firms quoted in NSE consider when choosing their DBMS? What aspects of the selection processes that firms quoted at NSE use in their choice of DBMS should be documented. These questions are therefore the focus of this study.

## 1.4 Objectives of the Study

(a) To establish the relative importance of factors that firms quoted at the NSE consider in their choice of DBMS.

(b) To document aspects of the DBMS selection process that are used by firms quoted at the NSE.

## 1.5 Importance of the Study

(a) **Managers**-------- to make them aware of the processes and factors most organizations have applied and consider their adoption when they are faced with a situation where they have to make a choice for the organization to acquire a DBMS.

(b) **Academicians/Researchers**---------the findings of this study will provide an insight into the current DBMS acquisition practices in organizations and this might stimulate further research in the area.

(c) **Systems developers/vendors**------the findings will broaden their understanding of the factors considered and selection process that organizations put emphasis on when making their choice of DBMS. They could use this to re-direct their effort towards meeting them.

(d) **Government**------The study will be useful to those who have been mandated to draft ICT policy and those who are responsible for ensuring successful implementing e-government strategy because in one way or another DBMS acquisition issues must arise.

(e) **Kenya Computer society**--------The findings of the study will be useful to members of the society because most of them are involved in the process of DBMS acquisition in the organizations they are engaged in either as proprietors, consultants or employees. This will only be possible if the research proposal will be available in the society's library or central Information service.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.0 Introduction

This chapter concerns DBMS concepts, documented processes on DBMS choice and the factors that are considered in the DBMS choice process both in Kenya and other countries and past studies relating to DBMS.

## 2.1 Database Management Systems

A database system consists of four major components, data, hardware, software and users. Software includes DBMS, a very important database component. DBMS is a layer between the physical database itself (data as physically stored) and the user of the system. It handles all requests for access to the database. These requests cover, adding or removing files, retrieving data from and updating data in such files or tables. DBMS is just a server that supports all the basic functions such as data definition language, data manipulation language, optimization and execution, data security and integrity, data recovery and concurrency and data dictionary (directory, catalog or data encyclopedia). DBMS therefore is comprehensive software that represents the interface between the user and the computer's operating system and the databases (Hutchinson and Sawyer, 1995).

DBMS according to Connolly and Begg (2002) has its roots in the 1960s Apollo moon-landing project, which was initiated in response to President Kennedy's objective of landing a man on the moon by the end of that decade. At that time, there was no system available that would be able to handle and manage the vast amount of information that the project would generate. The project contractor North America Aviation (Now Rockwell International) developed software based on the concept that smaller components come together as part of large components and so on, until the final product is assembled. This

structure, which conforms to an upside-down tree, is also known as the hierarchical structure.

Hierarchical DBMS organize data in a tree structure, beginning with a single record type at the top of the tree structure. It is a hierarchy of parent and child record types, with each parent child relationships being in a 1: N relationship and accesses data using a hierarchical data manipulation language a single record at a time. The earliest commercial DBMS and still the main hierarchical DBMS used by most large mainframe installations emanated from information management systems (IMIS) which was developed by IBM with Rockwell international (Bercich, 2003). An example of Hierarchical DBMS available in the market and the vendors of the systems is IMIS (IBM CORP).

In the mid 1960's, General Electric headed by Charles Bachmann, developed Integrated Data Store (IDS). These developments led to a new type of database system known as Network DBMS. The Network DBMS was developed partly to address the need to represent more complete data relationships than could be modeled with hierarchical structure (many to many relationships), and partly to impose database standards (Connolly and Begg, 2000). According to Bercich (2000) records are accessed in a Network database one record at a time using data manipulate language embedded in a host programming language.

Codd (1970) in his article for association for computing machines (ACM) detailed what he felt were deficiencies in the existing DBMS adhering to the network and hierarchical data model could be overcome with relational model. The first commercial relational DBMS product appeared in the late 1970's and early 1980's. Of particular note is system R project at DBM'S San Jose research laboratory in California, which developed, structured query language (SQL), which has since become the standard language for relational DBM'S (Connolly and Begg, 2002).

In relational data model, all data is logically structured within relations (tables). Each relation has a name and is made up of named attributes (columns) of data. Each tuple (row) contains one value per attribute. Connolly and Begg (2002) assert that the great strength of the relational model is the simple logical structure. Yet, behind this simple structure is a sound theoretical foundation that is lacking in the first generation of DBM'S (the network and hierarchical DBM'S). Most of the DBMS available in the market today are relational or offspring of relational DBMS.

Object- relational database management system (ORDBMS) for example is a hybrid of object and relational databases. These databases grew from the effort of the RDBMS vendors to address the deficiencies in the relational DBMS. Object relational databases now hold a significant position of database market share, largely due to users upgrading their previously relational database to the vendors' newer object relational database.

Table 1 shows examples of DBMS available in the market and the vendors of those systems. The following abbreviations are used to represent the respective databases: R (Relational DBMS) and OR (Object-Relational DBMS).

**Table 1:Types of Relational DBMS Products**

| | VENDORS | DBMS PRODUCTS | Type |
|---|---|---|---|
| 1 | Sybase inc | Adaptive Server Enterprise 12.5 | OR |
| 2 | IBM Corp. | DB2 and Database 7.1 | OR |
| 3 | Empress Software Inc. | Empress RDBMS | R |
| 4 | File Maker Inc. | File Maker Pro4.5 | R |
| 5 | Informix software Inc. | Informix Dynamic Server<br>Universal Server | R<br>OR |
| 6 | Computer Associates International, Inc | Oenlngres | R |
| 7 | Microsoft Corp. | Access | R |
| 8 | Oracle Corp. | Oracle 7x | R |

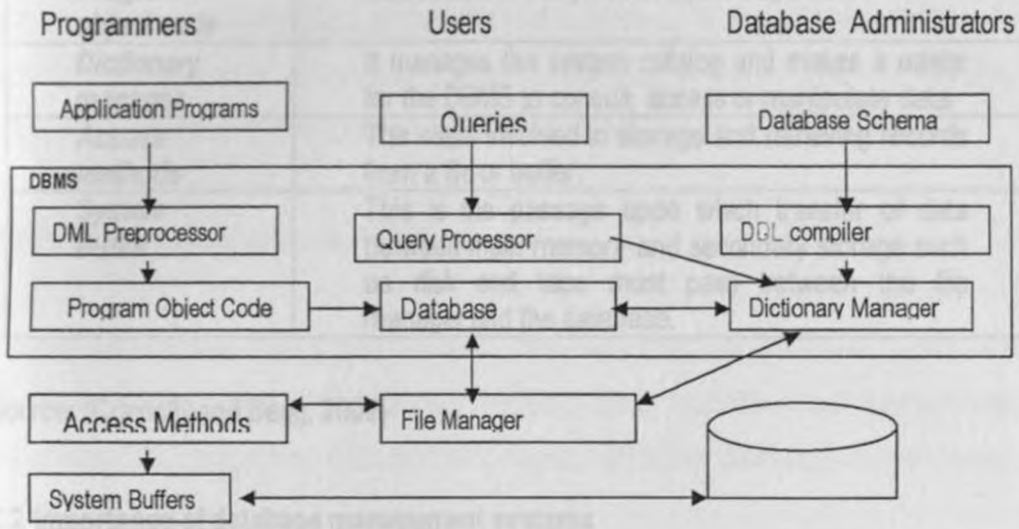
| | | | |
|---|---|---|---|
| | | Oracle 8i, 9i | OR |
| 9 | Corel corporation | Paradox 8 | R |
| 10 | Microsoft Corp. | SQL Server | OR |
| 11 | Cincom Systems, Inc | UniSQL | OR |

Source: (Li, Alijani and Koong, 2005)

Atkinson and Barcilhon et al (1993) first attempted to define object oriented database management system (OODBMS) in 1993 in their paper entitled "The object-oriented database system manifesto." The object management group (OMG) has taken over this task. The concepts behind OODBMS are the same concept behind all objects oriented technologies encapsulation, polymorphism and inheritance. They store two types of data, object and values. OODBMS have several advantages over their predecessors. They allow for persistence storage of complex data types. There is therefore no need to disassemble objects already stored and retrieved into their relational parts (Bercich, 2003). Examples of object oriented DBMS available in the market include: Cache (intersystem Corp; Gemstone (Gemstone Systems Inc); Itasca (Ibex systems Inc); Jasmine 1.1 (Computer associates international Inc); Matisse (ADB Inc); Fox Pro (Microsoft Corp); NeoAccess (NeoLogic Systems); Objectivity 5.0 (Objectivity, inc); Poet 5.0 (Poet software Corp); Dbase (Dbase Inc.); Voss 3.0 (Logic Arts Ltd) and Versant (Versant Object Technology Corp.).

A Database management system is partitioned into several software components (or modules) each of which is assigned specific operations. The major components and functions are as shown in Figure 1 and Table 2 respectively.

**FIGURE 1: Components of DBMS**




Source: (Conolly and Begg, 2002)

Database and Systems Catalog

**Table1: Functions of Components of DBMS**

| Component | Functions |
|---|---|
| ***Query processor*** | It transforms queries into a series of low level instructions directed to the database manager |
| ***Database manager*** | It is an interface with user-submitted applications programs and queries. It accepts queries and examines the external and conceptual schemas to determine what conceptual records are required to satisfy the request. It places a call to the file manager to perform the request. |
| ***File manager*** | It manipulates the storage files and manages storage space on disc and establishes and maintains the list of structures and indexes in the internal schema. It also passes requests onto the system buffer. |
| ***DML preprocessor*** | It converts DML statements embedded in application program into standard function calls in the host language. The DML preprocessor must interact with the query processor to generate the appropriate code. |
| ***DDL compiler*** | The DDL compiler converts DDL statements into a set of tables containing meta-data. These tables are |

| | |
|---|---|
| | then stored in the system catalog while control information is stored in data file headers. |
| ***Program object code*** | Instructions to carry out a required operation. |
| ***Dictionary manager*** | It manages the system catalog and makes it easier for the DBMS to consult, access or manipulate data. |
| ***Access methods*** | The steps involved in storage and retrieving records from a file or buffer. |
| ***System Buffer*** | This is the passage upon which transfer of data between main memory and secondary storage such as disk and tape must pass between the file manager and the database. |

Source: (Connolly and Begg, 2002)

**2.2 Importance of database management systems**

Many organizations have achieved impressive results using DBMS. Many features that a DBMS possesses make it attractive to use in preference to other systems (Lucas Jr, 1978). The benefits of DBMS are many and have been documented (McAllen, Turban and Wetherbe 1996; Hutchinson and Sawyer 1995; Connolly and Begg 2002; Gordon and Gordon 1996; and Barbara and Ralph 1993). They could be summarized as follows:

First, DBMS have brought improved data accessibility and responsiveness and better services by allowing end users great access to organizational information, acts as an interface between data and programs and with one database, users in the entire organization can share all data files, reduce duplication of same data and hence controls redundancy, and ensure there is no data confusion.

Secondly, DBMS ensure database security, allows standardization of data definitions by use of data dictionary and identification of Enterprise requirements and balances users conflicts that arise from these requirements. It has brought increased productivity, efficiency, and economies of scale and lower development and maintenance of the system.

Thirdly, many DBMS manage concurrency of data access and ensure that two or more users are allowed to access the same file simultaneously without the access interfering with one or loss of information or integrity in the process. It also provides facilities to minimize the amount of processing that is lost following a failure. There is therefore improved backup and recovery service, provided by DBMS.

### 2.3 Problems associated with DBMS.

Despite the fact that DBMS have benefits, they have problems (McAllen, Turban and Wetherbe, 1996; Kalman, 1995; Connolly and Begg 2002; Hutchinson and Sawyer 1995; Davenhall, 2002; Sarah and Stanley, 1995; Walsh, 2003; and Silberschertz and Allman, 1990).

Firstly, DBMS can be an extremely complex piece of software. Relating multiple files can be complicated and concepts can be confusing to users.

Secondly, legacy data in older, perhaps obsolete, database still needs to be available to new DBMS. It has been observed that 85% of the data in typical organization resides in legacy non-relational data format. Utilization of DBMS is however slow with these kind of databases.

Thirdly, DBMS is an extremely large piece of software occupying many megabyte of disc space requiring sustained amount of memory to run efficiently. Fourthly, though cost of DBMS varies significantly, depending on the environment and functionality provided, in general it is very costly. Personal computer DBMS only cost US$100 but, a large mainframe multi-user DBMS serving hundreds of users can be extremely expensive, perhaps US$100,000 or even US$1,000,000. There is also the high recurrent annual maintenance cost, which is typically a percentage of the purchase price of the DBMS. Cost in terms of hardware, software and personnel can be very high also.

Fifthly, some DBMS have few graphical and statistical capabilities and Consolidating business data in the central database increases vulnerability to system failure that can bring operations in an organization to a halt.

## 2.4 Database Application Lifecycle

According to Zwass (1998) there are four alternative ways of realizing a computer-based information system. They are internal development by contacted professional; end-user development; outsourcing; and finally purchase and customization of a software package. In all of the above alternatives one must purchase the DBMS software if it is to realize the information system being developed. For major information systems development, information systems life cycle is involved. This applies to database application life cycle. Database application life cycle involves the following: Database planning; system definition; requirement collection and analysis; database design (conceptual, logical and physical); application design; implementation prototyping (which is optional); database conversion and loading; testing and operation maintenance. DBMS selection is carried out between the design of the conceptual database and the logical database (Laudon and Laudon, 1996,Connolly and Begg, 2002)

## 2.5 DBMS choice, factors considered and selection process.

Whether the database application is internally develop by contracted professional, end user developed, outsourced or purchased, as a software package and customized, DBMS selected must be purchased. When the purchase is being considered request for proposals (RFP) may be send out to potential DBMS vendors through various media, following an initial study of user requirements. Some organizations, however, do not send out RFP's but use other methods to purchase their DBMS. The RFP's outline the requirements of the organization and ask questions about how the vendor's DBMS may satisfy them. Potential vendors could be identified from the following sources: the Internet, the competition, industry trade groups, and selection services (Strub, 2003).

The first source of DBMS is the Internet. When the Internet facilities are available, Internet search is the quickest and cheapest way to find potential DBMS software vendors. However, Typically, it is the information contained on the vendor's website, which is placed there by the vendor that will be available. This may be misleading (Strub, 2003)

The second source of DBMS is the competition. According to Strub (2003), competition however, may appear to be an unlikely source for advice on the surface. Obviously competition may try to deliberately mislead, sending down dead end paths and working with unscrupulous vendors for their advantage. In any case, it is surprising how often competition is willing to share advice, mistakes or poor decisions made.

