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Barriers to adoption of open-source ERPs in parastatals in Kenya; Case of energy sector

BY

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DECLARATION

I declare that this is my original work and has not been presented for a degree in any other University.

Signature: ⎰⎱ Date: 13/09/2021

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P54/33357/2019

This research project has been submitted for examination with my approval as the University Supervisor

Signature: _____ Date: __13/09/2021_____

Prof Robert Oboko

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ABSTRACT

Enterprise Resource Planning (ERP) Systems are not being fully utilized by Kenyan parastatals in the energy sector and other industries. While the expenses of implementing an ERP system have always been a concern for many businesses, Open-Source ERP systems are now accessible, providing the benefits of an ERP system at a lower cost. The main objective of this study is to identify the barriers to adoption of open-source ERPs in parastatals in the energy sector in Kenya. The study used qualitative research methodology. Data collection was done through content analysis, open-ended questions shared through online questionnaires and follow up through one-on-one interviews where responses were deemed unclear or incomplete. Using Technology–organization–environment (TOE) framework this study found that lack of skilled personnel, lack of management support, privacy and security, reliability and uncertainty and lack of organizational awareness are the barriers to adoption to open-source ERP systems in energy sector parastatals in Kenya. Therefore, from the results only technology and organizational factors hinder adoption of open-source ERPs in energy sector in Kenya. No environmental factor was identified to be hindering adoption of open-source ERPs in energy sector parastatals in Kenya. Open-source ERP vendors and OSS vendors in general can use this study as a starting point to find solutions to these barriers of adoption and enable energy sector parastatals in Kenya which are a strong pillar in Kenyan economy, adopt open-source ERPs and reduce their cost of operation. This research was however done only in energy parastatals in Kenya. It can be extended to other parastatals and private organizations in Kenya to enable them benefit from adoption of low cost open-source ERPs.

Keywords: Barriers to adoption, ERP, open-source software, Parastatals in Kenya

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LIST OF ABBREVIATIONS

OSS: Open-source Software

ERP: Enterprise Resource Planning

IDT: Innovation diffusion theory

TOE: Technology Organization Environment

TAM: Technology Acceptance Model

UTAUT: Unified Theory of acceptance and use of Technology

SME: Small and medium-sized enterprises.

OWASP: Open Web Application Security Project

DEFINITION OF KEY TERMS

Open-source software - is software that is distributed with its source code, making it available for use, modification, and distribution with its original rights.

Enterprise resource planning - is the integrated management of main business processes, often in real time and mediated by software and technology.

Adoption - Refers to the acceptance, integration, and use.

Energy sector - The energy industry is the totality of all the industries involved in the production and sale of energy, including fuel extraction, manufacturing, refining and distribution.

CHAPTER ONE: INTRODUCTION

1.1 Background

Many businesses see OSS as a quite feasible alternative to proprietary solutions. According to a recent Gartner poll, the percentage of proprietary solutions in companies' portfolios of software has been progressively decreasing with time, and most businesses now rely virtually entirely on open technology (Gartner, 2011; Ruscio & Pelliccione, 2014; Wurster, 2011).

Different organizations in different parts of the world are in different stages of adopting open-source software.

Proprietary ERPs cost a lot of money. From Oracle's official website, Global Price for Oracle Suite of Applications shows that license fees are billed by Oracle for each module. Even though KPLC uses SAP, SAP has not published their price list in their website, therefore the following analysis uses Oracle E-Business suite HR module to paint the picture on how expensive these proprietary ERPs are.

Oracle E-Business suite has 21 modules. This analysis uses or is based on the following modules: payroll (USD 225), Performance management (USD 105), Time and labor (USD 110). The total becomes USD 440. Given KPLC has about 7000 employees who would be using these modules; the total license fee becomes USD 3,080,000. This figure increases with the increase in the number of modules the company implements and the number of application users/processors/computers/expense report/employees depending on the licensing terms.

The analysis shows how expensive the proprietary fees are. However, based on cost analysis we can conclude that if they adopt open-source ERPs, they can be able to save a lot of money. The savings would be beneficial to Kenya govt parastatals which are already struggling when it comes to financial performance.

Kenya Government parastatals struggle when it comes to financial performance. Some of them like Kenya Power and Lighting Company (KPLC) and Kenya Airways (KQ) have been reporting

losses or a drop in profit in the recent past. Kenya Power announced its audited figures for the financial year ended June 30, 2019, according to The Star on 7th Sept 2020, confirming a 91.9 percent reduction in profit. According to Standard Media on 23rd March 2021, Kenya Airways, on the other hand, lost Sh36.6 billion after taxes in the fiscal year that ended in December 2020, compared to Sh12.9 billion in the previous year.

With this kind of poor performance, there is a need to reduce the operation cost. By use of open-source ERPs would be a good avenue for government parastatals to reduce their IT operation cost which in return would reduce the total company operation cost and have a positive effect on the company's net profit.

However, Kenyan government parastatals are known to be using proprietary ERPs which prove to be expensive as shown by the cost analysis. Just to sample a few, KQ implemented Oracle E-Business suite, KPLC, KETRACO, KRA and Kenya Pipeline Company implemented and use SAP. SAP and Oracle E-Business suite are both proprietary ERP solutions as reported by their official websites.

This research tries to establish why government parastatals opted for proprietary ERPs instead of using open source which would help save on money.

1.2 Open-Source Software

Open-source software (OSS) is a type of software in which the source code is made publicly available under a license that permits anybody to study, change, use and distribute the software for any purpose. Open-source software can be developed in a collaborative, public setting. Open-source software is widely used (Open-source software, 2021).

1.3 Enterprise Resource Planning

Enterprise resource planning (ERP) is enterprise resource planning, which is the integrated management of important business processes, always done in real time and mediated by technology/software. It is a business management software which is a group of integrated applications which allows an organization to gather, understand, manage, and store data from a variety of business processes (Enterprise resource planning, 2021).

There are open source and proprietary ERPs available in the market. It is upon different organizations to decide which option they would like to take. Below are a list of open-source and proprietary ERP solutions available in the market currently.

Open-source ERPs available for implementation by organizations include, Adempiere, Apache OFBiz, Dolibarr, ERPNext, OpenBravo and Odoo. On the other side, popular proprietary ERPs available in the market include Oracle Fusion, SAP, Microsoft Dynamics, and Sage ERP.

1.4 Problem statement

In the software industry open innovation in the form of OSS has been a very disruptive force (Fougatsaro, 2009). The rise of open source has given rise to new approaches for businesses to develop, distribute, and utilize software.

Several organizations in developing countries, however, still depend on proprietary software with high licensing fees which increases their operation costs, and in the end contribute to financial loss (Josiline Phiri, 2018). However, there is an option to use open-source ERPs to reduce this operation cost. This research tries to establish why organizations, specifically energy sector parastatals in Kenya opted for proprietary ERPs instead of using open-source ERPs (Josiline Phiri, 2018) and reduce their IT operations cost.

There is sufficient literature on barriers of open-source software adoption in general. (Petrov, 2018) found that there are organizational, environmental, technological, and individual factors that slow down adoption of open-source software. Factors identified include lack of open-source vendors, privacy and security, lack of management support, vendor lock-in and lack of awareness by people and organizations among many other. There is limited research on barriers to adoption of open-source ERPs (Mwikya, 2019). These studies have been carried out in other countries. However, limited similar study has been carried out in Kenya.

Energy sector parastatals are critical to the country's economy since they support many sectors of the economy including but not limited to transport, health, security, manufacturing, technology, food industry etc. From the background information, all energy sector parastatals use proprietary ERPs, specifically SAP which is quite expensive.

Energy sector parastatals are currently on a downward trend in terms of profit while they spend more money on proprietary ERPs. If they continue spending money while making losses, they may end up going down and shutting down the economy. This makes it worth investigating why energy sector parastatals have not been able to use open-source ERPs to reduce the cost of their IT operations.

So far, there is no study that has been carried out to find out why energy sector parastatals in Kenya have not adopted open-source ERPs. Study on open-source ERP adoption has been carried out in South Africa (Tome, Johnston, Meadows, & Nyemba-Mudenda, 2014) but this may not fully explain adoption barriers in Kenya since the two countries have different political environments and at the same time have different market conditions.

Study (Mwikya, 2019) has been carried out on open-source ERP in the private sector in Kenya, but these barriers may not fully explain the adoption barriers in the public sector since the public and private sector have different business goals and are controlled by different forces.

There is a need to establish why government parastatals in the energy sector have opted for proprietary ERPs instead of using open-source ERPs which would help them save on money. This study sets out to investigate why energy sector parastatals shied away from using open-source ERPs to reduce their IT operations cost given the low cost of open-source ERPs.

1.5 Research question

Why are energy sector parastatals which are a critical sector of the economy using expensive proprietary ERPs while their yearly profits continue to dip and yet there are free open-source ERPs which could help improve their financial position?

1.6 Research objectives

1.6.1 Main Objective

Identify the barriers to adoption of open-source ERPs in parastatals in the energy sector in Kenya.

1.6.2 Specific objectives

i. To identify technological barriers to adoption of open-source ERPs in energy sector parastatals in Kenya.

ii. To identify organizational barriers to adoption of open-source ERPs in energy sector parastatals in Kenya.

iii. To identify environmental barriers to adoption of open-source ERPs in energy sector parastatals in Kenya.

iv. To evaluate the theoretical underpinning and model for use in studying the barriers to adoption of open-source ERPs in the Energy sector parastatals.

v. To identify barriers and concerns related to the uptake of open-source ERPs in energy sector parastatals guided by the proposed model.