The third source of DBMS is the industry trade group. Typically, every industry has a trade group or association. Some trade groups are dedicated to promoting particular industries. An example would be one for information system /technology. Using data from a trade group, as sole source of data can be a serious mistake If Data are outdated. Strub (2003) notes that significant research must be performed so as to ascertain the reliability of the data. Before considering using a trade group as a source of information the following questions should be asked:

a) How often are the data updated?
b) When was the last time the data were updated?
c) Does the trade group independently confirm the data?
d) Have other members used this service and can one talk to them about their experiences?

The fourth source of DBMS is the selection service. Assisted by current knowledge bases of process features and vendor attributes, a selection service's primary mission is to systematically match a company's requirements with vendors' capabilities in order to

identify the best prospective DBMS software vendors. However, with the service comes a cost (Strub, 2003).

When choosing a selection service, Strub (2003) notes that there are basic criteria that need to be verified. First, the service should encompass ones industry. If one is looking for DBMS software to run a Beer company database, then one should select a service that covers brewing industry. At this point of discovery, the knowledge that the selection service covers ones industry and the related DBMS software being sort, the service should be able to match ones company needs and requirements against the vendors identified in the database and suggest those vendors appearing to meet the business needs of the company.

Perez (1999) asserts that in the current DBMS market place, where the Internet, competition, industry trade group, or selection service has been used, ones specifications may only narrow the choice down to some 500 or 600 DBMS packages. There is then the additional issue of deciding among the many quality products available in the commercial market. Furthermore, this DBMS choice and selection decision is going to be the basis for a significant investment that will cost the organization enormous amounts of money and mistakes should therefore not be entertained

Findings from studies undertaken in the developed world and literature on DBMS indicate that there are variations as to how firms may narrow down their DBMS choices to a few probably less than ten and eventually the winning DBMS to be delivered for implementation. These are presented in the discussion that follow as part of the documented DBMS selection process that various firms adopt in their choice of winner DBMS.

### 2.5.1 The read, talk and consider approach

Perez (1999) pointed out that there is lack of published counsel in the area of DBMS selection process. He beliefs that there are only three major activities that one needs to carry out and they are: one read, read, read; two, talk, talk, talk and three consider, consider, consider.

"Read" means one has to absolutely have to check out the literature, both old and new and identify whatever it has bearing on one's unique DBMS needs. The "talk", part involves doing just that, physically and virtually. One should discuss needs of the firm and trade war stories with the colleagues and power user people respect in the industry.

"Consider" means brainpower processing, thinking, weighing pros and cons, and considering alternatives. This is simply healthy reflection. One cannot be totally objective, but all that information that has been absorbed in the reading and talking steps will give one some qualified intuitive judgment. It may also be time for some considered documentation. Now is the time to use notes and photocopies and e-mails to help in the construction of tables of features listing and comparative evaluations. While doing so, it is always productive to get group - input synergy by using committee or task force evaluation groups. Committees come up with a better evaluation and recommendation.

### 2.5.2 Step-by-step approach

The step-by-step approach is rigorous and has been used over time by organizations both in the private sector and in public sector and has successfully enabled them zero in on the DBMS they consider best for their needs. The approach uses scores and weights to rank factors.

A typical approach to selecting the best DBMS according to Connolly and Begg, (2002) would involve the following main steps: Define terms of reference of study, short list two or three products, evaluate products, recommend selection and produce report.

### 2.5.2.1 Terms of Reference of Study.

The terms of reference for DBMS selection must be drawn stating the objectives and scope of study and the tasks that need to be undertaken. The terms of reference will include a description of the criteria (based on the users requirements specifications) to be used to evaluate the DBMS products, a preliminary list of possible products and all necessary constraints and the time scale for the study.

### 2.5.2.2 Short-listing of the Product

An excellent source of information to identified candidate DBMS are those suggested by Strub (2003) namely the Internet, competition, industry trade group, or selection service. The criteria considered critical to a successful implementation can be used to produce a preliminary list of DBMS products for evaluation. The decision to include a product in the list of DBMS products for evaluation will depend on such factors as the organization budget line, support level for the product, compatibility of the DBMS product with other software within the organization among others. Once a decision is reached to consider the product, it is then ranked with others and a shortlist of two or three products is identified.

### 2.5.2.3 Evaluate Products

At the stage of product evaluation, the various factors of each of the products chosen for evaluation are identified. These factors can be assessed as group or individuals. The groups can be based on: data definition, physical definition, accessibility, transaction handling, utility or development.

After grouping the features of each product, a useful approach to subject the features is to weight the features and or group of features with respect to their importance to the organization and maintain an overall weighted value that can be used to compare products. Each selected feature is given rating out of 10, a weighting out of 1.0 to indicate its importance relative to other features in the group. The score is weighing times rating.

When we sum all scores for each evaluated feature, we get the total score for the group. All the weighted scores for each assessed group of factors are summed to produce a single score for the DBMS product, which is compared with the score for the other products. The DBMS product with the highest score is the 'Winner".

In addition to this type of analysis, vendors are allowed to demonstrate their products or test the products in-house. Each product is tested against its ability to meet the user's requirements for the database application. They can also benchmark their products against criterion set out in published journals and web sites.

#### 2.5.2.4 Recommend selection and produce report

The final step in the DBMS selection process is to document the process and to provide a statement of findings and recommendations. It is then that the particular winning DBMS product should be purchased and implemented.

### 2.5.3 The tree diagram approach

Like the step-by step approach the tree diagram approach is also a scores-and-weight approach and allows organizations to score the attributes of a DBMS and assign our own weights to those attributes, in order to arrive at a comparative figure of merit. According to Zwass (1998), all attributes of a DBMS are analyzed and broken down into more detailed sub aspects. We thus obtain a tree like figure of object attributes (usually shown horizontally). The major attributes could be DBMS specification, access capabilities,

output, file merge capability, protection, error recovery, documentation, and vendor support among others.

Based on a firms own needs the percentage weights are established by answering the question: just how important is the given aspect to the needs? These weights add up to 100% on each tree branching point. In the process learning about the DBMS and the envisaged uses for it are expected. For each candidate DBMS, aspects indicated at the tips of the tree diagram are scored.

Zwass (1998) observes that the scores should be totally independent of the weights and should be based on investigation carried out on the particular product. While the weights are subjective (they reflect the firm's needs), the scores are objective (they reflect the quality of the candidate DBMS). In the process, it is possible to totally eliminate from further consideration any candidate DBMS that obviously do not satisfy the firms major objectives; for example, those that are not compatible with the existing environment.

The total figure of merit for a candidate DBMS is obtained by going up the tree diagram and multiplying scores by weights. In most situations figures of merit are meaningful only in a comparative sense, and only significant differences between figures of one DBMS and the other point to a decision. The DBMS with the highest figure will be the winner

.

### 2.5.4 The automated approach

The proposed combination is a two-step process. First, a DBMS software selection service is used to develop a short list of two or three vendors. Then, the vendors are asked to conduct orchestrated demos to ensure that the firm's business critical processes can be accommodated (Strub, 2003). The selection service will provide the user with the comfort and confidence that their needs are considered. After going through factors, functions and features checklist and using an automated software tool to match these requirements

against vendor capabilities, users should be assured that their needs have been adequately addressed.

According to Strub (2003) after a short list of vendors has been selected using an automated software tool, it is then that one can proceed with a degree of confidence into the vendor demonstrations and presentations. These demonstrations would concentrate on the processes critical to how your company does business and what makes it unique. While users would provide the scenarios and data, vendors "strut their stuff" and prove their statements and claims of functionality. This is not to say that other uncertainties cannot be addressed within the user community, but this can be kept to a minimum and of course, users will have the opportunity to talk to their counterparts when checking references. Consultants familiar with the class of DBMS software being selected can assist in developing the scenarios.

## 2.6 Other important considerations in DBMS choice

The process of selecting and acquisition of DBMS and the factors considered rank first. However, there are other important issues that should be taken into consideration in making the final decision on which DBMS should be purchased. They include long term and architectural considerations, and the effect of expertise on the choice process.

The wrong choice of DBMS could lock the user into a technology that does not serve the enterprise well and is expensive to change. The considerations for each type of database and reviews of the technical issues provide a roadmap for making DBMS decisions (Deveau, 2000).

According to Mullins (2002) if an organization has variety of databases with different characteristics and special requirements, as well as an organizational need for each to fully satisfy those requirements, it makes sense to take a best- of- breed approach and

choose a DBMS for each database on its own merits rather than choosing one DBMS for all the databases available in the organization.

Mullins (2002) considers the supporting architecture for the DBMS environment as very critical to the DBMS application being built. One wrong choice or poorly implemented component of the overall architecture can cause poor performance, downtime or unstable application. Problems arise then as there are different types of each DBMS for different architecture and purpose and further that more Information Technology infrastructure is distributed and heterogeneous. It is most likely that DBMS architecture consists of multiple platforms and interoperating pieces of system software.

Mullins (2002) stresses that the final architecture must be based on the business needs of the organization; That it should not be made by a single person or group, but by a team consisting of business experts and IT experts. There are basically four levels of DBMS architecture that can be selected: enterprise architecture, departmental architecture, personal architecture and finally Mobile architecture. He further stresses that when an organization requires DBMS solution at different levels, whenever possible one should favour the selection of a group of DBMS solution from the same vendor.

Galletta, King and Rateb (1993) carried out a research on the effect of expertise on DBMS selection. The result of the study suggested that expert seemed to exhibit more agreement on criteria weights that were used in the studies than did novices. The study also showed that experts were about twice as consistent in applying the weights they assigned to the choice task compared to novices. It was observed that experts tended to bring their own experience to the choice task, were distracted less frequently, and used superior strategies in elimination of weakest alternatives. This study implies that staff members with significant domain expertise should be used in DBMS selection and acquisition tasks.

The study carried out by Michiko (2003) found out that it is critical to choose the right DBMS software for an organization from the beginning, but the choice of DBMS Software

vendor is not easy because the DBMS Software consists of several components that are large and complex. It is not always clear which DBMS software is better than the other.

Michiko (2003) observed that it is important to consider many aspects when it comes to choice of DBMS. It constitutes very complex software and usually has far reading effects on all groups and individual in any organization. The criteria that have to be met to fulfill the needs of an organization must be clarified and characterized in detail. According to him there are thousands of selection processes, criteria and benchmarks (commercial and free ware) to support the choice of DBMS.

A study was carried out by Kannangara, Fraser, and Radicevic (2002) using the survey method. A questionnaire was administered to find out the DBMS that are used and the factors that are considered in selection in education institutions and industrial establishments in New Zealand. The study showed that factors such as suitability of the DBMS to the user needs, wide local usage, and compatibility with existing hardware and software seem to be most important in deciding new DBMS for organizations.

## CHAPTER THREE

## RESEARCH METHODOLOGY

### 3.0 Introductions

This chapter covers the methodology used in the research project. This includes the research strategy or approach, the population of study, type of data collected, method of data collection and the data analysis and procedures applied.

### 3.1 Research Design

The study used a survey design. This design was suitable for this kind of research study because the study intended to collect data meant to ascertain facts about DBMS. This kind of research method makes use of surveys to solicit management and practitioner opinion. It is often used to study the general condition of people and organizations as it investigates the behavior and opinions of people usually through questioning them (Cooper and schindler, 2003).

### 3.2 The population and sample

The population of study consisted of all the 47 firms quoted in Nairobi Stock Exchange as of 11 April 2005. The respondents were IT managers in their respective firms. These individuals were chosen as they were expected to be highly knowledgeable and therefore give the knowledge sought.

Firms quoted in Nairobi Stock Exchange are required to meet some stringent listing requirements one of which is to remit Annual Audited financial statements. It is therefore expected that these firms store and maintain massive data, which is logically possible and beneficial when these databases use DBMS. Operations on data such as adding or

removing files, retrieval and updating data in such files or tables and any other manipulation of data can only be effectively carried out by use of DBMS. A census study was preferred to sampling because the population of study was small (Kerlinger, 2002).

### 3.3 Data collection

The researcher used a structured questionnaire to gather primary data required for this study. The researcher pre-tested and discussed the questionnaire with three firms quoted at the NSE and made the necessary changes to improve the content and enhance clarity. The researcher and his hired assistants contacted the respondents on phone and agreed on when to drop the questionnaire. On drop off, the researcher and his assistants, ensured that the questionnaire was intact and explained to the respondents what was expected of them. Agreement on when to pick the questionnaires was reached.

The questionnaire contained predominantly closed ended questions with a few open-ended questions. The questionnaire consisted of three sections. Section A of the questionnaire comprised demographic questions about the organizations.

Section B comprised questions about the importance of factors considered by firms in their choice of DBMS software while section C comprise questions on the aspects of DBMS selection processes adopted by the firms when collecting data in their firms.

### 3.4 Data Analysis

The data collected was edited for accuracy, uniformity, consistency and completeness and then arranged to enable coding and tabulation before statistical analysis was carried out (cooper and Emery 1995). One returned questionnaire was identified to be incomplete because the firm does not have a DBMS and therefore was not included in the analysis. The data was then analyzed by use of descriptive statistics. Microsoft spread sheets applications, Excel was used to manipulate, process and view the data graphically.

Questionnaire responses were analyzed using tables, percentages and bar charts among others to provide different perspectives on the results. Section A of the respondent's questionnaires received was analyzed using tables, bar and pie charts and Percentages to present the demographic information on organizations.

Section B of the questionnaire-collected data on the factors considered relatively important in selection of DBMS. These were presented using various tools and techniques to show the occurrence in line with the objective. Computation of percentages and measures of central tendency such as mean, standard deviation among others on the factors considered important when chosing DBMS were made. Also factor analysis was carried out to measure the various levels of agreement on the factors considered in the choice and selection of DBMS.

. Factor analysis method group together factors with the same characteristics, and reduced the responses to manageable factors. Factor analysis is a statistical technique for classifying a large number of interrelated variables to a limited number of factors. It is an efficient method for re-organizing the factors a researcher is investigating into conceptually more precise groups of variables. The analysis also ranked the factors to indicate which factors are considered more important than others. The analysis was performed using more advanced data management and statistical analysis software package, SPSS, to ease the work of generalization and formatting of the output.