1.7 Significance of the study

In the software industry and beyond, open innovation in the form of open-source software (OSS) has been a game-changer. Open source's expansion has given rise to new approaches for businesses to develop, distribute, and deploy software. However, parastatals in Kenya still struggle with reduction of IT operations cost. The use of open-source software could be one of the ways to reduce this cost.

Despite the rapid rise of open-source research and hurdles to open-source software adoption, there is no literature concentrating on the challenges of open-source ERP adoption in Kenya's parastatals.

The results on barriers of adoption of open-source ERP in energy sector parastatals in Kenya can be used by these parastatals to develop strategies on how to handle these barriers in order to implement and use open-source ERPs and consequently reduce their operation cost.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction to use of open-source ERPs

There exists open-source ERPs that can be used in various organizations, both small, medium, and large (Fougatsaro, 2009). Using open-source ERPs instead of proprietary ERPs means an organization doesn't have to pay for software license fees which in most cases are very high. However, other costs of using open-source ERPs may be involved. These costs include implementation and maintenance which requires skilled personnel and other technology infrastructure which include storage and servers.

2.2 Open-source vs Proprietary software.

Both open-source and proprietary software have merits and demerits. (Optimus Information Inc, 2015) Open-source software is divided into two categories in this paper: community OSS and commercial OSS. Community open source is created and maintained without charge by a distributed community of developers, whereas commercial open-source software is protected by patents, trademarks, and copyright.

2.3 Benefits and limitations of open-source software

2.3.1 Benefits of OSS

Open-source software is free to try before you use it. To try open-source software, you only need to download and install according to the instructions given in the public documentation. They have free support. Open-source software has an online community who answer questions and provide fixes free of charge. The advantages of using open-source software include they adopt Open Standards, bug fixes happens faster hence few bugs, little chance of vendor lock-in and are more secure (Optimus Information Inc, 2015).

2.3.2 limitations of OSS

Using OSS leads to reduced competitive advantage. Use of OSS means a competitor can also easily get the solution and implement, therefore losing competitive advantage that may be achieved with this solution.

Organizations using open-source software end up having minimal support leverage. In addition, open-source projects are software packages that are not closely aimed at unskilled users (Optimus Information Inc, 2015). Unskilled users may not open-source code to find out how a certain feature works which in most cases open-source solutions assume. This reduces usability of these products.

Using open-source software may mean increased business risk. Large and financially strong open-source vendors are few. This means for open solutions it may be difficult to get support when you need it the most. Posing a significant business risk.

2.4 Benefits and limitations of proprietary software

2.4.1 Benefits of proprietary software.

Proprietary solutions are focused on a smaller scope of features but are more focused on ease of use and functionality resulting in a better usability experience. Proprietary products are designed to nurture a long successful future exhibiting stability than in open-source solutions. A company may pay a bigger fee to acquire proprietary solutions but get full ownership of the software and the vendor may commit to provide bug fixes and documentations of new versions (Optimus Information Inc, 2015) Proprietary software vendors provide their customers with well-defined long running customer support.

2.4.2 Limitations of proprietary software.

Customers of proprietary software have less influence on the product design unless they are their biggest customer. Once the software is entrenched into the organization it becomes an uphill task to replace with a different software solution. This makes the organization heavily dependent on the specific vendor or software. Proprietary software internals and source codes are closed from viewing and modifications. This means customers may not be able to customize the software to their needs by themselves without involving the software vendor (Optimus Information Inc, 2015).

2.5 ERP Systems

ERP systems have numerous benefits to both large and small organizations (Sadrzadehrafiei, Chofreh, Hosseini, & Sulaiman, 2013). This pushes every organization to desire to implement ERP systems to gain competitive advantage. However, because of the availability of a large variety of ERPs to select from, many organizations are faced with the challenge of deciding which way to go, open-source or proprietary ERPs and which specific ERP solution to go with.

2.5.1 Benefits of ERP Systems

An organization can gain ERP benefits in every aspect of corporate relationships by deploying ERP technology. Every internal company relationship, for example, can improve the accuracy, speed, quality, and availability of information. Furthermore, suppliers and consumers can improve their interactions with the company. Furthermore, these advantages are divided into three levels: in every internal and external corporate partnership, there are strategic, tactical, and operational benefits. The strategic benefit is defined as the long-term benefits that a firm can derive from ERP deployment. Tactical benefits are those that support the execution of strategic planning throughout all levels of a company**.** Operational benefits are those that are realized on day-to-day operations of the company**.**

2.6 Suitability of Open-Source ERPs to Large organizations.

A study carried out at Blekinge Institute of Technology, School of Management (Fougatsaro, 2009) on open-source ERP solutions analyzed suitability of the open-source ERP systems to large organizations. Since Kenyan parastatals fall under a large organization category, the result of this study is useful in evaluating suitability of open-source ERPs to these parastatals.

 Large organizations are keen on flexibility of the ERP and the improvements it brings to the organization. They may consider if the software is widely used on a global scale before implementing it. They are keen on the stability of ERP providers, their history, and their market position.

These businesses prioritize ERP package upgradeability and enhancements, as well as product and functionality stability and better innovation capabilities. Large organizations prefer short

implementation time. In addition, they require good support during and after implementation and integration to other systems that may be available in the organization. Large organizations may use ERP on a larger scale, and this may tend to be dynamic and therefore the scalability aspect of the ERP is key (Paré, Delannoy, & Wybo, 2008).

The study evaluated nine open-source ERPs which includes − OpenERP, OpenBravo, ERP5, Opentaps, Compiere, Adempiere, WebERP, BlueERP and GNU Enterprise. Out of these, only OpenERP, OpenBravo and Adempiere proved to have competitive offerings. From the results OpenBravo, OpenERP and Adempiere were found to be suitable for large organizations.

The open-source ERPs were found to be suitable because they support multi-currency and multiple languages which makes it easy to localize. They were found to have a long history having been in existence for more than 15 years hence high stability. All functionalities required by large organizations were found to be available in the three open-source ERPs (Fougatsaro, 2009). Other open-source ERP solutions were found to be unsuitable because they are difficult to localize and have missing features like customization for local tax and accounting systems (Fougatsaro, 2009).

2.7 Use of open-source ERPs in energy sector in Kenya

Energy sector parastatals in Kenya, just like most government parastatals are large organizations with many departments or divisions with complex processes which need software systems to manage. ERP systems are a good choice for the parastatals to manage their processes in human resource finance, marketing, sales procurement, and many others (Fougatsaro, 2009).

These parastatals just like parastatals in other African countries (Tome, Johnston, Meadows, & Nyemba-Mudenda, 2014) have implemented ERP systems. Even with the available option of open-source ERPs, the parastatals have implemented proprietary ERPs which include SAP, Oracle business suite and Microsoft dynamics (Josiline Phiri, 2018).

2.8 Use of open-source ERPs in energy sector in Kenya

One of the benefits of using open-source ERPs in state agency like energy sector parastatals is that they have autonomy of altering and customizing it the way the way they want (Muchiri &

Godana, 2021). They can use it in multiple organizations across energy sector without incurring additional costs. Energy sector parastatals in Kenya are known to be using proprietary ERPs, specifically SAP ERP and Oracle business suite (Josiline Phiri, 2018). Therefore, this sector has missed out on the benefits provided by open-source ERPs in terms of cost and flexibility even they continue to struggle financially.

2.9 Barrier to adoption of OSS.

In 2018, research carried out at the School of Business and Economics Universität Erlangen-Nürnberg, Germany, identified barriers to adoption of open-source software (Petrov, 2018). The research used the TOEI framework of adoption (Technology–organization–environment framework, 2021) to categorize these barriers as shown in Fig 2.1.
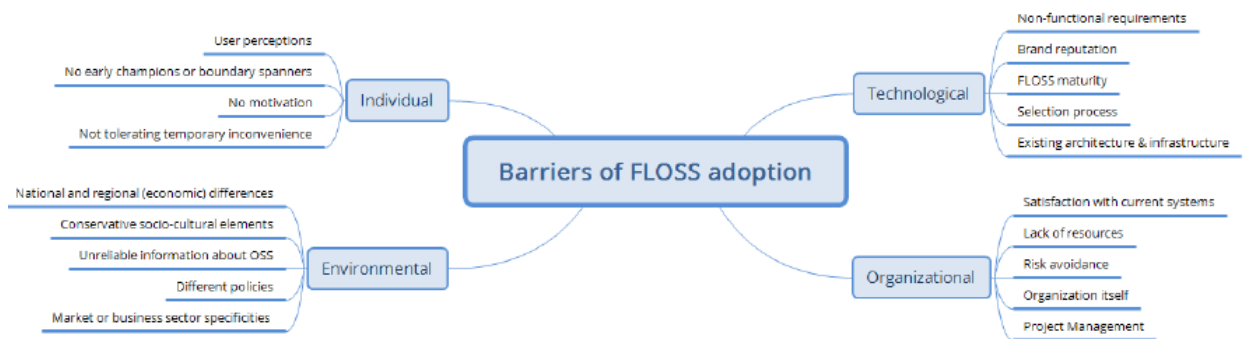
Figure 2. 1 Barriers to adoption.