In section C the data on documentation of aspects of DBMS and selection process was analyzed using tables, percentages and bar and pie charts and especially to bring out clearly the percentage of organizations that use rigorous formal selection methods. This effectively met the study 's second objective.

## CHAPTER FOUR

## DATA ANALYSIS AND FINDINGS

### 4.0 Introduction

This chapter documents and presents the findings on specific issues that were raised in the objectives of the study. After the questionnaires were filled in, they were edited and coded. The results are presented by use of frequency tables, bar charts, pie charts and percentages among others.

### 4.1 Demographic Information

The effective response rate to the questionnaires was 72.34% as described below.

**Table 3: Response Rate**

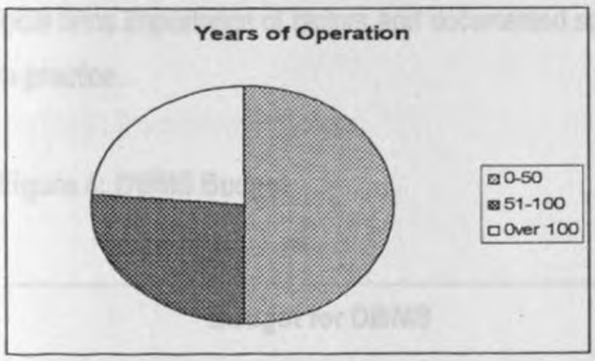
| Description of companies | Expected response | Actual response | |
|---|---|---|---|
| Financial and investment | 11 | 11 | |
| Commercial and Service | 7 | 5 | |
| Industrial and Allied | 16 | 11 | |
| Agricultural | 4 | 3 | |
| Alternative investment | 9 | 4 | |
| Total | 47 | 34 | |

Source: Research Data

As shown in Table 3, 34 out of 47 questionnaires were received back. This represents a response rate of 72.34%. This response rate is quite representative and is consistent with the widely held rule of thumb that a sample of 30 respondents and above is adequate for the application of statistical tools proposed and will give an insight into the database management system choice.

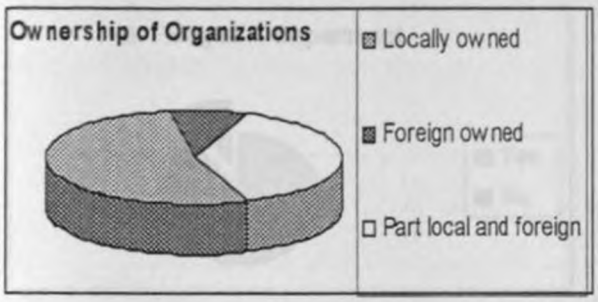
Majority of the surveyed companies fall under Industrial and Allied and financial and investment which have 11 responses each, followed by Commercial and Services with 5, alternative investment had 4 and last was Agricultural sector with 3 respondents.

**Figure 2: Age of the firms**



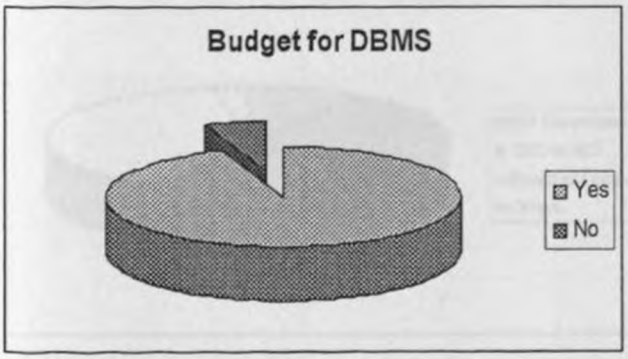

Of the companies surveyed, half of them have been in operation for less than 50 years, suggesting that they were registered after Kenya got independence. Out of the 34 companies 9 or 26% have been in operation for between 51-100 years, while 8 or 24% have operated for more than 100 years. It can be construed that most of the organizations are mature in operations and as such would have a good experience, knowledge of what DBMS would meet their needs, and what factors and processes they should take into account in their choice.

**Figure 3: Ownership of Organization**




Locals own 18 of the 34 firms representing 53% of the organizations surveyed, 13 representing 38% of them are co-owned by locals and foreigners while 3 representing 9% are fully owned by foreigners. Therefore the study results would be a fair indicator of the local firms importance of factors and documented selection processes aspects considered in practice.

**Figure 4: DBMS Budget**




When the respondents were asked whether they have a budget for DBMS, 94% of the respondents confirmed that they have a budget for DBMS while 6% do not. This suggests that the firms consider investment in DBMS as value for money and critical for their success.

**Figure 5: Full fledged IT Department**

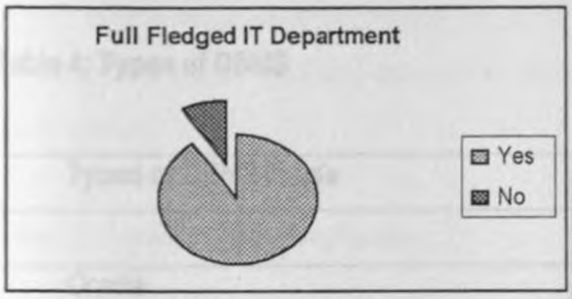



Figure 5 shows that 91% of the companies surveyed have a full-fledged IT Department while the remaining 9% do not. Of those without IT department none of them cited the person who handles IT matters. This shows that majority of the firms use professionals to select and manage their organizations DBMS.

**Figure 6: Reporting Structure**

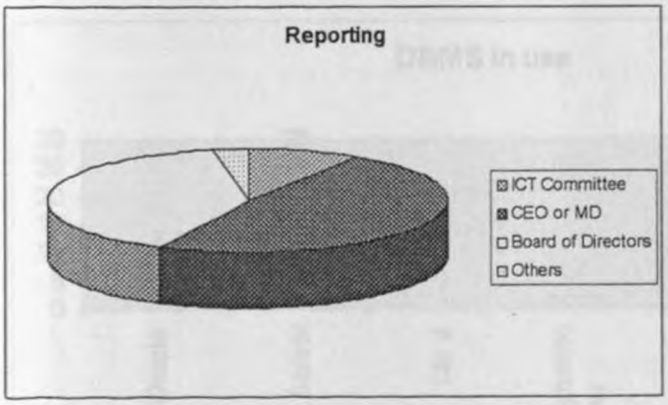


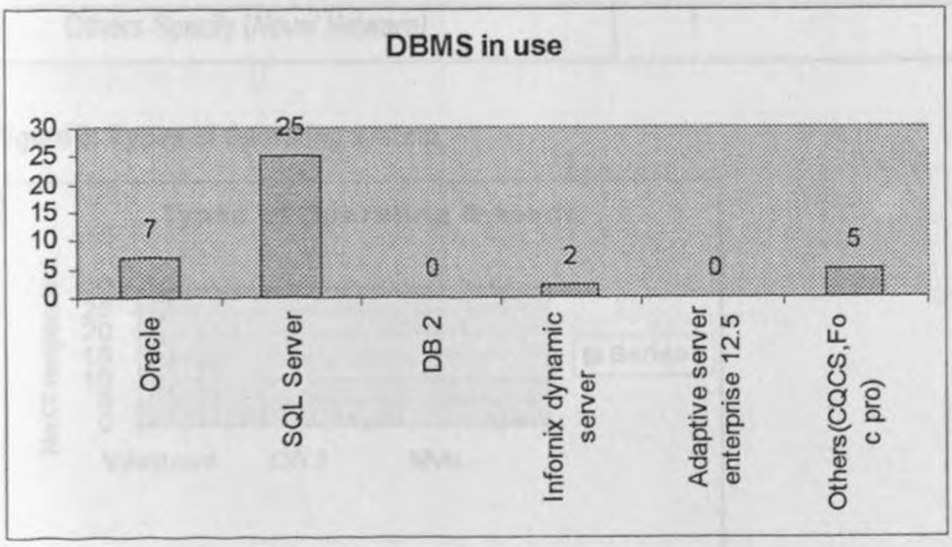

Figure 6 shows that 47 % of the respondents report to the CEO/Managing director, while 9% report to ICT committee. The remaining 44% of the respondents indicated that they report to other offices and the leading being the Finance Director/Manager where 13 out of 34 or 38% of respondents reports, while 6% reports to risk manager and group technical director. None of them reports to the board of directors. This is consistent with the literature that DBMS decisions are second to non-

because information is power and generation and manipulation of that information by use of DBMS is critical to the growth of organizations.

**Table 4: Types of DBMS**

| Types of DBMS in use | Number of Companies |
|---|---|
| Oracle | 7 |
| SQL Server | 25 |
| DB 2 | 0 |
| Informix dynamic server | 2 |
| Adaptive server enterprise 12.5 | 0 |
| Others (CQCS, Fox pro) | 5 |

**Figure 7:types of DBMS in use**



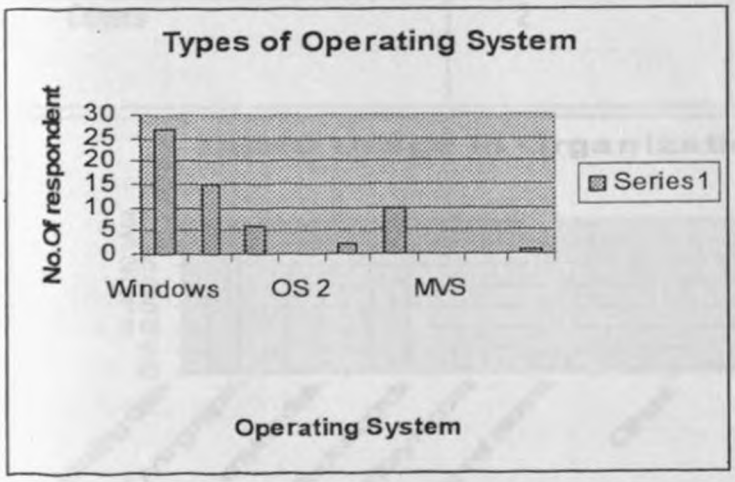

On the type of DBMS in use, the findings as shown in Table 4 and Figure 7 indicate that 25 out of 34 or 64% of the companies use SQL server while 7 or 18% use Oracle, 2 or 5% use Informix Dynamic Server, and 5 or 13% of the companies use other DBMS

applications which include, CQCS, matisse, Fox Pro, Itasca among others. The findings are not consistent with the literature that the leading world market vendor of DBMS today is IBM. In fact Microsoft is the third in the world market. This shows that Microsoft has penetrated the local market and has a lot of influence on the choice of DBMS NSE firms would opt for.

**Table 5: Types of Operating System**

| | |
|---|---|
| Windows | 27 |
| Windows NT | 15 |
| Linux | 6 |
| OS 2 | 0 |
| Macintosh | 2 |
| Unix | 10 |
| MVS | 0 |
| VMS | 0 |
| Others Specify (*Novel Netware)* | 1 |

**Figure 8: Types of Operating system**




Source: Research Data

On the type of Operating System, the respondents had an option of choosing more than one type. The findings show that majority of the companies use Windows and Windows NT with 27 and 15 respectively out of the 34 or 79% and 44% surveyed indicating them. 10 or 29% of the companies use Unix, 6 or 18% uses Linux while 2 or 6% chose Macintosh. None of the companies analyzed use OS 2, MVS and VMS. In the others category Novel Netware was sited by one company. This is consistent with the type of DBMS in use in majority of the firms quoted at the NSE where Microsoft led probably because of compatibility as both products belong to the same vendor.

**Table 6 and Figure 9:Purpose of DBMS in use**

| Usage | Frequency | Percent |
|---|---|---|
| Storing data | 30 | 88.2 |
| Running report | 23 | 67.6 |
| Querying data | 25 | 73.5 |
| Stock records | 10 | 29.4 |
| Inventory records | 4 | 11.8 |
| Personnel records | 6 | 17.6 |
| Others | 2 | 5.9 |

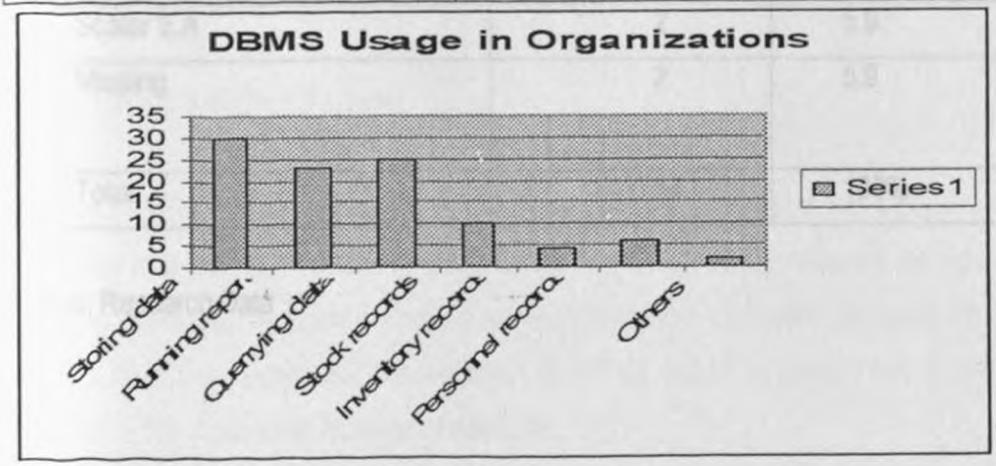


Table 6 and Figure 9 show that companies use DBMS for more than one purpose, as depicted 30 out of 34 or 88.2% analyzed respondents use it for storing data alongside other purposes, 25 or 73.5% for querying data, 23 or 67.6% for running report, 10 or 29.4% for stock records, 6 or 17.6% for personal records and 4 or 11.8% use it for inventory records. 2 or 5.9% of the companies use it for other purposes not specified in the questionnaire .The results imply that DBMS have multiple uses in the firm's quoted at the NSE.