The TOEI framework is organized around the Technological, Organizational, and environmental factors and therefore the barriers that were discovered are therefore organized in this manner. Technological factors slowing down adoption of open-source ERPs include Vendor lock-in, Security and privacy concerns , reliability and uncertainty issues, open-source project's reputation, low maturity and quality of open-source software, software availability and discovery issues, ostensibly chaotic release, and ownership issues (Petrov, 2018).

Important organizational barriers reported include lack of human and financial resources, unavailability of qualified open-source specialists and unavailability of open-source vendors, inadequate OSS support among vendors, satisfaction with current systems, small organizations may have inadequate qualified personnel, a lack of managerial support, a lack of awareness of

alternative solutions, and satisfaction with existing systems. Small organizations may lack a fully equipped IT department and skilled employees, lack of support by management, limited awareness of alternatives (Open-source software, 2021).

Important environmental challenges have been different policies, pressure from politicians and the public, business regulations, firm's market conditions, Type of industry, Unreliable, or otherwise unclear information about OSS projects and the lack of commercial vendors (Paré, Delannoy, & Wybo, 2008).

Individual factors affecting adoption of open-source ERPs include end-user ease of use and perceived usefulness, lack of the role of champions or sponsors, lack of individual awareness of alternatives to proprietary software and challenge in overcoming temporary inconvenience for employees (Josiline Phiri, 2018).

2.10 Theoretical Framework

2.10.1 Adoption Theories

This study focuses on adoption of technology, in this case adoptions of open-source ERPs. It is, therefore, worth looking at available adoption theories that can be used in this study because they provide a good foundation for developing a theoretical framework for the study on barriers to adoption of open-source ERPs.

Adoption theories are divided into two groups. This encompasses both process- and factor-based methods. TAM2, TAM, UTAUT, TOE model, and IDT are some of the factor-based theories that have been presented to help in understanding technology adoption.

Adoption theories can further be classified into organization based and individual based. TAM2, TAM and, UTAUT focusses on individuals hence user based while TOE, Innovation IDT and institutional theory focuses on organization hence organization based.

Even though factor-based theories allow for the identification of causality as well as the classification of adoption factors, they do not explain how the unit of analysis arrived at the observed adoption level (Murphy, 2016). IDT can be used to understand at what rate open-source ERPs are being adopted in government parastatals, but this is not the focus of this research.

2.10.2   Technology-Organization-Environment Framework

Technology-Organization-Environment (TOE) framework is a framework that explains technology adoption in organizations. According to TOE adoption is influenced by the technological, organizational, and environmental context. Rather than detailed actions of individuals in the organization, TOE focuses on high level qualities (technology, organizational, and environmental factors).

Despite its widespread use, the TOE framework has had little theoretical progress since its inception. According to (Kraemer & Zhu, 2005) the lack of progress is due to the TOE framework being "too broad" and allowing for a great deal of flexibility in terms of factors and metrics, therefore there is little need to update the theory itself. Another argument is that the hypothesis "too perfectly" coincides with other technology adoption hypotheses and does not provide competing interpretations. As a result, there is virtually little pressure to change the framework (Technology–organization–environment framework, 2021).
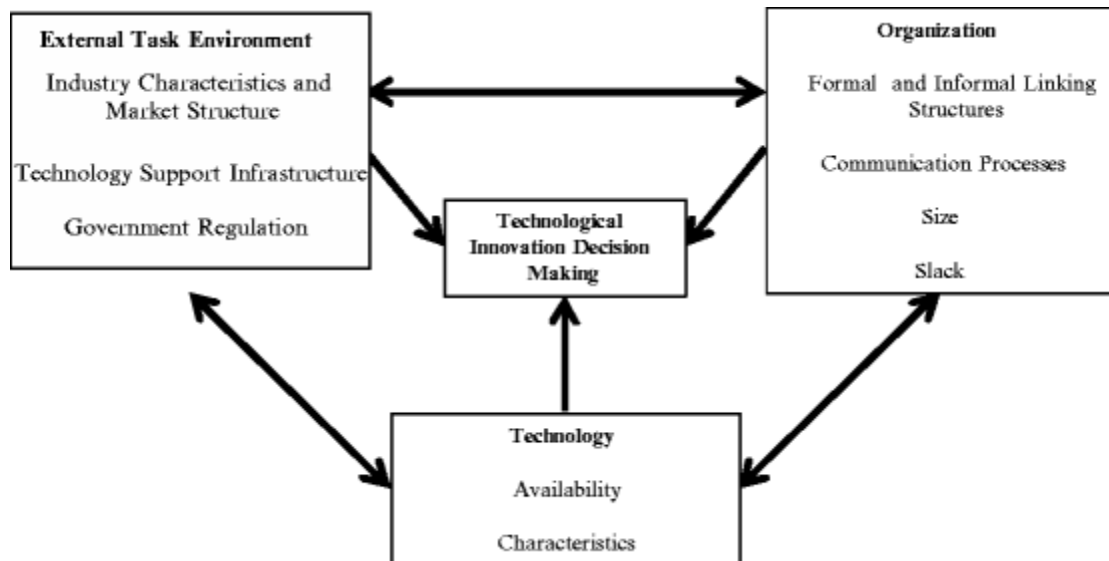

Figure 2. 2 Technology-Organization-Environment Framework

Under technology, availability, and characteristics of the technology in question is key. Availability would mean how easy it is to access the technology, in this case open-source ERPs.

The process and time used to acquire open-source ERPs would possibly influence the decision of a company to implement it. The process needs to be simple and the time to access or acquire needs to be short. Technology characteristics such as privacy and security, reliability, ease of use may also influence company decisions.

The organizational context alludes to the firm's characteristics and resources, e.g., size of the company, degree of centralization, structure of management, level of formalization, human resources, slack resources, and employee links. Formal and informal linking structures include the management structure which affects how decisions made flow within the organization. Communication processes entail how people within the organization are informed about the availability or existence of specific technology in question for adoption. Size of the firm may determine the kinds of technology to adopt. In addition, large organizations tend to have a fully-fledged IT department which makes it easier for them to adopt new technologies. Slack entails both human and financial resources which are not yet committed and can be used in adopting new technology.

Industry factors and market structures may impact a company's decision to adopt a certain technology to gain a competitive advantage. Technology support infrastructure available within and outside the organization may play a role in adoption. This may include the technology itself and people's support around the technology. Government regulations, especially in government institutions may encourage or discourage adoption of a specific technology.

2.10.3   Institutional Theory

Institutional theory attempts to show that adoption decisions go beyond rational considerations. Important for institutional theory is understanding organizations as expressions of social values and observing organizations as a distinct kind of social system guided by internal and external institutional logics. The organization's external environment is comprised of an assemblage of actors ranging from suppliers to consumers, regulatory agencies, partner organizations and

so on in a recognized institutional camp. Internally, corporate doctrines, positions, schemes, and procedures are influenced by governmental laws, public opinion, education systems or other

institutions and put in effect by managers with the intention of fostering organizational efficiency and/or legitimacy.

There are three kinds of institutional pressures that affect technology adoption: 1) mimetic; 2) coercive; and 3) normative. Institutional theory points out that organizations in the same institutional environment become more similar due to experiencing similar pressures. Specifically, the incorporation of new technologies or management practices as part of innovation, is a practice that, when legitimated, is likely imitated by others to avoid risky decisions, leading to mimetic isomorphism among organizations. Isomorphism might also emerge from regulation that requires certain levels of technology adoption or gives legitimization and possibly preferential treatment to organizations that respond to such coercive pressures and adopt certain innovations. The State is one of the largest originators of coercive pressures. The State refers to government (public sector) institutions, e.g., destination marketing organizations, government departments and agencies, and regulatory bodies. The third type of institutional pressure results from the need to legitimize the organization with respect to norms established by trade associations, educational institutions, or certification programs. Conceptual framework

Having analyzed the different adoption theories, there is a need to develop a suitable conceptual framework that will form the framework of this study on barriers to adoption of open-source ERPs.

This research does not intend to understand the rate of adoption therefore, IDT is not used. Instead, the study choses to use the TOE model to identify the barriers of adoption of open-source ERPs since this model focuses on organization and technology which is the center of focus in this research.

Because an organization's ability to adopt or reject new technology is influenced by 3 dimensions of technology, organization, and environment (TOE), TOE has been employed in this research. For several years, the Technology-Organizational-Environment (TOE) framework has been used to better understand how businesses use technology (Tome, Johnston, Meadows, & Nyemba-Mudenda, 2014). This study focusses on government organizations which makes the TOE framework the most ideal.

Although individuals influence hurdles to OSS adoption based on variables such as personal rejection, personal reluctance or fear, and insufficient skills or experience, these are not addressed in the TOE framework. Uncertainty avoidance, power distance, and individualism are all cultural factors that might affect OSS (Tome, Johnston, Meadows, & Nyemba-Mudenda, 2014). This research is however focused on organizations and not individuals and therefore elements of TAM may not be appropriate.

Both TAM and UTAUT are focused on end users alone and not on organization which may not be conclusive for this research, therefore may not be used in isolation. In addition, TAM is mostly used to predict user acceptance of new technology.

External pressures, mimetic, coercive and normative, may influence adoption decisions made by organizations. Coercive pressure is already covered in environmental factors to be considered in TOE as far as government regulations and policies are concerned. By the fact that most government parastatals in Kenya, especially energy sector parastatals are a monopoly, there is little influence as far as external pressure from other players is concerned. This, therefore, eliminates mimetic and normative external pressure to be considered in this study.

Other factors not considered in the study include *Industry characteristics and market structures* can only influence the decision of an organization whether to implement an ERP. Since open-source ERPs provide similar functionality, whichever the market adopts does not necessarily provide competitive advantage over the other. Furthermore, most energy sector parastatals in Kenya are a monopoly and therefore there is not much comparison on what is happening in the market. *Size of organization* which lacks fully equipped IT department and skilled personnel. All Kenyan government parastatals which are in the scope of this study are considered large organizations with full-fledged IT departments. Therefore, this factor cannot be considered in our research. *Availability of open-source ERPs,* as mentioned in the background, there are several open-source ERPs available. Some of them are suitable for large scale organizations like government parastatals. As for the *type of industry*, this study is focused on energy sector parastatals in Kenya. Therefore, there is no comparison between other sectors as a control case studies to provide objective results. As much as the energy sector is not inclined to IT industry

and would most likely influence adoption of open-source ERPs, this factor is not considered in this research. Most government organization IT decisions are influenced by government or management and not the public. This makes us leave the *public pressure* factor out of consideration in our research. *Satisfaction with existing systems have been left out since* this study is evaluating why energy sector parastatals in Kenya prefer proprietary ERPs as opposed to open-source. If the organizations have implemented proprietary, then the question would be why not open-source solutions. Since the researcher does not seek to consider situations where no ERP has been implemented this factor is out of scope.

2.11 Conceptual framework

In Technology-Organization-Environment conceptual framework used in this study groups challenge of open-source software adoption into 3 pillars. The pillars are technological, organizational, and environmental.

Several factors have been identified under technological, organizational, and environmental factors that affect adoption of OSS. These factors are important in building the conceptual framework for this study and help highlight some of the potential barriers to adoption of open-source ERPs in energy sector parastatals in Kenya.

The figure 2.3 below is a conceptual framework that illustrates how different variables play a role in influencing success in adoption of open-source software.
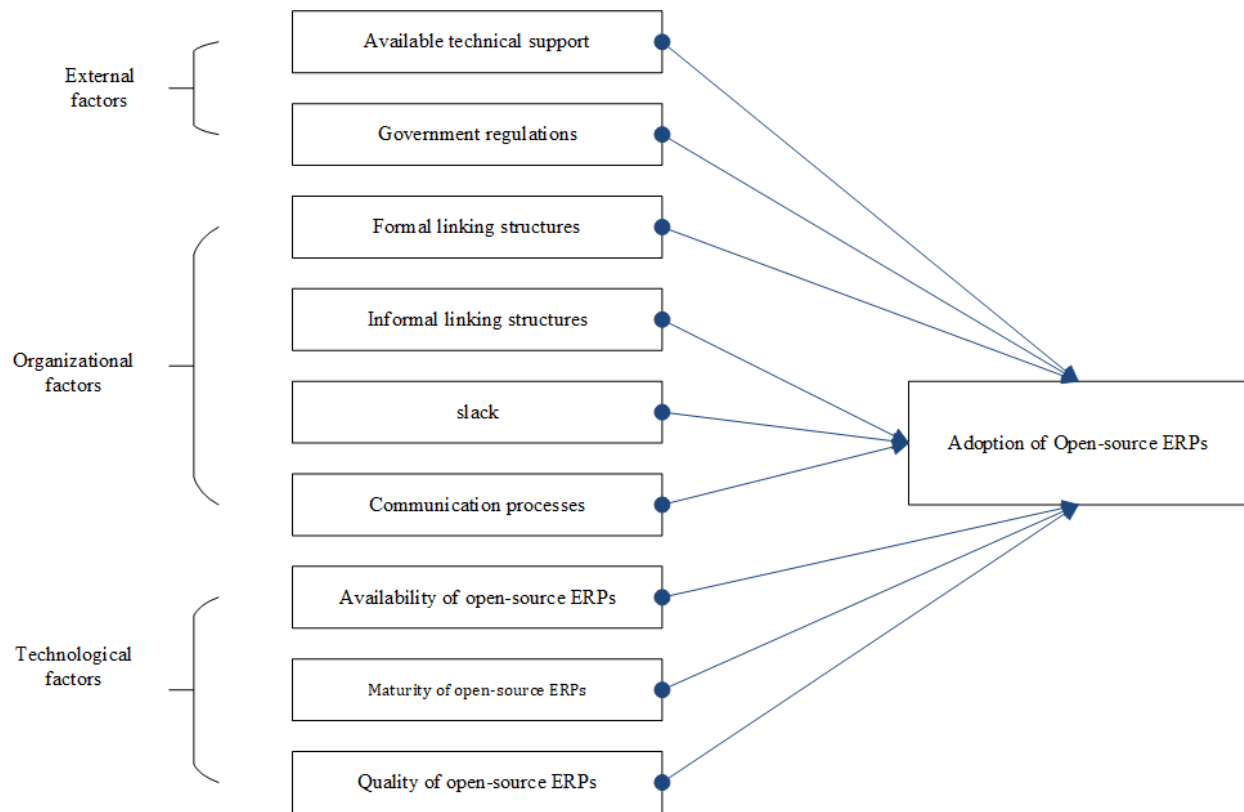
Figure 2. 3 Conceptual Framework

Under each pillar there are a number of factors that need to be investigated to find out if they are barriers to adoption of open-source ERPs in energy sector parastatals in Kenya.

H1 – **Low maturity of open-source ERPs** contributes to low adoption in energy sector parastatals in Kenya. This is in terms of reliability and certainty, privacy and security, vendor lock-in when the solution does not integrate with many other solutions in the market and solution localized in local languages, in this case English which is an official language in Kenya.

H2 – **Low quality of open-source ERPs** contributes to low adoption in energy sector parastatals in Kenya.

H3 - **Unavailability of open-source ERPs** leads to low adoption in energy sector parastatals in Kenya. If an open-source solution cannot be easily discovered, meaning it is not easily available then it can't be adopted by organizations.

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H4 - **Lack of financial and human resource (slack)** to cover switching costs for parastatals with proprietary ERPs or skilled personnel for new implementations contributes to low adoption of open-source ERPs in energy sector parastatals in Kenya. Open-source ERP implementation and maintenance is human resource intensive due to customization required. With availability of source code for their modification, organizations without enough financial and human resources may be disadvantaged in adopting open-source ERPs.

H5 - **Lack of support by top management (formal linking structures)** is a contributing factor to low adoption of open-source ERPs in energy sector parastatals in Kenya. This could be through a champion or sponsor from the top management. Top management which may include managing director, board of management and division heads in government parastatals have a lot of influence on the direction the company needs to take. Without their support, implementation of open-source ERPs may be derailed.

H6 - **Government regulations** unfavorable for implementation of open-source ERPs in energy sector parastatals in Kenya slows down adoption. Parastatals are owned by governments. Therefore, any government policy discouraging use of open-source ERPs/OSS may impact negatively on adoption of open-source ERPs.

H7 - **Lack of people and organizational awareness (communication processes)** of available open-source ERP solutions in energy sector parastatals in Kenya is a contributing factor to low adoption. The managers making decisions might not be aware of available open-source ERP solutions.

H8 – **Lack of open-source ERP vendor support** discourages energy sector parastatals in Kenya from adopting open-source ERPs. Organizations rely on vendors to provide technical support during implementation and whenever they have issues with their systems. Lack of these vendors in the market to support open-source ERPs may discourage these organizations from adopting them.

CHAPTER THREE: METHODOLOGY

3.1 Research design

There are two types of research methodologies, qualitative and quantitative research methodology.

Qualitative research involves collecting and analyzing non-numerical data e.g., video, audio, or text to understand concepts. It is oriented towards user experience and perspective. Qualitative research requires in-depth, subjective and context. While quantitative research emphasizes objective measurements and the statistical, mathematical, or numerical analysis of data collected. Qualitative research just like quantitative study is subjective rather than objective as is the case with a quantitative study.

This research used qualitative methodology because barriers of adoption of open-source ERPs in energy sector parastatals in Kenya are not yet known and this study attempts to find these barriers. These barriers will be identified by gathering in-depth users' perspectives. Therefore, the study intends to develop a theory why government parastatals in the energy sector are not adopting open-source ERPs and instead use proprietary ERPs which are expensive. A theory is a system of ideas intended to explain something.

In addition to developing a theory the research requires in-depth, subjective and context reasoning of the parastatals using proprietary ERPs and has a small sample size owing to the small number of energy sector parastatals. Therefore, *qualitative methodology* is the most suitable research methodology and is used in this study which involves collecting and analyzing non-numerical data.

Research design is the framework of research methods and techniques used in the study. There are five types of qualitative research designs or ways to design qualitative research which includes ethnography, narrative, phenomenological, grounded theory and case study. Phenomenological studies examine human experiences through the descriptions provided by the people involved. Ethnographic studies involve the collection and analysis of data about cultural groups. Grounded theory studies are studies in which data are collected and analyzed and then a

theory is developed that is grounded in the data. Case study is used to describe in-depth the experience of one person, family, group, community, or institution.

This research seeks to gain tangible, contextual, in-depth knowledge about a barrier of adoption of open-source ERPs by studying only the energy sector parastatals. Hence the research is designed as a case study of energy sector parastatals in Kenya. A case study could also look into a specific organization(s), such as hospice care for the terminally ill.