**Table 7: Vendors of DBMS**

| Vendor | Frequency | Percent |
|---|---|---|
| Software Technologies Ltd | 4 | 11.8 |
| Microsoft | 14 | 41.3 |
| Cyber science | 1 | 2.9 |
| Novel | 2 | 5.9 |
| Akili Africa | 2 | 5.9 |
| SAP Germany | 1 | 2.9 |
| Quantum | 1 | 2.9 |
| Land tech | 1 | 2.9 |
| Planc | 3 | 8.8 |
| MC windows | 1 | 2.9 |
| Scalar E.A | 2 | 5.9 |
| Missing | 2 | 5.9 |
| Total | 34 | 100% |

Source: Research Data

Table 7 shows that majority of the respondents, 14 or 41.3% gave Microsoft as the vendor of their DBMS, followed by software technologies 4 or 11.8% and Planc 3 or 8.8%, 2 or 5.9% sited Novel, Akili Africa and scalar E.A respectively. Cyber science, SAP Germany, Quantum, land tech and MC windows had 1 or 2.9% each, While 2 or 5.9% of them had no idea of the vendors of their DBMS. This reinforces the question on the use of DBMS shown in Table 4 where majority of the respondents stated that they use Microsoft SQL. It implies that some of the vendors such as software technologies, planc and Akili Africa also supply Microsoft SQL DBMS software.

**Figure 10: DBMS Warranty**

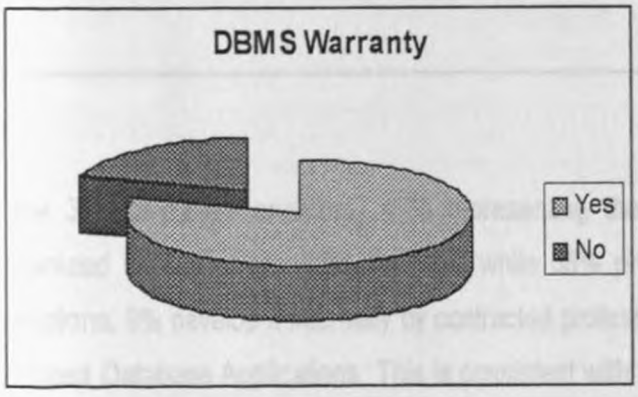
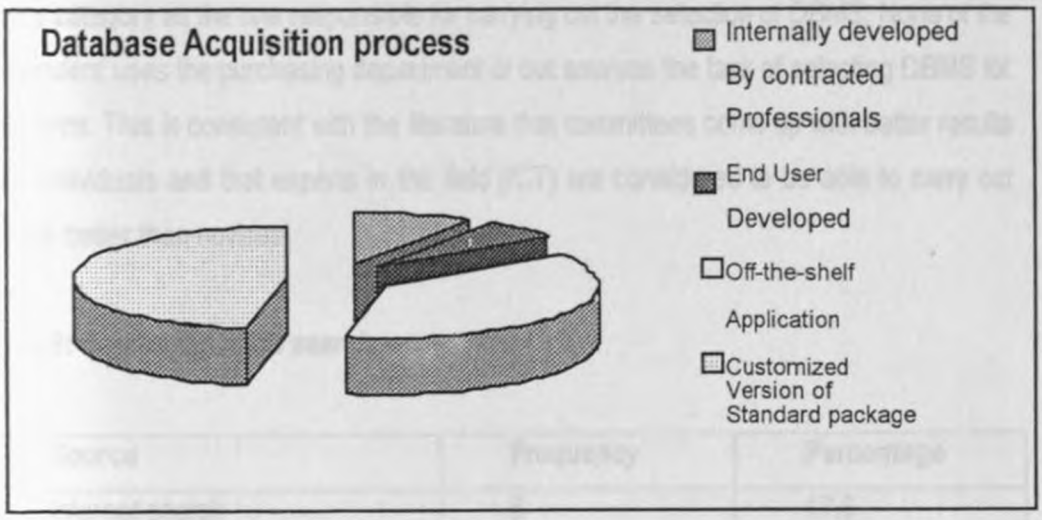



Figure10 shows that 79% of the respondents have a warranty for their DBMS while 21% do not. This is an indication that the firms at the NSE do not take for granted the decision to purchase DBMS.

## 4.2 DBMS Selection Process

One of the objectives of this study was to document aspects of the DBMS selection process that are used by firms quoted at the NSE. The DBMS selection process would usually be carried out within one of the stages of database application life cycle. This stage is the database design and the selection of DBMS would be carried out between the design of the conceptual and logical database.

**Figure 11: Database Application acquisition process**




Of the 34 companies analyzed, 47% representing the majority of the firms choose Customized version of standard package, while 38% prefer to purchase off- the -shelf applications, 9% develop it internally by contracted professionals while 6% go for end-user developed Database Applications. This is consistent with the literature that the aspects of DBMS selection process that organizations prefer differ from one organization to the other.

**Figure 12: DBMS selection process**

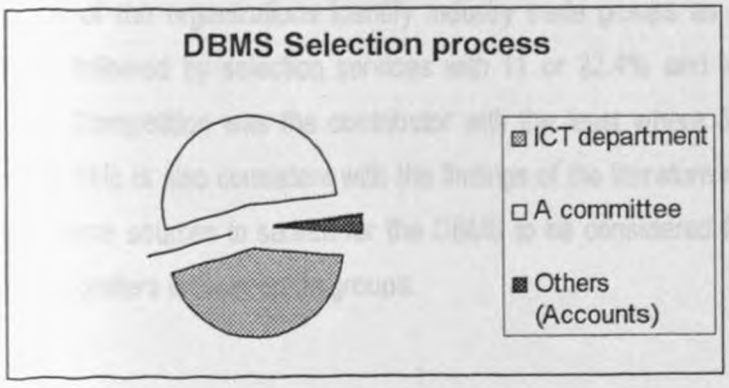


Figure 12 shows that 53% of the respondent use a committee to carry out the selection process, 44% use the ICT department while 3% specified accounts Department in the others category as the one responsible for carrying out the selection of DBMS. None of the respondent uses the purchasing department or out sources the task of selecting DBMS for their firms. This is consistent with the literature that committees come up with better results than individuals and that experts in the field (ICT) are considered to be able to carry out this job better than novices.

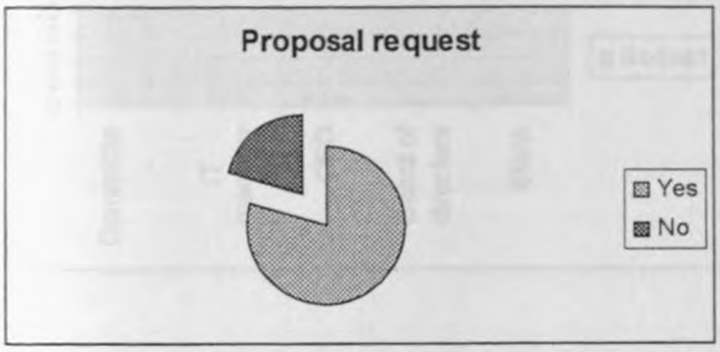
**Table 8: Source of DBMS search**

| Source | Frequency | Percentage |
|---|---|---|
| Internet search | 6 | 17.6 |
| Industry trade groups | 23 | 67.6 |
| Competition | 5 | 14.7 |
| Selection service | 11 | 32.4 |
| Others | 0 | 0 |

Source: Research Data

Table 8 above shows that most organizations use more than one source to identify DBMS to be included in the pool of those to be selected. 23 out of 34 or 67.6% representing majority of the organizations identify industry trade groups as the source of to identify DBMS, followed by selection services with 11 or 32.4% and Internet search with 6 or 17.6%. Competition was the contributor with the least where 5 respondents sited as a source. This is also consistent with the findings of the literature review, that organizations use diverse sources to search for the DBMS to be considered for selection although the majority prefers industry trade groups.

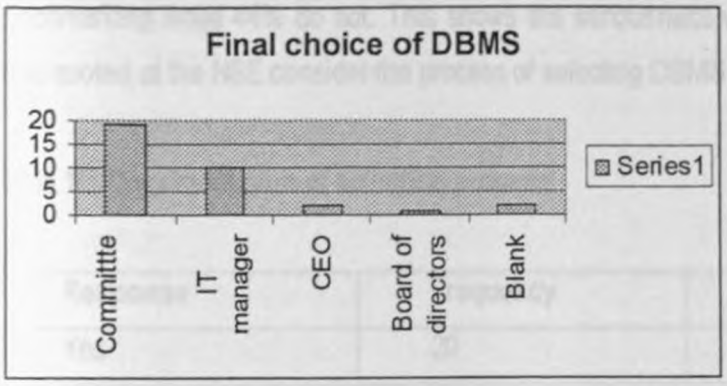
**Figure 13 : Request for proposals**




As demonstrated in Figure 13, 79% of the respondent stated that their firms request for proposal before acquiring DBMS while 21% do not. This implies that the firms at the NSE prefer formal, rigorous and transparent procedures in selection and acquisition of their DBMS.

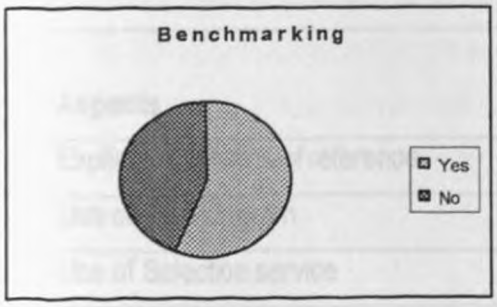
**Table 9 and Figure 14: Decision makers Final choice of DBMS**

| Person/body | Frequency |
|---|---|
| Committee with relevant Dept reps | 19 |
| IT manager | 10 |
| CEO | 2 |
| Board of directors | 1 |
| Blank | 2 |




Out of 34 respondents 19 of them or 55.9% stated that the final choice of DBMS in their firm is a decision to be made by a committee with relevant department representatives, while 10 or 29.4% citing the IT manager, 2 or 5.9% the CEO and 1 or 2.9% board of directors and 2 or 5.9% of the respondents did not indicate the person/body that make the final decision. When the answers to earlier question on whether IT is fully fledged and who carries out DBMS selection process and who makes final DBMS choice are looked at together there is a common attribute of consistency both in the literature and the response that committees and experts in the field are better placed to carry out the DBMS selection process as well as to make the final decision on what DBMS to buy.

**Figure 15: Benchmarking**




When asked whether the organizations they work for benchmark their selection process with other organizations in the industry, 56% of the respondents stated that they carry out

benchmarking while 44% do not. This shows the seriousness with which majority of the firms quoted at the NSE consider the process of selecting DBMS of their choice.

**Table 10: Documentation of selection process**

| Response | Frequency | Percent |
|---|---|---|
| Yes | 20 | 59 |
| No | 14 | 41 |
| Total | 34 | 100 |

Source: Research Data

Table 10 is a summary of responses on whether the organizations in the study document the selection processes they have adopted in carrying out DBMS choice. The results of the study show that 20 out of 34 or 59% document their selection processes, while 14 or 41% do not. Although majority of the firms document the process, the results indicate that some firms if given another chance may use another process other than the one they have previously used because they prefer not to document.

**Table 11: Aspects of Selection process in DBMS choice**

| Aspects | YES (%) | NO(%) |
|---|---|---|
| Explicitly set terms of reference | 76 | 24 |
| Use of Tree diagram | 38 | 62 |
| Use of Selection service | 76 | 24 |
| Use of Automated software | 38 | 62 |
| Extensive information search | 76 | 24 |
| Judgmental selection of Candidate DBMS | 38 | 62 |

| | | |
|---|---|---|
| Short listing DBMS | 76 | 24 |
| Assigning weights to various DBMS | 38 | 62 |
| Vendor Demonstrations | 76 | 24 |
| Statements of Recommendations and findings | 38 | 62 |
| Influence from other firms | 76 | 24 |
| Documented selection | 38 | 62 |

Source: Research data

Table 11 show that respondents use more than one aspect of DBMS selection process. The most popular aspects of selecting DBMS were cited as explicitly set term of reference, use of selection service, influenced by other firms, short-listing DBMS and vendor demonstration. Each of these aspects was cited by 76% of the respondents. The aspects that were rarely used by the firms were cited as use of tree diagram, judgmental selection of candidate DBMS, assigning weights to various DBMS, statement of findings and recommendations, documented selection and use of Automated software where 62% of the respondents stated that they do not use.

This response is consistent with the literature review where different organizations prefer to use different aspects of DBMS selection process. It is however not consistent with the view in the literature that modern technique such as use of automated software selection of DBMS is common. This could be attributed to the fact that Kenyan firms embraced the use of technology to carry out tasks efficiently recently and have not got up with the rest of the world in recent times.

## 4.3 Importance of factors in the choice of DBMS by firms quoted at the NSE.

### 4.3.1 Introduction

One of the objectives of the research project was to establish the importance of factors that firms quoted at the NSE consider in their choice of DBMS. When factor analysis was carried out to establish the importance of the factors, it was necessary to tally respondents rating of the factors from very important on one extreme end to not important at all on the other. The results were then tabulated and SPSS was used as a tool to analyze the data into characteristics that could be interpreted.

### 4.3.2 Representation of factors

Table 12 shows the alphanumeric variables assigned to represent each of the factors and indicated as initial, in order to enable SPSS to carry out analysis on them in a simplified manner.

**Table 12: Representation of factors**

| Initial | Factor |
|---|---|
| VAR01 | Constant data independence |
| VAR02 | Strength of integrity controls |
| VAR03 | Ease of restructuring data |
| VAR04 | System availability in the market |
| VAR05 | Adequacy of backups and recovery routines upon crashes |
| VAR06 | Support for many concurrent users |
| VAR07 | Reasonably minimum redundancy of data |
| VAR08 | Performance on transactions benchmarks/throughput |
| VAR09 | Ease of use and suitability to needs |
| VAR10 | Support for encryption routines |
| VAR11 | Well defined Memory and storage requirements |
| VAR12 | Compatibility with the existing Hardware |
| VAR13 | Compatibility with existing operating system |
| VAR14 | Ease of web integration |

| | |
|---|---|
| VAR15 | Cost of DBMS software acquisition |
| VAR 16 | Cost of DBMS maintenance |
| VAR 17 | Ease with which data could be migrated from old to new database |
| VAR 18 | Popularity of DBMS |
| VAR 19 | Frequency of updates and revision |
| VAR 20 | Availability of documentation |
| VAR 21 | Availability of term license agreement with the DBMS software vendor |
| VAR 22 | Ease of use of query languages |
| VAR 23 | Multi-user access |
| VAR 24 | Availability of Multilevel security features |
| VAR 25 | Network or distributed system support |
| VAR 26 | Ease of User usage monitoring |
| VAR 27 | Database administration support |
| VAR 28 | Availability of Load/unload facilities |
| VAR 29 | Training support |
| VAR 30 | Support for Parallel query processing |
| VAR 31 | Portability of DBMS |
| VAR 32 | DBMS Support for objects, image, graphics and voice |
| VAR 33 | Upgradability of the DBMS |
| VAR 34 | Scalability of the DBMS |
| VAR 35 | After sale vendor support |
| VAR 36 | Familiarity of personnel with the DBMS |
| VAR 37 | Organization-wide philosophy |
| | |
| | |

Source: Research Data

### 4.3.3 The Correlation matrix

Factor analysis has been used to identify the cluster of related factors as marked by the respondents thus resolving sets of variables that are linearly correlated in terms of small number of factors. According to Harman (1976) this resolution can be accomplished by the analysis of the correlation among the variables. In a correlation matrix of variables, the existents of clusters of large correlation coefficients between subsets of the variables suggest that the variables could be measuring aspects of the same underlying dimension or factors (Field, 2000). Appendix iv is a correlation matrix, which has been extracted using component analysis method giving the correlation between all pairs of data sets. Attempts were made to reduce it down to its components.