Qualitative technique is utilized due to the limited sample size and nature of the study. It entails gathering and analyzing non-numeric data to form a detailed understanding of a subject to develop new theories.

3.2 Data to be collected

In this study, data collected include responses from IT managers from different organizations giving their perspective on why they decided to adopt proprietary ERPs instead of open-source ERPs. In addition to this, information on government of Kenya policies around open-source software and specifically open-source ERPs needed to be collected. Information on technical aspect of these open-source ERPs also needed to be collected.

3.3 Data collection methods

In case study research, the methods of data collection that can be used include interviews, documents, reports, and observations. In this case study research both documents and open-ended questionnaires have been used to collect data since the documents are readily available and energy sector parastatals are also accessible for interviews.

Reports and observations which are also methods of data collection in case study research are not applicable in this case due to time and the availability of reports and are not used.

For population based, data collection happened through online questionnaires with open and closed-ended questions. One-on-one interviews, which is the most appropriate method, was not achievable due to current Covid-19 situations and social distance guidelines put in place by energy sector parastatals in Kenya. Interview questions were sent through online google form

which was preferred than interviews by most respondents since it takes a short time to respond and is flexible since the respondents can fill it anywhere anytime when they are free. The managers were also hesitant to allow one on one interviews during this pandemic period.

For document based, online research was carried out by analyzing official policy documents, websites, code repositories and other technical product artifacts.

3.4 Data collection instruments

In this study an online questionnaire was developed to collect responses from IT managers in energy sector parastatals in Kenya. There was also use of the internet to search for policy documents and open-source ERPs technical artifacts.

3.5 Study Population

This study is focused on energy sector parastatals in Kenya. Therefore, information was gathered from all energy sector parastatals in Kenya. These energy sector parastatals include KPLC, KENGEN, KPC, KETRACO and GDC.

3.6 Sampling Technique

All energy sector parastatals were included in this study therefore no sampling was done from the organization level.

Purposive sampling was utilized to sample the respondents within each organization. Purposive sampling is a type of sampling where researchers use their own judgement to decide on the people to respond to the survey.

This research targeted the office General manager in IT and head of ERP system. In each organization, the aim was to collect responses from at least 2 people under these two offices. In the case where data collected are not deemed sufficient using the data saturation model, more responses are sorted out from various managers and team leads in the IT department until saturation is realized.

The targeted interviewees/respondents for the research were *managers in the IT department* who are deemed to have decision making powers and have an overall view of the organization. In each organization, response from *ERP systems manager* was required since it is the core of this research. Responses from other IT managers were also gathered to ensure data validity through *data triangulation*.

There are no clear guidelines on how to determine sample sizes in case study research. .Hence the sample equals the total population. However, the number of respondents in each organization needed to be defined. Qualitative research predominantly uses data saturation models to determine sample sizes.

In this study data *saturation* model was used to decide on sample size of respondents in each organization which is the degree in which data is repeating itself. Data saturation is when no new information is discovered in data analysis, and this shows data collection should stop. Saturation means that a researcher can be reasonably assured that further data collection would have the same results and serve to confirm emerging themes and conclusions. This study uses data saturation as well to detect when the responses collected are enough.

3.7 Data analysis methods

The following are the steps for data analysis used.

Step 1: Creating and implementing codes: This involves data categorization. Code is a word that represents a subject or concept. Codes should have meaningful naming. In this study, a priori coding technique where the researcher created codes in advance was used. The coding scheme in Table 3.1 was applied to the responses of each question to decode the meaning as far as each hypothesis is concerned.

Emerging(From Literature) issues that act as barriers to adoption of	Codes

Maturity and quality of open-source ERPs. This is in terms of reliability and certainty, privacy and security, vendor lock-in when the solution does not integrate with many other solutions in the market and solution localized in local languages, in this case English which is an official language in Kenya.	● Vendor lock-in ● Reliability and uncertainty ● Localization ● Privacy and security
Difficult discovery, and chaotic release of open-source ERPs.	● Ease of availability of open-source ERP.
Lack of financial and human resource to cover switching cost for parastatals with proprietary ERPs or skilled personnel new implementations.	● Availability of resources.
Lack of support by top management. This could be through a champion or sponsor from the top management.	● Management support
Government regulations or IT policies unfavorable for implementation of open-source ERPs in parastatals.	● Government support
Lack of people and organizational awareness of available open-source ERP solutions.	● Awareness

Lack of support from vendors.	● Vendor support

Table 3. 1 Coding framework

Step 2: Finding themes, patterns, and connections. Qualitative data analysis has no group of techniques which are universally adhered to. Of importance is the critical thinking of the researcher. Therefore, qualitative research cannot be replicated with the same results.

In qualitative research Constant comparison analysis, Keywords-in-context, Word count, Content analysis and domain analysis are used to identify patterns. Content analysis is when coding categories are derived directly and inductively from the raw data. Constant comparison is the data-analytic process whereby each interpretation and finding is compared with existing findings as it emerges from the data analysis. Domain analysis involves identifying data domains and identifying references to data domains. Word count involves counting specific words being used. used. Usually, word counts are used when the entire data set has been collected, but it can also be used throughout the research process. One drawback is that word count can decontextualize the word to a point where it is not understandable. Keywords-in-context is a data analysis method that reveals how respondents use words in context by comparing words that appear before and after keywords.

This study used content analysis since the codes can easily be defined from the possible barriers to adoption of open-source ERPs.

There are 3 types of content analysis. The first one being conventional qualitative content analysis, in which coding categories are derived directly and inductively from the raw data. This is the approach used for grounded theory development. The second approach is directed content analysis, in which initial coding starts with a theory or relevant research findings. The third approach is summative content analysis, which starts with the counting of words or manifest content, then extends the analysis to include latent meanings and themes.

This research started with analyzing the initial theories of barriers to adoption of open-source software in general to build on barriers to adoption of open-source ERPs, directed content analysis was the most appropriate. Therefore, the study uses directed content analysis.

According to the directed content analysis process, at first, each interview response was read several times carefully to gain a deep understanding of the data. In the second stage, important statements were underlined to identify the initial codes or meaning units that exist in the interview text. In the next phase, these similar meaning units (codes) were placed in different codes developed for barriers to adoption factors. In the last phase the statements that did not fit in any category were given a new code. This approach was used to analyze text data.

Step 3: Putting the information together in a nutshell connecting results to objectives. This involves using the patterns and themes identified above to derive conclusions. The main objective in this case is to find main barriers to adoption of open-source ERPs in energy sector parastatals in Kenya. In this case, after identifying all the codes that appeared in the responses using the coding framework, conclusions are then drawn and tied to the objectives that are defined earlier in the study.

3.8 Validity

This study applied a triangulation strategy to ensure validity of research results. The use of various processes or sources to cross-check information and conclusions is known as triangulation. Corroboration occurs when many techniques or sources are in agreement. To be more specific, data triangulation was employed to obtain information from both content analysis and online questionnaires.

Member checking has also been applied to seek clarifications where necessary, especially when it comes to number of skilled personnel.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

The data acquired during the study on impediments to open-source ERP adoption in Kenya's parastatals is analyzed in this chapter. The data presented have been collected both from online official document/website analysis, literature review and interviews and surveys. In content analysis government policy documents analyzed include Public Procurement and Asset Disposal Act 2016 *(PPADA)* and *National ICT Policy document* from Ministry of Information, Communications and Technology. Information from open-source ERP official websites was collected. Responses from IT managers and ERP systems managers were also collected.

4.2 Findings from interviews in energy sector parastatals in Kenya

This section presents analysis of data collected from energy sector parastatals in Kenya under the study.

4.2.1 Response Rate

Questionnaires were distributed to 5 energy sector parastatals. The table below shows the number of responses received from each organization. Response was obtained from managers who have a high-level overview of the organization and are responsible for decision making as shown in the table 4.1.

Organization	Sent out	Respondents (IT manager & ERP systems manager)
GDC	5	2
KENGEN	5	2
KETRACO	5	2

KPC	5	2
KPLC	5	3

Table 4. 1 Response Rate

4.2.2 Availability of resources

Table 4.2 shows the average of the numbers of skilled resources as reported by respondents. Appendix 2 shows the questions asked to find out the availability of skilled resources for implementation of open-source ERP.

Organization	ERP implemented	No. of Developers needed to implement open-source ERP	Available skilled developers	Available Skilled admins	Available ERP specialist
GDC	SAP	22	2	2	3
KENGEN	SAP	17	3	3	2
KETRACO	SAP	16	2	3	3
KPC	SAP	15	3	2	2
KPLC	SAP	18	3	4	4

Table 4. 2 Skilled human resources

Data collected showed that in all the organizations there is a shortage of the number of developers required to implement ERP systems(GDC 2/22, KENGEN 3/17, KETRACO 2/16, KPC 3/15, KPLC 3/18). For successful implementation of an open-source ERP system these organizations will either be required to hire more developers or sort the services of a consultancy firm for implementation. Availability of ERP specialists and skilled database admins are sufficient since in most cases these resources are shared. This information was verified by HR in each organization.

4.2.3 Privacy and security

Some responses collected through questionnaires indicate that energy sector parastatals are worried about privacy and security of open-source ERPs even though top OWASP vulnerabilities have been handled in open-source ERPs. Although others are confident with the privacy and security of open-source ERPS. Table 4.3 shows the responses collected from the organizations.

Question	24. What do you think about using open-source ERP with open-source code? Does it pose privacy and security challenges? The question was posed to 5 respondents in each organization and got responses from one respondent in each. Assumption made is that respondents shall have used open-source ERP before.
GDC	Most open-source licenses require opening your other associated code. Not Acceptable.
KENGEN	No response on this.
KETRACO	Yes
KPC	Somehow
KPLC	- Open-source ERPs are the best in terms of privacy and security because you can see what is happening. I don't think there is a security issue. - Open codebase is not an issue since the companies are already using open-source software with public codebase like Jenkins, Red Hat servers etc. - Two other respondents however were worried about privacy and security of open-source ERPs.

Table 4. 3 Interpretation and discussion of results

4.2.4 Government support

Most of the respondents indicated there are no government regulations barring parastatals from implementing open-source ERPs. Two organizations however reported the following regulations which on reviewing government policy documents such restrictions do not exist. Therefore, this

comes down to people and organization awareness of government policy on implementation of open-source solutions. Table 4.4 shows the organizations reporting the existence of regulations discouraging adoption of open-source ERPs.

	Government policy/regulations
KENGEN	Government procurement act
KPLC	Data privacy laws which open source might not guarantee.

Table 4. 4 Government regulations

In response from KPLC, data privacy regulations like General Data Protection Regulation (GDPR) only regulates how user data is handled. Open-source ERP does not mean user data is open to everyone. It only means the source code of the solution is free to everyone to use and modify. These regulations do not govern how source code of any software is distributed.

4.2.5 Awareness

Data collected showed that all respondents were aware of the existence of open-source ERPs, especially the most popular one Odoo. However, there are other elements of open-source ERPs that they are not aware of and are contributing factors to slow adoption.

The data showed most of the organizations are worried about vendor support since they do not have enough skilled manpower to implement and support open-source ERPs. Table 4.5 shows the responses received from these organizations.

Question	If you have implemented proprietary ERP, what is the other factor that made your company implement proprietary ERP instead of open-source ERP?
GDC	- Governance Regulation and Control capability - Availability of support, strong contracts to enhance business continuity.
KENGEN	- Availability of vendor support
KETRACO	- Availability of Support
KPC	- Support and Maintenance

	- Support from vendors, availability of upgrades and security patches
KPLC	- The main issue is support. - Contractual support/mitigation of risk factor - Software assurance

Table 4. 5 People and organization awareness

From earlier content analysis, it showed that open-source ERPs are commercial vendors that have been approved and certified by these open-source ERP companies and have successfully implemented open-source ERPs in major companies like Hyundai and Nike. Therefore, this only means that there is a lack of awareness by these organizations of the existence of open-source ERP vendors.

Some of the organizations are also not aware that the government of Kenya through its National ICT Policy is actually in support of open-source software and encourages parastatals to make their source code open to be used by other government institutions in the country.

4.2.6 Vendor lock-in

Most organizations use REST/SOAP web services and a means of data communication between different systems as shown in the table 4.6. The ease of integration with different systems ensured there is no vendor lock-in.

Question	How do your systems communicate with each other?
GDC	SOAP/REST/Data pipelines
KENGEN	Web Service, RFC, IDOCs, BAPI
KETRACO	Webservice & Offline Data Migration
KPC	Web Services
KPLC	Web Service (SOAP & REST) and Db Links

Table 4. 6 Vendor lock-in

4.2.7 Management support

From the data collected, all the organizations do not have an open-source sponsor/champion. All respondents in all organizations including ERP systems managers did not recommend implementation of open-source ERPs for the fear of vendor support and privacy and security. This shows little or no support from the management.

4.3 Findings from document analysis

The documents were collected from official websites. The data presented have been collected both from online official document/website analysis, literature review and interviews and surveys. In content analysis government policy documents analyzed include Public Procurement and Asset Disposal Act 2016 *(PPADA)* and *National ICT Policy document* from Ministry of Information, Communications, and Technology. Information from open-source ERP official websites was collected. These include policy documents, technical artifacts, product documentations and code repositories. Each document was read at least three times to identify themes specified in our coding schemes for barriers to adoption of open-source ERPs in energy sector parastatals in Kenya. The government policy documents (PPADA and National ICT policy document) were used to assign government support code. Official websites were used to decode vendor-lock in, reliability and uncertainty, localization, privacy and security and ease of availability. Reading through these documents and assigning these codes meant the coded name is a barrier to adoption of open-source ERPs.

Some barriers of adoption of open-source ERPs required document analysis as opposed to population research. These include, *lack of commercial vendors*, *lack of reliable information*, *software availability*, *difficult discovery*, and *chaotic release*, *localization*, *privacy and security* and *reliability and certainty*. (Fougatsaro, 2009) found three open-source ERPs (*OpenBravo*, *Adempiere* and *OpenERP*) are suitable for large scale organizations. The researcher focused on these three which could also be suitable for energy sector parastatals in Kenya which are in the same large organization category. OpenERP, a popular open-source ERP, changed to *Odoo ERP*. Odoo is an open-source ERP available for free. Commercial version is available as well. Its features and functionality can assist businesses in streamlining processes, cutting expenses, and expanding their operations.

4.3.1 Vendor support

According to (Optimus Information Inc, 2015), large scale and financially strong organizations would want stable and reliable support from vendors who can be available to resolve issues in the shortest time possible. The researcher reviewed open-source ERPs recommended for large scale organizations and below are the findings.

Odoo ERP (formerly OpenERP), an open-source ERP with both free and enterprise version has 1,567 partners according to their official website, spread across multiple countries in the world who can provide technical and functional support. In Kenya specifically, 13 official partners which includes, *Sainath Solutions Ltd*, *OTB Africa, iBOS*, *ATLANCIS Technologies*, *HyperThink Systems Limited*, *Jenga Tech Solutions Limited*, *Sailotech Kenya Ltd*, *Simplify IT*, *Sybyl Kenya Limited (certified v13)*, *ERPBox Solutions (certified v12)*, *Innovus Tech Consultants Limited*, *Trinate Global Limited* and *Wingo.net*. In addition, according to *Software Advice* (owned by Gartner) Odoo reviews, customer support had a score of *4.0/5.0* which should be good enough considering 397 respondents who submitted their reviews by June 2022.

OpenBravo, which has More than 18,000 back-office users and 60,000 points of sale in a variety of industries has support from leading vendors of advanced technology solutions according to the official website including, *Blue Springs Technology Inc*, *Exceloid*, *SMF Consulting*, *Agility ERP* who are all gold partners and many more categorized as gold, silver and blue partners. These partners can help organizations adopt OpenBravo ERP by providing both technical and functional support. OpenBravo has been implemented by large organizations like *Decathlon*, *Nike Factory Store*, *CAROLL Paris*, *Opticians* and many more. This shows the trust companies have on OpenBravo. According to *Software Advice* (owned by Gartner) *OpenBravo 2021 reviews*, shows it has scored 5.0/5.0 in terms of customer support. However, this is based on only 9 respondents who have registered their reviews for this year. Nonetheless, that is still impressive.

According to their official website, Adempiere offers an internationally maintained network of approved partners with thousands of implementations in over 30 countries. E-Evolution, based in Mexico, has more than 20 years' experience and hundreds of ADempiere deployments in Latin America, ERP Consultores y Asociados, a consulting and application development organization

in Venezuela, has hundreds of ADempiere implementations in Latin America, and OFB Consulting, based in Chile, is an official world class implementer of the ADempiere.

4.3.2 Reliability and uncertainty

To measure reliability and uncertainty, aspects like time the solution has been in the market is considered. The more users and developers a project can attract, or if the initiative is backed by a corporate or sponsor, the more credibility and reputation it will get. Furthermore, lack of roadmaps around future goals typically deters businesses from adopting such technologies. Reliability is further enhanced by accurate information and the availability of software and source code.

As discussed later in this section, all the three open-source ERPs recommended for large organizations have reliable information, well organized documentation and their binaries and source code are easily accessible from GitHub or sourceforge.

OpenBravo has been in existence since 2006 according to (Wikipedia, 2021). According to their official website, Openbravo is a vibrant and modern enterprise software firm with a fully constituted board and investors such as Amadeus Capital, Adara Ventures, and Sodena. OpenBravo has a clear roadmap to become a mobile-enabled, cloud-based omnichannel platform that will help midsize to big retail and restaurant organizations accelerate innovation and business change.

According to (Wikipedia, 2021) , *Odoo* was first developed in 2005. Odoo has won multiple honors. Odoo won successive BOSSIE Awards in 2014, 2015, and 2016 after changing its name. Odoo is a Belgium company with offices in USA, Germany, UAE, Mexico, India, and China. It has over 1500 employees, 3550 partners and over 7 million users. However, Odoo has not published their roadmap on their official website.

Adempiere had its initial release on 12th October 2006. Adempiere is a foundation with high profile sponsors like e-Evolution, and a fully constituted board. However, its roadmap is not published on their official website. It also has no employees under the foundation responsible for maintaining the solution. It is fully maintained by the community. This could be a source of worry for potential adopters.

4.3.3 Localization

According to (Wikipedia, 2021), internationalization and localization are terms used to describe the process of translating software systems to multiple languages, regional variances, and technical needs of a target market.

In Kenya, Kiswahili is the national language and English the official language. The language of operations or business government institutions and even the private sector is English. Therefore, software solutions being implemented would be required to support the English language. Analysis of the recommended ERP systems shows the following.