### 4.3.4 Factor Loadings Component

Table 13 shows the factor loadings for each variable on the 37 factors. From the analysis based on covariance, there are raw and rescaled values. Raw values are covariance between variables and factors, i.e. they are in the scale of the original variables. Rescaled values are standardized so that all values are measured on the same scale, and then arranged in order of importance from the highest to the lowest.

Compatibility with the existing Hardware (var12) (That is the hardware that fits into the DBMS of the firm) was on top of the list indicating that it was the most important factor in selection of DBMS. Followed by factor (var 07) minimum redundancy of data, cost of DBMS maintenance, in that order. The rest of the factors ranked in descending order as follows: Database administration support, System availability in the market, After sale vendor support, Performance on transactions benchmarks/throughput, Well defined Memory and storage requirements, Ease of restructuring data, Compatibility with existing operating system, Support for many concurrent users, Adequacy of backups and recovery routines upon crashes, Ease of User usage monitoring, Ease of use of query languages, Constant data independence, Support for Encryption routines , Ease of use and suitability to needs.

Others in the same order include; Availability of term license agreement with the DBMS software vendor, Availability of documentation, Availability of documentation, Upgradability of the DBMS, Availability of Load/unload facilities, Training support, Popularity of DBMS, Network or distributed system support, Multi-user access, Support for Parallel query processing, Ease with which data could be migrated from old to new database, Scalability of the DBMS, Availability of Multilevel security features Portability of DBMS, Frequency of updates and revision, Cost of DBMS software acquisition, Ease of web integration, DBMS Support for objects, image, graphics and voice, Familiarity of personnel with the DBMS, Organization –wide philosophy.

Table 13: Factor loadings component matrix

| | Raw Factor | | | Rescaled Factor | | |
|---|---|---|---|---|---|---|
| | | | | 1 | | |
| VAR12 | 7.152 | | | .995 | | |
| VAR07 | 7.514 | | | .989 | | |
| VAR16 | 5.876 | | | .984 | | |
| VAR27 | 5.876 | | | .984 | | |
| VAR04 | 7.267 | | | .983 | | |
| VAR35 | 5.221 | | | .975 | | |
| VAR08 | 6.791 | | | .973 | | |
| VAR11 | 5.991 | | | .963 | | |
| VAR03 | 8.198 | | | .962 | | |
| VAR13 | 7.824 | | | .958 | | |
| VAR06 | 8.694 | | | .945 | | |
| VAR05 | 7.706 | | | .944 | | |
| VAR26 | 6.586 | | | .939 | | |
| VAR22 | 6.699 | | | .932 | | |
| VAR01 | 9.037 | | | .929 | | |
| VAR10 | 5.921 | | | .928 | | |
| VAR09 | 6.433 | | | .927 | | |
| VAR21 | 4.451 | | | .924 | | |
| VAR20 | 6.106 | | | .924 | | |
| VAR02 | 8.391 | | | .917 | | |
| VAR33 | 5.953 | | | .890 | | |
| VAR28 | 5.361 | | | .885 | | |
| VAR29 | 5.933 | | | .846 | | |
| VAR18 | 2.544 | | | .839 | | |
| VAR25 | 7.099 | | | .827 | | |
| VAR23 | 6.489 | | | .826 | | |
| VAR30 | 5.457 | | | .798 | | |
| VAR17 | 4.338 | | | .796 | | |
| VAR34 | 5.000 | | | .793 | | |
| VAR24 | 6.642 | | | .790 | | |
| VAR31 | 3.845 | | | .790 | | |
| VAR19 | 3.743 | | | .786 | | |
| VAR15 | 3.424 | | | .735 | | |
| VAR14 | 2.042 | | | .472 | | |
| VAR32 | 3.535 | | | .633 | | |
| VAR36 | 4.261 | | | .645 | | |
| VAR37 | 2.141 | | | .435 | | |

Extraction Method: Principal Component Analysis.

### 4.3.5 The Communalities

Table 14 shows extraction communalities. Extraction communalities are estimates of the variance in each variable accounted for by the factors (or components) in the factor solution. Small values indicate variables that do not fit well with the factor solution, and should possibly be dropped from the analysis.

**Table 14**

**Communalities**

| | Initial | Extraction |
|---|---|---|
| VAR01 | 1.000 | 1.000 |
| VAR02 | 1.000 | 1.000 |
| VAR03 | 1.000 | 1.000 |
| VAR04 | 1.000 | .991 |
| VAR05 | 1.000 | .999 |
| VAR06 | 1.000 | 1.000 |
| VAR07 | 1.000 | 1.000 |
| VAR08 | 1.000 | .998 |
| VAR09 | 1.000 | .991 |
| VAR10 | 1.000 | .986 |
| VAR11 | 1.000 | 1.000 |
| VAR12 | 1.000 | .999 |
| VAR13 | 1.000 | .995 |
| VAR14 | 1.000 | .976 |
| VAR15 | 1.000 | .984 |
| VAR16 | 1.000 | .992 |
| VAR17 | 1.000 | .998 |
| VAR18 | 1.000 | .998 |
| VAR19 | 1.000 | .947 |
| VAR20 | 1.000 | .994 |
| VAR21 | 1.000 | .968 |
| VAR22 | 1.000 | .995 |
| VAR23 | 1.000 | .994 |
| VAR24 | 1.000 | .999 |
| VAR25 | 1.000 | .999 |
| VAR26 | 1.000 | .992 |
| VAR27 | 1.000 | .992 |
| VAR28 | 1.000 | .984 |
| VAR29 | 1.000 | .999 |
| VAR30 | 1.000 | .999 |
| VAR31 | 1.000 | .996 |
| VAR32 | 1.000 | .978 |
| VAR33 | 1.000 | 1.000 |
| VAR34 | 1.000 | .991 |
| VAR35 | 1.000 | .999 |
| VAR36 | 1.000 | .994 |
| VAR37 | 1.000 | .981 |

Extraction Method: Principal Component Analysis.

### 4.3.6 Total Variance Explained

Table 15 shows explanation of total variance. Out of the 37(thirty seven) variables accepted by the respondents that they apply in the choice of DBMS, 3(three) factors were extracted using Varimax rotation. Eigen values: which are the sum of the squares of its factor loadings were set at greater than I(one). The factors being uncorrelated to all previous factors are assigned a decreasing proportion of total variance to a minimum set out of points of greater than 1(one). For example component or factor 1(one) explains 46.221% of the total variations, component or factor 2(two) explains 44.403% of the total variance and component or factor 3 (three) explains 8.588% of the total variance as shown in the column-highlighted **yellow** in Table 15.

**Table 15**

**Total Variance Explained**

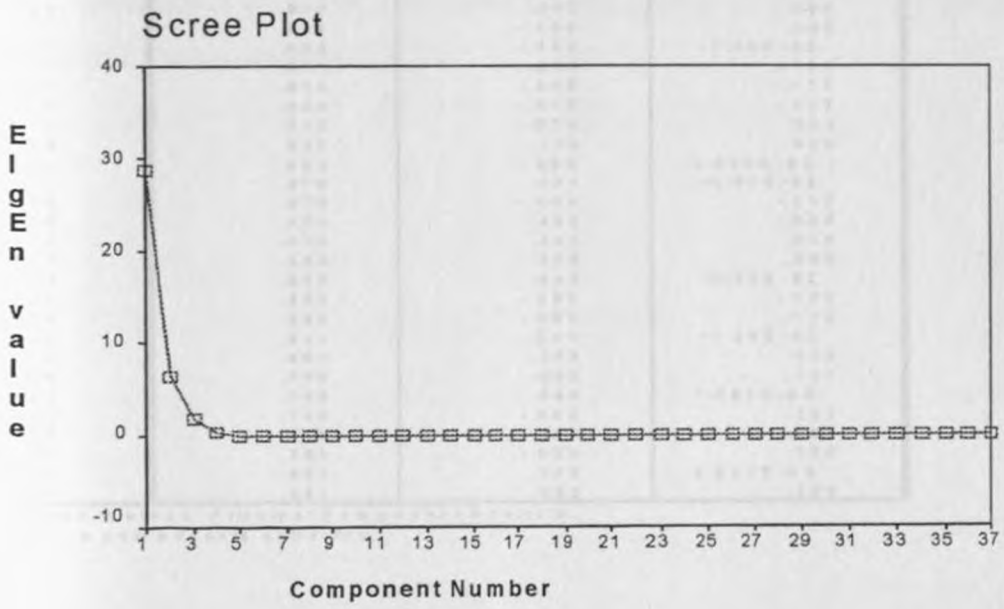
| | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 28.700 | 77.568 | 77.568 | 28.700 | 77.568 | 77.568 | 17.102 | 46.221 | 46.221 |
| 2 | 6.282 | 16.978 | 94.546 | 6.282 | 16.978 | 94.546 | 16.429 | 44.403 | 90.624 |
| 3 | 1.726 | 4.666 | 99.212 | 1.726 | 4.666 | 99.212 | 3.178 | 8.588 | 99.212 |
| 4 | .292 | .788 | 100.000 | | | | | | |
| 5 | 2.215E-15 | 5.985E-15 | 100.000 | | | | | | |
| 6 | 1.364E-15 | 3.686E-15 | 100.000 | | | | | | |
| 7 | 6.396E-16 | 1.729E-15 | 100.000 | | | | | | |
| 8 | 5.075E-16 | 1.371E-15 | 100.000 | | | | | | |
| 9 | 4.607E-16 | 1.245E-15 | 100.000 | | | | | | |
| 10 | 4.555E-16 | 1.231E-15 | 100.000 | | | | | | |
| 11 | 4.124E-16 | 1.114E-15 | 100.000 | | | | | | |
| 12 | 3.170E-16 | 8.569E-16 | 100.000 | | | | | | |
| 13 | 3.100E-16 | 8.378E-16 | 100.000 | | | | | | |
| 14 | 2.506E-16 | 6.773E-16 | 100.000 | | | | | | |
| 15 | 1.742E-16 | 4.709E-16 | 100.000 | | | | | | |
| 16 | 1.693E-16 | 4.576E-16 | 100.000 | | | | | | |
| 17 | 1.125E-16 | 3.041E-16 | 100.000 | | | | | | |
| 18 | 9.927E-17 | 2.683E-16 | 100.000 | | | | | | |
| 19 | 6.098E-17 | 1.648E-16 | 100.000 | | | | | | |
| 20 | 2.767E-17 | 7.478E-17 | 100.000 | | | | | | |
| 21 | 5.129E-18 | 1.386E-17 | 100.000 | | | | | | |
| 22 | -3.37E-17 | -9.097E-17 | 100.000 | | | | | | |
| 23 | -4.59E-17 | -1.239E-16 | 100.000 | | | | | | |
| 24 | -1.01E-16 | -2.725E-16 | 100.000 | | | | | | |
| 25 | -1.21E-16 | -3.268E-16 | 100.000 | | | | | | |
| 26 | -1.76E-16 | -4.758E-16 | 100.000 | | | | | | |
| 27 | -1.88E-16 | -5.083E-16 | 100.000 | | | | | | |
| 28 | -2.10E-16 | -5.664E-16 | 100.000 | | | | | | |
| 29 | -2.89E-16 | -7.819E-16 | 100.000 | | | | | | |
| 30 | -3.38E-16 | -9.146E-16 | 100.000 | | | | | | |
| 31 | -3.71E-16 | -1.003E-15 | 100.000 | | | | | | |
| 32 | -4.16E-16 | -1.124E-15 | 100.000 | | | | | | |
| 33 | -4.66E-16 | -1.259E-15 | 100.000 | | | | | | |
| 34 | -5.06E-16 | -1.368E-15 | 100.000 | | | | | | |
| 35 | -1.33E-15 | -3.591E-15 | 100.000 | | | | | | |
| 36 | -1.81E-15 | -4.901E-15 | 100.000 | | | | | | |
| 37 | -5.39E-15 | -1.458E-14 | 100.000 | | | | | | |

Extraction Method: Principal Component Analysis.

### 4.3.7 Scree plot

Table 16 is a graph of the eigen values plotted against all factors. The point of interest is usually where the curve starts to flatten. The curve begins to flatten after factor 3 but given that it has eigen value of less than 1(one) it is considered insignificant. The plot thus confirms the selection of three factors (components).

**Table 16**




### 4.3.8 Component Matrix

The factors with Eigen value of greater than 1 were then picked, that is a total of 3(three) component factors. A component matrix Table 17 was created to assign each of the variables to be considered in the choice of DBMS 3(three) factor loading showing the loading of the variable has on each of the 3 (three) factors. The higher the absolute value of the loading the more the factor (component) contributes to the variable.

**Table 17**

Component Matrix[a]

| | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| VAR11 | .992 | .108 | -6.47E-02 |
| VAR27 | .991 | -2.17E-02 | -9.51E-02 |
| VAR16 | .991 | -2.17E-02 | -9.51E-02 |
| VAR04 | .991 | -1.18E-02 | -9.55E-02 |
| VAR08 | .990 | 4.531E-02 | -.125 |
| VAR12 | .985 | -.123 | -.121 |
| VAR20 | .971 | .222 | -3.58E-02 |
| VAR10 | .967 | .184 | -.124 |
| VAR26 | .960 | 9.574E-02 | -.248 |
| VAR07 | .954 | -.275 | -.115 |
| VAR33 | .945 | .288 | -.154 |
| VAR28 | .933 | .252 | -.224 |
| VAR21 | .929 | -.105 | .305 |
| VAR35 | .926 | -.369 | -7.98E-02 |
| VAR29 | .911 | .364 | -.191 |
| VAR03 | .908 | -.380 | -.177 |
| VAR13 | .899 | -.415 | -.117 |
| VAR22 | .890 | -.375 | .251 |
| VAR18 | .882 | .118 | .454 |
| VAR05 | .882 | -.465 | 6.620E-02 |
| VAR31 | .879 | .474 | -4.61E-03 |
| VAR06 | .878 | -.464 | -.112 |
| VAR30 | .874 | .432 | -.220 |
| VAR34 | .870 | .433 | -.215 |
| VAR17 | .868 | .306 | .388 |
| VAR19 | .866 | .443 | -3.76E-02 |
| VAR01 | .856 | -.498 | -.139 |
| VAR09 | .856 | -.495 | -.118 |
| VAR02 | .841 | -.541 | -1.00E-02 |
| VAR15 | .804 | .263 | .519 |
| VAR36 | .760 | .632 | .131 |
| VAR32 | .749 | .646 | 1.061E-02 |
| VAR25 | .748 | -.600 | .282 |
| VAR23 | .742 | -.627 | .227 |
| VAR24 | .705 | -.639 | .306 |
| VAR14 | .607 | .779 | 9.541E-03 |
| VAR37 | .561 | .652 | .492 |

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

### 4.3.9 Factor Rotation

The component matrix Table 17 was then rotated orthogonally using varimax to extract variables with the maximum or near maximum loading. This produced Table 18.

Table 18 shows 3 (three) factors by 37 variable matrixes. The rotated component matrix gives the revised initial factor matrix after it has been orthogonally rotated using Varimax rotation with Kaiser normalization. This attempts to simplify the columns of factor matrix by making all values close to either 0 or 1. The coefficient in the matrix represents both

regression weights and correlation coefficient. The loading in a given row represents regression coefficient of factors that describe a given variables.

We can then group together the variables into the 3(three) factors that were extracted according to how heavy this variables load on each factor. For example the first variable (Var02) on the Table 18 strength of integrity control' has 97.3% loading on factor 1(component) and is the highest loading for the variable grouped within the same principle factor as shown and highlighted yellow within the column. The last variable (var 04) 'system availability in the market' has the least 69.9% loading on factor 1. The rotation converged in 7(seven) iterations.

## Table 18

**Rotated Component Matrix** [a]

| | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| VAR02 | .973 | .217 | 7.289E-02 |
| VAR23 | .962 | 2.368E-02 | .262 |
| VAR01 | .955 | .293 | -3.90E-02 |
| VAR09 | .952 | .289 | -1.85E-02 |
| VAR06 | .946 | .323 | -2.38E-03 |
| VAR25 | .946 | 2.952E-02 | .321 |
| VAR05 | .946 | .274 | .169 |
| VAR24 | .944 | -3.29E-02 | .327 |
| VAR13 | .926 | .372 | 6.622E-03 |
| VAR35 | .910 | .410 | 5.691E-02 |
| VAR03 | .907 | .418 | -4.21E-02 |
| VAR22 | .883 | .287 | .364 |
| VAR07 | .863 | .503 | 4.682E-02 |
| VAR12 | .775 | .627 | 7.611E-02 |
| VAR21 | .716 | .479 | .476 |
| VAR27 | .706 | .692 | .122 |
| VAR16 | .706 | .692 | .122 |
| VAR04 | .699 | .698 | .123 |
| VAR30 | .301 | .951 | 6.176E-02 |
| VAR34 | .297 | .948 | 6.609E-02 |
| VAR32 | 5.539E-02 | .942 | .295 |
| VAR14 | -.138 | .935 | .288 |
| VAR29 | .375 | .923 | 8.459E-02 |
| VAR31 | .270 | .920 | .277 |
| VAR36 | 7.132E-02 | .906 | .410 |
| VAR19 | .284 | .900 | .237 |
| VAR33 | .453 | .884 | .114 |
| VAR28 | .471 | .872 | 3.712E-02 |
| VAR20 | .516 | .824 | .220 |
| VAR10 | .539 | .824 | .128 |
| VAR26 | .602 | .793 | -9.34E-03 |
| VAR11 | .613 | .770 | .175 |
| VAR08 | .657 | .744 | .106 |
| VAR17 | .376 | .688 | .619 |
| VAR15 | .360 | .577 | .722 |
| VAR37 | -8.81E-02 | .679 | .716 |
| VAR18 | .520 | .553 | .650 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

### 4.4.0 Factor Isolation

Isolation of determinants for each factor involves isolating each determinant that constitutes each of factors based on the factor loadings. This has been based on minimum of **0.6** and are as shown below.

**Factor 1(Component)** groups together what may be deduced as **reliability of DBMS software.** The following factors in order of importance in the choice of DBMS belong to this grouping:

- Strength of Integrity controls
- Multi-user access
- Constant data independence
- Ease of use and suitability to needs
- Support for many concurrent users
- Network or distributed system support
- Adequacy of backups and recovery routines upon crashes
- Availability of Multilevel security features
- Compatibility with existing operating system
- After sale vendor support
- Ease of restructuring data
- Ease of use of query languages
- Reasonably minimum Redundancy of data
- Compatibility with existing Hardware
- Availability of term license agreement with the DBMS software vendor
- Data base administration support
- Cost of DBMS maintenance
- System availability in the market

- Support for Parallel query processing
- Scalability of the DBMS
- DBMS Support for objects, image, graphics & voice
- Ease of web integration
- Training support
- Portability of DBMS
- Familiarity of personnel with the DBMS
- Frequency of updates and revision
- Upgradability of the DBMS
- Availability of Load/unload facilities
- Availability of documentation
- Support for Encryption routines
- Ease of User usage monitoring
- Well defined Memory and storage requirements
- Performance on transactions benchmarks/throughput
- Ease with which data could be migrated from old to new database

**Factor 3(Component)** groups together what may be deduced as **non-technical factors of DBMS software.** The following factors in order of importance in the choice of DBMS belong to this grouping:

Cost of DBMS software acquisition

- Organization –wide philosophy
- Popularity of DBMS

## CHAPTER FIVE

## SUMMARY, DISCUSSIONS AND CONCLUSIONS

### 5.0 Introduction

This chapter of the study outlines the summary, discussions and conclusions. Limitations of the research, recommendations and suggestions for future research are also included.

### 5.1 Summary and discussions

#### 5.1.1 Demographic information

The demographic data were collected primarily to enrich the study and to get a profile of the organizations under study. The results of the study confirm that majority of the organizations with DBMS have been in operation for less than 50 years, and are industrial and allied organizations owned locally. Many of them have a budget for DBMS with full fledged IT departments whose heads reports to the Managing Directors of the respective companies and most of them have Microsoft as their vendor of both the DBMS server and operating system.

We further found that majority uses their DBMS for storing data, querying data, running reports and keeping stock records respectively in order of priority among others.

#### 5.1.2 DBMS selection process

One of the objectives of the study was to document aspects of the DBMS selection process that are used by firms quoted at the NSE. The results of the research project

indicate that most firms acquire customized version of standardized database applications and have a warranty for the DBMS they buy. Committees carry out the selection of DBMS in most of the firms. Although firms use more than one source to identify DBMS they intend to buy, Most of them attribute the industry trade groups as the source of their DBMS and ask for proposals before carrying out DBMS selection process, but the a committee made up of representatives of departments makes the final choice. A number of firms carry out benchmarking with other firms in their industry or outside and the selection process is documented formally for future reference.

The research found that to a large extend this firms use more than one aspect of DBMS selection process. There were however some aspects that were rarely used by the firms.

### 5.1.3 Factors considered in selection of DBMS

The other objective of the study was to establish the relative importance of factors that firms quoted at the NSE consider in their choice of DBMS. The findings indicate that those factors that were considered more important than the others were ranked higher in a scaled presentation and a list of the same produced.

It was further established that all the factors could be compressed and summarized into three main factors. The most important factor among the three could be deduced as the reliability of DBMS software. This implied that the DBMS of choice should be capable of coping with any unforeseen condition during its use. The second most important factor is the versatility of the DBMS; that is the software should be flexible enough to provide the users with new functionalities according to their needs as they arise.

The third and the last factor derived from grouping of factors are non-technical requirements of the DBMS software. This means that the software should meet the firms' needs such as economic and organizational among others that must be considered initially and subsequently after acquisition of the DBMS.

## 5.2 Conclusions

The factors that were brought out by various researchers and scholars in the literature review as relatively important in the selection of DBMS appears to be the same as those that were identified by the research findings. It can then be concluded that whether a firm is operating in a developed or developing country, the firms must and ought to consider the factors identified in these study in their selection of DBMS.

The study also confirmed that organizations consider various aspects of DBMS selection process in their choice of the winning DBMS to be purchased. No particular selection aspect, method or procedure stood as the favorite of the firms quoted at the NSE. Literature on the same is consistent with this finding.

Unlike in Kenya use of Automated selection software in the DBMS selection process in the developed countries where the literature is based is common. Firms in Kenya should endeavor to introduce this technology in order to keep pace with the rest of the world.

## 5.3 Limitation of study

First the use of predetermined questions in the survey may have forced the respondents to respond to questions without even understanding them. It is also possible that the study may carry some of the weaknesses inherent in using questionnaires as a technique for data collection.

Secondly Some respondents did not return the questionnaires. This may be attributed to the fact that respondents are busy people. There were instances where some of them misplaced the set of questionnaires necessitating replacement thus contributing to an

increase in financial costs and time. All these shortcomings reduced the responds rate to 72.34%. Although this reduced the probability of reaching a more conclusive study, conclusions were however made within the responds rate as the data collected was considered sufficient and a fair representation of the population for the purpose and scope of the research.

## 5.4 Recommendations

All Organizations whether quoted at the NSE or not should have a clear DBMS acquisition policy that state procedures management should be involved in. These procedures should be updated from time to time and benchmarked with the industry the firms belong. It is also advisable that committees are always used to carry out DBMS selection process because committees are almost free of bias and are therefore more likely to make the best decision for the interest of the firm.

The criteria and the factors to be considered by the DBMS committee should be set out in advance and documented as these form the basis for justification of the choice made.

Before making a DBMS acquisition choice organizations should have factors already laid down which they may use in the choice process. It is also advisable to use many sources to identify candidate DBMS and use the best technology in the market to carry out the exercise such as Automated software selection kit as these will guarantee purchase of quality DBMS software. However non-technical factors such as cost and organizational politics should never be overlooked.

Such bodies as the computer society of Kenya and other professional bodies should regularly conduct workshops and seminars to increase the level of skill and awareness of the best practices, benefits and challenges in the choice of DBMS.

## 5.5 Suggestions for further research

The following are possible areas for future research;

Because this study concentrated on the factors and the process of choosing a DBMS by firms quoted at the NSE, it is suggested that future research be directed towards the other organizations operating in Kenya and are not quoted at the NSE.

Future studies could also focus on challenges the firms quoted at the NSE and those not quoted face in implementing the chosen DBMS software. The same research could also be carried out after five years.

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## APPPENDICES

**Appendix i**

**47 COMPANIES LISTED IN NSE AS AT 11th APRIL 2005**

***AGRICULTURE***

1. Unilever Tea Kenya Ltd
2. Kakuzi
3. Rea Vipingo Plantations
4. Sasini Tea and Coffee

***COMMERCIAL AND SERVICES***

1. Cars and General (K) Ltd
2. CMC Holdings Ltd
3. Kenya Airways Ltd
4. Marshalls (K) Ltd
5. Nation Media Group
6. TPS Ltd
7. Uchumi Supermarket

***FINANCE AND INVESTMENTS***

1. Barclays Bank Ltd
2. C.F.C Bank Ltd
3. Diamond Finance Company Ltd

4. ICDC Investment Co. Ltd
5. Jubilee Insurance Co. Ltd
6. Kenya Commercial Bank Ltd.
7. National Bank of Kenya Ltd.
8. NIC Bank Ltd
9. Pan Africa Insurance Holdings Ltd
10. Standard Chartered Bank Ltd
11. Housing Finance Company

***INDUSTRIAL AND ALLIED***

1. Athi River Mining
2. BOC Kenya Ltd
3. Bamburi Cement Ltd
4. British American Tobacco Kenya Ltd
5. Carbacid Investment Ltd
6. Crown Berger Ltd
7. Olympia Capital Holdings
8. E. A. Cables Ltd
9. E. A. Portland Cement Ltd.
10. East African Breweries
11. Firestone East Africa Ltd
12. Kenya Oil Co. Ltd
13. Mumias Sugar Co. Ltd
14. Kenya Power and Lighting Co. Ltd
15. Total Kenya Ltd
16. Unga Group Ltd

**Alternative investments**

1. EAAGADS Ltd
2. City Trust Ltd
3. Standard Group Ltd
4. A. Baumann & Co. Ltd
5. Express Ltd
6. Williamson Tea Kenya Ltd
7. Kapchorua Tea & Co.
8. Kenya Orchards Ltd
9. Limuru Tea Co. Ltd

**Appendix viii: INTRODUCTION LETTER**

BOIT TOM KIPKOSGEI
UNIVERISITY OF NAIROBI,
FACULTY OF COMMERCE,
DEPARTMENT OF MANAGEMENT SCIENCE,
P. O. BOX 30197,
NAIROBI.

To whom it may concern,

I am a postgraduate student in the faculty of commerce, University of Nairobi, pursuing a Masters in Business Administration degree program. I a m undertaking a research on Database Management Systems Choice by Firms Quoted at the Nairobi Stock Exchange. It is aimed at establishing the relative importance of factors that firms quoted at the NSE consider in their choice of DBMS, and finally to document aspects of the DBMS selection process that are used by firms quoted at the NSE.

You have been selected as one of the respondents. I therefore kindly request you to fill in the attached questionnaire. The information from the questionnaire is needed purely for academic research purposes and will therefore be treated with the utmost confidentiality. In no way will your name or the name of your firm appear in the final report. A copy of the final report can be made available to you upon request. If you require any further information, please do not hesitate to contact me on cell phone number 0720 906638.