OpenBravo, has a page in their properly documented wiki written in English on localization. According to the official website, in openBravo you can include what you need in terms of language, tax and accounting configurations. In addition, OpenBravo has a system of community champions who support various localization initiatives.

Odoo, has support for English language and has proper documentation on accounting localization of the ERP solution. Many accounting and tax systems of many countries are being supported including the UK which has a similar tax system to Kenya. Therefore, Odoo is suitable for Kenyan government parastatals based on the language and tax systems being supported.

Adempiere, just like Odoo, has a well-documented wiki on localization and support for English and tax and accounting systems for 26 countries across the world including the UK which has a similar system as Kenya.

4.3.4 Ease of availability of open-source ERPs

Open-source software is expected to be easily discoverable online, easy to download and has proper documentation to start the process of trials and implementation. OSS that are not easy to discover with scanty information and a chaotic release may derail adoption efforts by organizations. Reviewing online information about the open-source ERPs recommended for large scale organizations, the researcher found out the following.

Odoo has an official website*,* where all official information about Odoo ERP can be found. On the website there is a tutorial, that demonstrates how to get started with Odoo, its advanced

features and many other courses that one can take to be certified Odoo ERP specialist. This can help organizations to upskill their resources to allow them to work with Odoo ERP.

The documentation section of the website contains an introductory Odoo guide for end users, an advanced developer guide for key technical details for modules, workflows, actions, security, and other development/operational features, and a full guide to Odoo installation.

Odoo also has an eLearning platform embedded on the website with videos, exercises, and quizzes.

Odoo website also has a mailing list for announcements, functional questions, education programs and technical discussions. Odoo ERP software is easily downloadable straight from the website.

Odoo has a systematic version release system indicated on the download page with different release versions organized as Odoo *v12*, *v13* and *v14* for Windows and Ubuntu/Debian platforms.

Odoo ERP source code has been made available in GitHub, for contributors and user customizations.

OpenBravo has an official website, which is the entry point to all required documentation and guidance for implementation and adoption. On the website, OpenBravo has a wiki, which has general information, system administration guide, quick guide, user guide, developers' guide, and localization guide. *General information* section provides information on "getting started" with Openbravo, which provides a summary of resources available to customers. System administration guide has important information on system requirements, and installation manual. The Quick Guide explains the essential processes for setting up and running fundamental functional flows in Openbravo for your firm, with explanations and executions kept as simple as possible. The User Guide's User Interface chapter teaches how to use Openbravo and navigate its user interface. The Business Flows section offers a list of Openbravo-supported processes as well as step-by-step instructions for executing them in the application. The Openbravo Application Areas outlines how to set up, operate, and evaluate each Openbravo application area, while the Similar Concepts & Procedures provides a review of concepts and processes that are common

throughout Openbravo. There are a number of How-To documents that cover a variety of topics. Many of the guides show how to achieve business objectives using Openbravo's tools. Developers can use the Openbravo Developer's Guide to learn how to modify, extend, and build on Openbravo. Openbravo development themes are described in development HowTos from the standpoint of specific development goals. The Localization Guide contains all of the necessary information for effectively adapting Openbravo to various languages, regional or geographical variances, and technical or legal needs of a target market. Videos and eBooks on OpenBravo are also available on the website.

OpenBravo has a consistent release system for every quarter of the year with well documented release notes, with the last release being in Q1 of 2021.

OpenBravo ERP source code and binaries are easily available on *sourceforge and* can be downloaded and customized for on premise or cloud deployment by organizations.

Adempiere just like Odoo and OpenBravo has an official website with all the necessary documentation and serves as an official entry point for the necessary resources required for implementation. It has a wiki, with the user guide, developers' guide, installation guide, training and features it offers. In addition, the website has video tutorials embedded which makes learning Adempiere ERP solution easier.

The researcher found out that the solution binary can easily be downloaded from the website for installation. The source code is available on GitHub, and can be forked, cloned, and customized to suit a specific organization needs.

Release system for Adempiere has been documented in the GitHub repository. The latest version of the solution is *v3.9.3*. Each release has well documented release notes on what has changed, the new features added and the bugs that have been fixed.

4.3.5 Security and Privacy

Security and privacy are an important aspect which most organizations consider before adoption. The researcher reviewed the 3 open-source ERPs recommended for large organizations and the following were the findings on each.

Open-source ERP source code is available to everyone and therefore lacks privacy in terms of systems architecture. This might prevent some organizations from adopting the solution. This is however dependent on what the organization thinks. Therefore, based on further response from the people in the organization, the researcher determined if this could be a barrier to adoption of open-source ERP.

Open-source ERPs, just like proprietary ERPs can be implemented in cloud or on premise. For both cases network security to access the ERP system fully depends on company implementation and not necessarily on the ERP itself. Therefore, this analysis is restricted to security features offered by the ERP solution. Some of the OWASP vulnerabilities that are that are analyzed include, Injection , Cross Site Scripting (XSS), Cross Site Request Forgery (CSRF), Malicious File Execution, Insecure Direct Object Reference, Insecure Cryptographic Storage, Insecure Communications and Failure to Restrict URL Access.

Table 4.7 below elaborate how open-source ERPs handle OWASP top vulnerabilities.

Vulnerability	Odoo	OpenBravo
Injection Flaws	Odoo is built on ORM foundation that isolates query creation and protects against SQL injections. Developers rarely write SQL queries by hand; instead, the ORM generates them, and arguments are always appropriately escaped.	Has guidelines for its contributors. These include, 1) Always use bind parameters whenever possible (either in SQL or HQL). 2) If it is not possible to use parameters, for HQL queries we must use OBCriteria and Criteria, as they are flexible solutions that allow dynamic modifications to queries. 3) If OBCriteria or Criteria are not an option or if the query is a SQL Query, then the developer must ensure that the input parameters are verified first with techniques such as filtering and whitelists.

Cross Site Scripting (XSS)	By default, the Odoo framework protects against XSS by escaping all expressions rendered into views and pages and are marked as safe.	Just like Odoo, OpenBravo escapes all expressions rendered into views and pages hence preventing Cross site Scripting.
CSRF	A built-in CSRF protection mechanism is included in the Odoo website engine. Controller that receives a request without the associated security token is blocked.	*CSRF Protection in Backoffice*; Standard Windows are protected against CSRF attacks out-of-the-box, both in grid and in form view. The generated token is available on the client side in OB.User.csrfToken. This token is attached automatically to add/edit/remove operations and if not present, it will show an error message.

CSRF Protection in POS; POST requests automatically send the User Session CSRF token as part of the request body. This token is also available on the client side in OB.MobileApp.model.get('csrfToken') . If the token verification fails, the server returns a 401 (Unauthorized) response. |
| Malicious File Execution | Odoo does not provide functionality for importing files from a remote location. It does, however, allow authorized users to | There are no functions in OpenBravo that allow you to include files from a remote location. |

	modify features by adding custom expressions to the system's evaluation.	
Insecure Direct Object Reference	In Odoo every request must pass through the data access validation layer, attackers cannot bypass the access control layer which makes it secure.	OpenBravo, like Odoo, does not implement access control at UI level, hence eliminating the risk of internal object references being exposed through the http endpoint.
Insecure Cryptographic Storage	To protect stored passwords, Odoo employs industry-standard security. In addition, other authentication mechanisms like LDAP or OAuth 2.0 can also be used to avoid storing user credentials locally.	Has a reference to passwords, which are encrypted at all times. External authentication methods, such as OAuth 2.0, can also be used to avoid storing passwords locally.
Insecure Communications	By default, Odoo Cloud uses HTTPS. It is advised to use a web server that implements encryption and proxying requests to Odoo, such as Apache, Lighttpd, or nginx, for on-premise installations.	It is advised to operate OpenBravo behind a web server that implements proxying and encryption requests to OpenBravo for on-premise installations.
Failure to Restrict URL Access	Odoo security does not rely on masking particular URLs, and access control is not enforced at the UI level. Because every request must still pass through the data access validation layer, attackers cannot bypass the access	Access control is not implemented at the UI in OpenBravo, and security is not based on masking particular URLs, as it is in Odoo.

		control layer by repeating or modifying the endpoint.	

Table 4. 7 OWASP top vulnerability analysis.

In addition, independent organizations are engaged by our customers and prospects to do audits and penetration testing on Odoo on a regular basis. When necessary, the Odoo Security Team receives the results and takes appropriate corrective action. Since 2018, both Odoo and OpenBravo have not had any OWASP top 10 vulnerabilities reported in Common Vulnerabilities and Exposures (CVE).

Table 4.8 below shows a summary of content analysis on different technological characteristics of Odoo.