Thank you in advance for your cooperation.
Yours faithfully,

TOM K. BOIT
MBA Student

**Appendix iii**

**QUESTIONNAIRE**

This survey is a research project on the choice of database management system (DBMS) by organizations. Please feel free to share your experience by answering questions below. I hope you will find completing the questionnaire enjoyable and thank you for taking your time for me. If you have any queries or you would like further information on the research, please do not hesitate to call me on Mobile number 0720906638 or landline number 604097 during the day. Thank you

**SECTION A**

**ORGANIZATIONAL DETAILS:**

1. How long has your organization been in operation? Tick where appropriate.

| | |
|---|---|
| 0-50 years | [ ] |
| 51-100 | [ ] |
| Over 100 | [ ] |

2. Tick from the list below, the classification of your organization.

| | |
|---|---|
| a) Financial and Investment | [ ] |
| b) Commercial and Services | [ ] |
| c) Industrial and Allied | [ ] |
| d) Agricultural | [ ] |
| e) Alternative investment Market | [ ] |

3. What is the ownership structure of your organization?

| | | |
|---|---|---|
| a) | Locally owned | [ ] |
| b) | Foreign owned | [ ] |
| c) | Part local and foreign | [ ] |

4. Do you have a budget for database management system (DBMS)?

Yes [ ] No [ ]

5. a) Does your organization have a fully fledged IT Department?

Yes [ ] No [ ]

b) If your answer to 7 (a) above is No, which department handles IT issues? ----------

6. To who does the Head of IT or the Head of department who handles IT issue report? Tick the appropriate authority

i) ICT committee [ ]

ii) CEO or Managing Director [ ]

iii) Board of Directors [ ]

iv) Others specify----------

7. Which type(s) of operating system(s) are in use in your organization?

a) Windows [ ]
b) Windows NT [ ]
c) Linux [ ]
d) OS2 [ ]
e) Macintosh [ ]
f) Unix [ ]
g) MVS [ ]
h) VMS [ ]

i) Others (please specify).----------

8. Which of the following database management systems (DBMS) are in use in your organization?

a) Oracle [ ]

b) SQL server [ ]

c) IBM DB2 [ ]

d) Informix dynamic server [ ]

e) Adaptive server enterprise [ ]

f) Others specify ----------

---

---

9. What do you use your DBMS for in your organization?

a) Storing data [ ]
b) Running report [ ]
c) Querying data [ ]
d) Stock [ ]
f) Personnel records [ ]
g) Others (please specify)----------

10. Who are the vendors of the database management system (DBMS) you use?

---

11. Does your database management system (DBMS) have a warranty?

Yes [ ] No [ ]

## SECTION B

## FACTORS CONSIDERED IN SELECTION OF DBMS

The following factors relate to DBMS choice. Indicate the importance of each of the factors in the choice of DBMS in your organization.

| | Factor | Very important | Important | Somehow important | Least important | Not important At all |
|---|---|---|---|---|---|---|
| 1 | Constant data independence | [ ] | [ ] | [ ] | [ ] | [ ] |
| 2 | Strength of Integrity controls | [ ] | [ ] | [ ] | [ ] | [ ] |
| 3 | Ease of restructuring data | [ ] | [ ] | [ ] | [ ] | [ ] |
| 4 | System availability in the market | [ ] | [ ] | [ ] | [ ] | [ ] |
| 5. | Adequacy of backups and recovery routines upon crashes. | [ ] | [ ] | [ ] | [ ] | [ ] |
| 6 | Support for many concurrent users | [ ] | [ ] | [ ] | [ ] | [ ] |
| 7 | Reasonably minimum Redundancy of data | [ ] | [ ] | [ ] | [ ] | [ ] |
| 8 | Performance on transactions benchmarks/throughput | [ ] | [ ] | [ ] | [ ] | [ ] |
| 9 | Ease of use and suitability to needs | [ ] | [ ] | [ ] | [ ] | [ ] |
| 10 | Support for encryption routines | [ ] | [ ] | [ ] | [ ] | [ ] |
| 11 | Well defined memory and storage requirements | [ ] | [ ] | [ ] | [ ] | [ ] |
| 12 | Compatibility with existing Hardware | [ ] | [ ] | [ ] | [ ] | [ ] |
| 13 | Compatibility with existing operating system | [ ] | [ ] | [ ] | [ ] | [ ] |
| 14 | Ease of Web integration | [ ] | [ ] | [ ] | [ ] | [ ] |
| 15 | Cost of DBMS software acquisition and maintenance | [ ] | [ ] | [ ] | [ ] | [ ] |
| 16 | Cost of DBMS maintenance | | | | | |
| 17 | Ease with which data could be migrated from old to new database | [ ] | [ ] | [ ] | [ ] | [ ] |
| 18 | Popularity of the DBMS | [ ] | [ ] | [ ] | [ ] | [ ] |
| 19 | Frequency of updates and revisions | [ ] | [ ] | [ ] | [ ] | [ ] |
| 20 | Availability of documentation | [ ] | [ ] | [ ] | [ ] | [ ] |
| 21 | Availability of term license agreement with the DBMs software vendor | [ ] | [ ] | [ ] | [ ] | [ ] |
| 22 | Ease of use of query languages | [ ] | [ ] | [ ] | [ ] | [ ] |
| 23 | Multi-user access | | | | | |
| 24 | Availability of multilevel security features | [ ] | [ ] | [ ] | [ ] | [ ] |
| 25 | Network or distributed system support | [ ] | [ ] | [ ] | [ ] | [ ] |
| 26 | Ease of User usage monitoring | [ ] | [ ] | [ ] | [ ] | [ ] |
| 27 | Data base administration support | [ ] | [ ] | [ ] | [ ] | [ ] |
| 28 | Availability of load/unload facilities | [ ] | [ ] | [ ] | [ ] | [ ] |
| 29 | Training support | [ ] | [ ] | [ ] | [ ] | [ ] |
| 30 | Support for Parallel query processing | [ ] | [ ] | [ ] | [ ] | [ ] |
| 31 | Portability of DBMS | [ ] | [ ] | [ ] | [ ] | [ ] |
| 32 | DBMS Support for objects, image, graphics and voice | [ ] | [ ] | [ ] | [ ] | [ ] |
| 33 | Upgradeability of the DBMS | [ ] | [ ] | [ ] | [ ] | [ ] |
| 34 | Scalability of the DBMS | [ ] | [ ] | [ ] | [ ] | [ ] |

| | | | | | | |
|---|---|---|---|---|---|---|
| 35 | After sale vendor support | [ ] | [ ] | [ ] | [ ] | [ ] |
| 36 | Familiarity of personnel with the DBMS. | [ ] | [ ] | [ ] | [ ] | [ ] |
| 37 | Organization –wide philosophy | [ ] | [ ] | [ ] | [ ] | [ ] |

38.Others (please specify)

.....

.....

.....

.....

## SECTION C

## DBMS SELECTION PROCESS

1. How does your organization acquire database applications?

   a) Internally develop by contracted professional [ ]
   b) In-house development by the organization [ ]
   c) Bought Off-the-shelf application [ ]
   d) Customized version of standard package [ ]
   e) Others, specify----------
   ----------

2. Who carries out DBMS selection in your organization?

   a) ICT Department [ ]
   b) Purchasing Department [ ]
   c) A committee of relevant departmental representatives [ ]
   e) Others (specify)----------

3. Which of the following sources contribute to the choice of DBMS software in your organization? (Tick the appropriate sources)

(a) Internet Search [ ]

(b) Industry trade groups [ ]

(c) Competition [ ]

d) Selection service [ ]

(e) Others specify ----------

4. Does your organization ask for request for proposals (RFP) before carrying out DBMS selection process?

Yes [ ] No[ ]

5. Who makes the **final** choice of DBMS in your organization?

(Title of individual or committee) ----------

6. Do you carry out benchmarking of your DBMS selection process with other Organizations? Yes [ ] No [ ]

7. Is your selection process documented? Yes [ ] No [ ]

8. Indicate with a tick, whether or not the following aspects describe the selection process that your organization uses in the choice of DBMS?

| | | Yes | No |
|---|---|---|---|
| a) | The terms of reference of the selection process are set explicitly. | [ ] | [ ] |
| b) | Tree diagram is used in DBMS selection process. | [ ] | [ ] |
| c) | A selection service is used to select DBMS | [ ] | [ ] |
| d) | An automated software tool is used to select DBMS. | [ ] | [ ] |
| e) | Extensive information search is done to match DBMS and organizational needs | [ ] | [ ] |
| f) | Candidate DBMS are selected on judgmental basis | [ ] | [ ] |
| g) | Short-listing is part of the DBMS selection process | [ ] | [ ] |
| h) | DBMS features are assigned weights and selected on the | [ ] | [ ] |

| | | | |
|---|---|---|---|
| | basis of the sum of the weights obtained | | |
| i) | Vendors are asked to conduct demonstrations of their DBMS | [ ] | [ ] |
| j) | A statement of findings and recommendations is part of the selection process | [ ] | [ ] |
| k) | When choosing DBMS we are influenced by the DBMS that other firms in the industry use | [ ] | [ ] |
| l) | Selection process is documented | [ ] | [ ] |
| m) | Others specify<br>.....<br>..... | | |

## Appendix iv

## Correlation Matrix

**Correlation Matrix[a]**

| | | VAR00001 | VAR00002 | VAR00003 | VAR00004 | VAR00005 | VAR00006 | VAR00007 |
|---|---|---|---|---|---|---|---|---|
| Correlation | VAR00001 | 1.000 | .991 | .991 | .868 | .978 | .999 | .970 |
| | VAR00002 | .991 | 1.000 | .970 | .842 | .993 | .991 | .953 |
| | VAR00003 | .991 | .970 | 1.000 | .919 | .965 | .993 | .991 |
| | VAR00004 | .868 | .842 | .919 | 1.000 | .877 | .888 | .960 |
| | VAR00005 | .978 | .993 | .965 | .877 | 1.000 | .984 | .962 |
| | VAR00006 | .999 | .991 | .993 | .888 | .984 | 1.000 | .979 |
| | VAR00007 | .970 | .953 | .991 | .960 | .962 | .979 | 1.000 |
| | VAR00008 | .842 | .810 | .902 | .997 | .846 | .863 | .947 |
| | VAR00009 | .995 | .987 | .987 | .856 | .974 | .993 | .966 |
| | VAR00010 | .752 | .714 | .826 | .979 | .762 | .778 | .886 |
| | VAR00011 | .804 | .777 | .871 | .988 | .821 | .829 | .925 |
| | VAR00012 | .921 | .896 | .962 | .991 | .919 | .936 | .988 |
| | VAR00013 | .993 | .983 | .994 | .914 | .981 | .997 | .987 |
| | VAR00014 | .130 | .087 | .256 | .577 | .168 | .168 | .364 |
| | VAR00015 | .484 | .527 | .540 | .731 | .616 | .524 | .634 |
| | VAR00016 | .872 | .845 | .926 | .983 | .875 | .890 | .963 |
| | VAR00017 | .536 | .561 | .602 | .824 | .650 | .577 | .699 |
| | VAR00018 | .634 | .674 | .675 | .834 | .755 | .670 | .757 |
| | VAR00019 | .527 | .492 | .620 | .878 | .564 | .563 | .710 |
| | VAR00020 | .726 | .698 | .802 | .971 | .754 | .755 | .870 |
| | VAR00021 | .804 | .833 | .833 | .876 | .882 | .828 | .880 |
| | VAR00022 | .914 | .949 | .904 | .869 | .978 | .929 | .924 |
| | VAR00023 | .915 | .959 | .873 | .713 | .958 | .916 | .854 |
| | VAR00024 | .879 | .935 | .829 | .675 | .939 | .881 | .813 |
| | VAR00025 | .900 | .951 | .857 | .724 | .958 | .904 | .846 |
| | VAR00026 | .809 | .759 | .877 | .982 | .789 | .828 | .919 |
| | VAR00027 | .872 | .845 | .926 | .983 | .875 | .890 | .963 |
| | VAR00028 | .703 | .649 | .793 | .931 | .686 | .726 | .846 |
| | VAR00029 | .626 | .572 | .722 | .919 | .623 | .654 | .792 |
| | VAR00030 | .563 | .503 | .668 | .879 | .555 | .591 | .741 |
| | VAR00031 | .516 | .482 | .619 | .860 | .552 | .551 | .708 |
| | VAR00032 | .316 | .278 | .435 | .719 | .355 | .354 | .535 |
| | VAR00033 | .687 | .641 | .775 | .949 | .690 | .714 | .841 |
| | VAR00034 | .558 | .498 | .665 | .868 | .548 | .585 | .735 |
| | VAR00035 | .987 | .978 | .995 | .926 | .982 | .993 | .994 |
| | VAR00036 | .318 | .297 | .425 | .740 | .388 | .361 | .537 |
| | VAR00037 | .088 | .116 | .172 | .514 | .229 | .137 | .300 |

**Correlation Matrix[a,b]**

| | | VAR08 | VAR09 | VAR10 | VAR11 | VAR12 | VAR13 | VAR14 |
|---|---|---|---|---|---|---|---|---|
| Correlation | VAR01 | .842 | .995 | .752 | .804 | .921 | .993 | .130 |
| | VAR02 | .810 | .987 | .714 | .777 | .896 | .983 | .087 |
| | VAR03 | .902 | .987 | .826 | .871 | .962 | .994 | .256 |
| | VAR04 | .997 | .856 | .979 | .988 | .991 | .914 | .577 |
| | VAR05 | .846 | .974 | .762 | .821 | .919 | .981 | .168 |
| | VAR06 | .863 | .993 | .778 | .829 | .936 | .997 | .168 |
| | VAR07 | .947 | .966 | .886 | .925 | .988 | .987 | .364 |
| | VAR08 | 1.000 | .835 | .987 | .995 | .985 | .890 | .628 |
| | VAR09 | .835 | 1.000 | .738 | .803 | .915 | .982 | .148 |
| | VAR10 | .987 | .738 | 1.000 | .988 | .947 | .815 | .714 |
| | VAR11 | .995 | .803 | .988 | 1.000 | .971 | .855 | .686 |
| | VAR12 | .985 | .915 | .947 | .971 | 1.000 | .953 | .497 |
| | VAR13 | .890 | .982 | .815 | .855 | .953 | 1.000 | .211 |
| | VAR14 | .628 | .148 | .714 | .686 | .497 | .211 | 1.000 |
| | VAR15 | .737 | .509 | .747 | .792 | .693 | .544 | .717 |
| | VAR16 | .988 | .879 | .956 | .987 | .988 | .906 | .598 |
| | VAR17 | .827 | .540 | .854 | .869 | .771 | .611 | .762 |
| | VAR18 | .824 | .639 | .824 | .859 | .800 | .694 | .625 |
| | VAR19 | .893 | .505 | .952 | .909 | .809 | .616 | .835 |
| | VAR20 | .980 | .718 | .995 | .990 | .935 | .791 | .750 |
| | VAR21 | .869 | .828 | .820 | .891 | .886 | .831 | .514 |
| | VAR22 | .836 | .910 | .767 | .826 | .894 | .931 | .240 |
| | VAR23 | .674 | .925 | .563 | .654 | .778 | .896 | -.024 |
| | VAR24 | .630 | .886 | .521 | .611 | .735 | .862 | -.063 |
| | VAR25 | .679 | .901 | .579 | .659 | .777 | .891 | -.015 |
| | VAR26 | .990 | .795 | .988 | .979 | .966 | .859 | .641 |
| | VAR27 | .988 | .879 | .956 | .987 | .988 | .906 | .598 |
| | VAR28 | .957 | .712 | .963 | .967 | .911 | .752 | .781 |
| | VAR29 | .944 | .620 | .977 | .956 | .876 | .693 | .831 |
| | VAR30 | .911 | .563 | .951 | .928 | .833 | .631 | .870 |
| | VAR31 | .889 | .524 | .932 | .923 | .806 | .590 | .912 |
| | VAR32 | .762 | .334 | .826 | .812 | .652 | .393 | .981 |
| | VAR33 | .969 | .683 | .989 | .979 | .914 | .750 | .794 |
| | VAR34 | .903 | .565 | .938 | .924 | .827 | .621 | .879 |
| | VAR35 | .908 | .987 | .832 | .884 | .966 | .993 | .278 |
| | VAR36 | .768 | .315 | .847 | .813 | .656 | .411 | .943 |
| | VAR37 | .530 | .086 | .620 | .595 | .416 | .185 | .832 |

**Correlation Matrix[a,b]**

| | | VAR15 | VAR16 | VAR17 | VAR18 | VAR19 | VAR20 | VAR21 |
|---|---|---|---|---|---|---|---|---|
| Correlation | VAR01 | .484 | .872 | .536 | .634 | .527 | .726 | .804 |
| | VAR02 | .527 | .845 | .561 | .674 | .492 | .698 | .833 |
| | VAR03 | .540 | .926 | .602 | .675 | .620 | .802 | .833 |
| | VAR04 | .731 | .983 | .824 | .834 | .878 | .971 | .876 |
| | VAR05 | .616 | .875 | .650 | .755 | .564 | .754 | .882 |
| | VAR06 | .524 | .890 | .577 | .670 | .563 | .755 | .828 |
| | VAR07 | .634 | .963 | .699 | .757 | .710 | .870 | .880 |
| | VAR08 | .737 | .988 | .827 | .824 | .893 | .980 | .869 |
| | VAR09 | .509 | .879 | .540 | .639 | .505 | .718 | .828 |
| | VAR10 | .747 | .956 | .854 | .824 | .952 | .995 | .820 |
| | VAR11 | .792 | .987 | .869 | .859 | .909 | .990 | .891 |
| | VAR12 | .693 | .988 | .771 | .800 | .809 | .935 | .886 |
| | VAR13 | .544 | .906 | .611 | .694 | .616 | .791 | .831 |
| | VAR14 | .717 | .598 | .762 | .625 | .835 | .750 | .514 |
| | VAR15 | 1.000 | .753 | .973 | .970 | .764 | .810 | .900 |
| | VAR16 | .753 | 1.000 | .812 | .825 | .833 | .954 | .910 |
| | VAR17 | .973 | .812 | 1.000 | .980 | .884 | .901 | .884 |
| | VAR18 | .970 | .825 | .980 | 1.000 | .810 | .870 | .938 |
| | VAR19 | .764 | .833 | .884 | .810 | 1.000 | .959 | .706 |
| | VAR20 | .810 | .954 | .901 | .870 | .959 | 1.000 | .854 |
| | VAR21 | .900 | .910 | .884 | .938 | .706 | .854 | 1.000 |
| | VAR22 | .737 | .860 | .758 | .857 | .612 | .777 | .930 |
| | VAR23 | .559 | .734 | .536 | .680 | .339 | .567 | .838 |
| | VAR24 | .560 | .686 | .534 | .684 | .311 | .530 | .820 |
| | VAR25 | .586 | .725 | .576 | .718 | .378 | .585 | .839 |
| | VAR26 | .656 | .965 | .770 | .750 | .904 | .969 | .790 |
| | VAR27 | .753 | 1.000 | .812 | .825 | .833 | .954 | .910 |
| | VAR28 | .716 | .952 | .794 | .746 | .899 | .960 | .795 |
| | VAR29 | .725 | .911 | .829 | .761 | .964 | .975 | .746 |
| | VAR30 | .705 | .880 | .804 | .721 | .951 | .951 | .705 |
| | VAR31 | .836 | .866 | .903 | .826 | .957 | .954 | .776 |
| | VAR32 | .796 | .740 | .844 | .735 | .900 | .859 | .658 |
| | VAR33 | .753 | .944 | .849 | .799 | .956 | .989 | .798 |
| | VAR34 | .714 | .882 | .799 | .717 | .931 | .941 | .715 |
| | VAR35 | .609 | .936 | .658 | .735 | .635 | .817 | .880 |
| | VAR36 | .835 | .720 | .908 | .808 | .951 | .880 | .666 |
| | VAR37 | .860 | .483 | .884 | .801 | .787 | .683 | .578 |

**Correlation Matrix[a,b]**

| | | VAR22 | VAR23 | VAR24 | VAR25 | VAR26 | VAR27 | VAR28 |
|---|---|---|---|---|---|---|---|---|
| Correlation | VAR01 | .914 | .915 | .879 | .900 | .809 | .872 | .703 |
| | VAR02 | .949 | .959 | .935 | .951 | .759 | .845 | .649 |
| | VAR03 | .904 | .873 | .829 | .857 | .877 | .926 | .793 |
| | VAR04 | .869 | .713 | .675 | .724 | .982 | .983 | .931 |
| | VAR05 | .978 | .958 | .939 | .958 | .789 | .875 | .686 |
| | VAR06 | .929 | .916 | .881 | .904 | .828 | .890 | .726 |
| | VAR07 | .924 | .854 | .813 | .846 | .919 | .963 | .846 |
| | VAR08 | .836 | .674 | .630 | .679 | .990 | .988 | .957 |
| | VAR09 | .910 | .925 | .886 | .901 | .795 | .879 | .712 |
| | VAR10 | .767 | .563 | .521 | .579 | .988 | .956 | .963 |
| | VAR11 | .826 | .654 | .611 | .659 | .979 | .987 | .967 |
| | VAR12 | .894 | .778 | .735 | .777 | .966 | .988 | .911 |
| | VAR13 | .931 | .896 | .862 | .891 | .859 | .906 | .752 |
| | VAR14 | .240 | -.024 | -.063 | -.015 | .641 | .598 | .781 |
| | VAR15 | .737 | .559 | .560 | .586 | .656 | .753 | .716 |
| | VAR16 | .860 | .734 | .686 | .725 | .965 | 1.000 | .952 |
| | VAR17 | .758 | .536 | .534 | .576 | .770 | .812 | .794 |
| | VAR18 | .857 | .680 | .684 | .718 | .750 | .825 | .746 |
| | VAR19 | .612 | .339 | .311 | .378 | .904 | .833 | .899 |
| | VAR20 | .777 | .567 | .530 | .585 | .969 | .954 | .960 |
| | VAR21 | .930 | .838 | .820 | .839 | .790 | .910 | .795 |
| | VAR22 | 1.000 | .946 | .942 | .963 | .762 | .860 | .670 |
| | VAR23 | .946 | 1.000 | .995 | .993 | .589 | .734 | .493 |
| | VAR24 | .942 | .995 | 1.000 | .997 | .537 | .686 | .431 |
| | VAR25 | .963 | .993 | .997 | 1.000 | .593 | .725 | .480 |
| | VAR26 | .762 | .589 | .537 | .593 | 1.000 | .965 | .964 |
| | VAR27 | .860 | .734 | .686 | .725 | .965 | 1.000 | .952 |
| | VAR28 | .670 | .493 | .431 | .480 | .964 | .952 | 1.000 |
| | VAR29 | .629 | .403 | .351 | .410 | .959 | .911 | .981 |
| | VAR30 | .559 | .330 | .273 | .332 | .933 | .880 | .977 |
| | VAR31 | .599 | .358 | .316 | .370 | .884 | .866 | .948 |
| | VAR32 | .416 | .164 | .121 | .171 | .764 | .740 | .878 |
| | VAR33 | .696 | .485 | .435 | .491 | .974 | .944 | .986 |
| | VAR34 | .551 | .332 | .273 | .327 | .921 | .882 | .981 |
| | VAR35 | .940 | .902 | .865 | .890 | .870 | .936 | .792 |
| | VAR36 | .478 | .192 | .170 | .228 | .765 | .720 | .829 |
| | VAR37 | .387 | .109 | .126 | .170 | .491 | .483 | .560 |

**Correlation Matrix[a,b]**

| | | VAR29 | VAR30 | VAR31 | VAR32 | VAR33 | VAR34 | VAR35 |
|---|---|---|---|---|---|---|---|---|
| Correlation | VAR01 | .626 | .563 | .516 | .316 | .687 | .558 | .987 |
| | VAR02 | .572 | .503 | .482 | .278 | .641 | .498 | .978 |
| | VAR03 | .722 | .668 | .619 | .435 | .775 | .665 | .995 |
| | VAR04 | .919 | .879 | .860 | .719 | .949 | .868 | .926 |
| | VAR05 | .623 | .555 | .552 | .355 | .690 | .548 | .982 |
| | VAR06 | .654 | .591 | .551 | .354 | .714 | .585 | .993 |
| | VAR07 | .792 | .741 | .708 | .535 | .841 | .735 | .994 |
| | VAR08 | .944 | .911 | .889 | .762 | .969 | .903 | .908 |
| | VAR09 | .620 | .563 | .524 | .334 | .683 | .565 | .987 |
| | VAR10 | .977 | .951 | .932 | .826 | .989 | .938 | .832 |
| | VAR11 | .956 | .928 | .923 | .812 | .979 | .924 | .884 |
| | VAR12 | .876 | .833 | .806 | .652 | .914 | .827 | .966 |
| | VAR13 | .693 | .631 | .590 | .393 | .750 | .621 | .993 |
| | VAR14 | .831 | .870 | .912 | .981 | .794 | .879 | .278 |
| | VAR15 | .725 | .705 | .836 | .796 | .753 | .714 | .609 |
| | VAR16 | .911 | .880 | .866 | .740 | .944 | .882 | .936 |
| | VAR17 | .829 | .804 | .903 | .844 | .849 | .799 | .658 |
| | VAR18 | .761 | .721 | .826 | .735 | .799 | .717 | .735 |
| | VAR19 | .964 | .951 | .957 | .900 | .956 | .931 | .635 |
| | VAR20 | .975 | .951 | .954 | .859 | .989 | .941 | .817 |
| | VAR21 | .746 | .705 | .776 | .658 | .798 | .715 | .880 |
| | VAR22 | .629 | .559 | .599 | .416 | .696 | .551 | .940 |
| | VAR23 | .403 | .330 | .358 | .164 | .485 | .332 | .902 |
| | VAR24 | .351 | .273 | .316 | .121 | .435 | .273 | .865 |
| | VAR25 | .410 | .332 | .370 | .171 | .491 | .327 | .890 |
| | VAR26 | .959 | .933 | .884 | .764 | .974 | .921 | .870 |
| | VAR27 | .911 | .880 | .866 | .740 | .944 | .882 | .936 |
| | VAR28 | .981 | .977 | .948 | .878 | .986 | .981 | .792 |
| | VAR29 | 1.000 | .995 | .972 | .911 | .996 | .989 | .724 |
| | VAR30 | .995 | 1.000 | .975 | .935 | .984 | .997 | .668 |
| | VAR31 | .972 | .975 | 1.000 | .973 | .966 | .976 | .640 |
| | VAR32 | .911 | .935 | .973 | 1.000 | .889 | .943 | .458 |
| | VAR33 | .996 | .984 | .966 | .889 | 1.000 | .978 | .780 |
| | VAR34 | .989 | .997 | .976 | .943 | .978 | 1.000 | .665 |
| | VAR35 | .724 | .668 | .640 | .458 | .780 | .665 | 1.000 |
| | VAR36 | .899 | .906 | .962 | .967 | .881 | .899 | .457 |
| | VAR37 | .658 | .660 | .791 | .826 | .645 | .652 | .235 |

**Correlation Matrix[a,b]**

| | | VAR36 | VAR37 |
|---|---|---|---|
| Correlation | VAR01 | .318 | .088 |
| | VAR02 | .297 | .116 |
| | VAR03 | .425 | .172 |
| | VAR04 | .740 | .514 |
| | VAR05 | .388 | .229 |
| | VAR06 | .361 | .137 |
| | VAR07 | .537 | .300 |
| | VAR08 | .768 | .530 |
| | VAR09 | .315 | .086 |
| | VAR10 | .847 | .620 |
| | VAR11 | .813 | .595 |
| | VAR12 | .656 | .416 |
| | VAR13 | .411 | .185 |
| | VAR14 | .943 | .832 |
| | VAR15 | .835 | .860 |
| | VAR16 | .720 | .483 |
| | VAR17 | .908 | .884 |
| | VAR18 | .808 | .801 |
| | VAR19 | .951 | .787 |
| | VAR20 | .880 | .683 |
| | VAR21 | .666 | .578 |
| | VAR22 | .478 | .387 |
| | VAR23 | .192 | .109 |
| | VAR24 | .170 | .126 |
| | VAR25 | .228 | .170 |
| | VAR26 | .765 | .491 |
| | VAR27 | .720 | .483 |
| | VAR28 | .829 | .560 |
| | VAR29 | .899 | .658 |
| | VAR30 | .906 | .660 |
| | VAR31 | .962 | .791 |
| | VAR32 | .967 | .826 |
| | VAR33 | .881 | .645 |
| | VAR34 | .899 | .652 |
| | VAR35 | .457 | .235 |
| | VAR36 | 1.000 | .913 |
| | VAR37 | .913 | 1.000 |

a. Determinant = .000

b. This matrix is not positive definite.