Open-Source ERP	Code for analysis	Findings	Conclusion
Odoo	Ease of availability of open-source ERP	- Comprehensive documentation available on the official website. - Product artifacts can easily be downloaded from the product website. - Source code is publicly available in the GitHub repository. - It has a systematic release system (*v12, v13, v14*)	Easily available and should not slow down adoption.

		documented on the website.	
	Reliability and uncertainty	- Has been in existence since 2005. - Has received major awards like Bossie award. - HQ in Belgium but has offices across the world. - Has over 1500 employees, 3550 partners and over 7m users - Has not published a roadmap.	Could be a factor to slow down adoption due to lack of clear roadmap and therefore adopters may not be certain of its future.
	Localization	- Support English language - Has localization guide on how to configure tax and accounting systems for countries including the UK which has a similar tax and accounting system to Kenya.	Can be localized hence should not be a factor to slow down adoption.

| | Privacy and security | - Has handled the top OWASP vulnerabilities.
- Since 2018, Odoo has not had any OWASP top 10 vulnerabilities reported in *cve.mitre.org*. Although other vulnerabilities have been detected and fixed by the Odoo team.
- Independent organizations are engaged by our customers and prospects to do audits and penetration testing on Odoo on a regular basis. When necessary, the Odoo Security Team receives the results and takes appropriate corrective action. | Privacy may be an issue due to open-source code. This is investigated further with the people in the organizations being studied. |

	Vendor support	- Has 1567 partners across the world and 13 official partners in Kenya who can support implementation. - Has scored 4.0/5.0 in *Software Advice* (owned by Gartner) survey in terms of customer support.	Vendor support is available for Odoo and should not be a factor of slow adoption.

Table 4. 8 Characteristics of Odoo ERP

Table 4.9 below shows the result of content analysis on technological characteristics of OpenBravo ERP.

OpenBravo	Ease of availability of open-source ERP	- Has proper documentation on the official website. - Well organized release system which is properly documented on the website. - Source code and other product artifacts can easily	Should not slow down adoption of OpenBravo ERP.

	Reliability and uncertainty	- Has been in existence since 2006. - Has a fully constituted board. - Has major investors like Amadeus capital. - Clear roadmap to transform into an omnichannel.	Could be an issue of adoption since it's all-over sudden transforming from a full ERP system into an omnichannel against the expectation of adopters and potential adopters.
		be found in *sourceforge*.	
	Localization	- Supports English language - It has a detailed localization guide to show how to configure tax and accounting systems for different countries, including Kenya.	Supports localization to Kenyan official language and tax and accounting system. Therefore, it should not be a factor of slow adoption.
	Privacy and security	- Since 2018, OpenBravo has not had any OWASP top vulnerabilities	Privacy may be an issue due to open-source code. This is investigated further

			reported in *cve.mitre.org.* However, other vulnerabilities have been reported and fixed. - Has handled the top OWASP vulnerabilities.	with the people in the organizations being studied.
	Vendor support		- Has official partners listed on their official website categorized as Gold, Silver and blue depending on their capacity who can and have provided support during and after implementation. - Has scored 5.0/5.0 in *Software Advice* (owned by Gartner) survey in terms of customer support.	- Should not be a factor to slow down adoption.

Table 4. 9 Characteristics of OpenBravo ERP

Table 4.10 below shows the result of content analysis on technological characteristics of Adempiere ERP.

Adempiere	Ease of availability of open-source ERP	- Adempiere has a detailed wiki with all the technical and user guides on which can be easily traced from the official website. - Artifacts can be downloaded from the website as well as from GitHub repository. - Source code is available in the public GitHub repository and each release is properly documented with changelog in the repository.	Easily available and should not affect adoption of Adempiere.
	Reliability and uncertainty	- First released on 12th Oct 2006 - Has high profile sponsors like e-Evolution.	Could be a factor of slow adoption due to lack of clear roadmap.

		- Adempiere foundation has no employees under it and is fully maintained by the community. - Has no clear roadmap.	
	Localization	- Support the English language. - Has localization guide on how to configure tax and accounting systems for 26 countries including the UK which has a similar tax and accounting system to Kenya.	Can be localized hence should not be a factor to slow down adoption.
	Privacy and security	- Since 2007, OpenBravo has not had any OWASP top vulnerabilities reported in *cve.mitre.org*.	Privacy may be an issue due to open-source code. This is investigated further with the people in the organizations being studied.
	Vendor support	- Has official partners listed on	Vendor support is available and

			their website who can provide support during and after implementation. Mostly found in South America, but with the world being a global village they have provided implementation support to more than 30 countries across the world.	therefore should not be a factor of slow adoption.

Table 4. 10 Characteristics of Adempiere ERP

4.3.6 Government support

The researcher went through the Public Procurement and Asset Disposal Act 2016 *(PPADA)* document published on Public Procurement Regulation Authority (PPRA) official websites together with the *National ICT Policy document* from the Ministry of Information, Communications and Technology and found the following.

PPADA does not limit a procuring entity to specific brands, rather it stipulates the technical requirements a vendor should respond to. It requires open tender for projects that exceed a certain value. Open-source ERPs have 0 procurement costs.

An excerpt from National ICT policy document on page 28 indicates that the government of Kenya would recommend the use of OSS where alternatives to proprietary software exist. It further states that government parastatals may share source code of solutions built with other parastatals or government institutions that may have similar needs. This statement shows that the

government of Kenya encourages parastatals to adopt open-source solutions where possible. Therefore, government regulations are not a factor that slows down adoption of open-source ERPs in energy sector parastatals in Kenya.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 Introduction

This section covers a summary of the key findings already demonstrated in chapter four and continues to discuss these findings in relation to the objectives of this study. Conclusions and recommendations are drawn based on the discussions found in this chapter.

5.2 Summary

The study started by identifying the overall objective as *"to identify the main barriers to adoption of open-source ERPs in parastatals in the energy sector in Kenya"* This section summarizes how the specific objectives were achieved and the corresponding research questions answered by the end of this study.

Objective 4: *"To identify barriers and concerns related to the uptake of open-source ERPs in energy sector parastatals guided by the proposed model".*

From the data collected during the study, barriers of adoption of open-source ERPs in the energy sector in Kenya include lack of management support, lack of organizational awareness on existence of open-source ERP vendors, lack of enough skilled personnel, privacy and security and reliability and certainty.

Based on the conceptual framework, it was found that only technological and organizational factors affect adoption of open-source ERPs in energy sector parastatals in Kenya. There was no evidence showing environmental factors contribute to slow adoption of open-source ERPs in energy sector parastatals in Kenya. Under organizational factors found are lack of enough skilled personnel, lack of management support and organizational awareness were contributing factors to slow adoption. Technological factors found include privacy and security and reliability and uncertainty.

5.3 Conclusions

The study investigated the barriers to adoption of OSS ERP Systems for energy sector parastatals in Kenya. Using the adapted TOE framework, the study identified the following constructs as OSS ERP barriers to adoption for energy sector parastatals in Kenya: Management Support, People and organizational awareness, Privacy and Security, Reliability and Certainty and lack of enough skilled human resources.

These barriers were derived from two major barriers to adoption, Technological and organizational factors. Privacy and security and reliability and certainty are open-source ERP characteristics that fall under technological factors. Management support, people and organization awareness and lack of enough skilled human resources are under organizational factors that slow inhibit adoption of open-source ERPs in energy sector parastatals in Kenya.

Generally, the barrier to adoption of OSS ERP identified for energy sector parastatals in Kenya are similar to those of adoption of open-source ERPs in South Africa. The differences observed were that reliability was not regarded as an adoption barrier in South Africa, and no reference to sunk costs was found relating to OSS adoption in SA as opposed to energy sector parastatals in Kenya.

Most of the technical barriers to adoption specific to OSS were found not to be applicable to OSS ERP. This was attributed to customization and the associated challenges being standard practice with most ERP implementations. However, technology characteristics like privacy and security where organizations raised concerns about. Compatibility was also discounted due to the fact that ERP systems are mostly internally focused in an organization. An insightful conclusion drawn from the research emanated around the concept of Sunk Costs. Human Resource factors, which are regarded as an adoption barrier to OSS in general, was found to be a factor of adoption of open-source ERP systems in energy sector parastatals in Kenya.

The environmental factors findings showed that government policies and regulations were not an adoption barrier for OSS ERP systems in energy sector parastatals in Kenya. Instead, the government of Kenya supports implementation of OSS. The study further found that vendor support is not a barrier to adoption. It is found that most open-source ERPs are a well-structured support system from a pool of vendors worldwide. However, the responses collected from

energy sector parastatals showed the organizations are not aware of availability of vendors. Therefore, this indicates lack of awareness is a barrier of adoption.

The study showed lack of enough skilled resources to implement and maintain open-source ERPs is a barrier to adoption. Open-source ERPs just like any other OSS needs to be customized to meet the specific needs of the organization. This needs a highly skilled and experienced workforce. However, organizations have an option to contract vendors for implementation and support of open-source ERPs. This would still save on high proprietary ERP license cost. Another organizational factor identified limiting adoption is lack of management support on implementation of open-source ERPs. No management sponsor or champion of open-source ERP or OSS in general in all organizations under this study.

The data collected showed there is awareness of the existence of open-source ERPs across all energy sector parastatals in Kenya. However, there is lack of awareness on other aspects of open-source ERPs like the existence of commercial vendors which is a limiting factor of adoption. Therefore, awareness is a barrier of adoption of open-source ERPs in energy sector parastatals in Kenya.

Due to the particular nature of the application type, the generally accepted adoption criteria associated with OSS may not apply to OSS ERP systems, according to this study. Due to financial constraints, many businesses do not have ERP systems. OSS ERP systems provide a way to get around this problem. Furthermore, the findings of this study have major significance for OSS ERP suppliers in developing effective strategies for recognizing and addressing market needs and dynamics.

5.4 Study Limitations

The time constraint for this investigation was the most significant. Furthermore, the survey method limited the capacity to potentially clarify any respondent doubt around a specific issue, as well as the option to dig deeper into potentially insightful responses in open-ended questions. However, through data triangulation (data from various sources), the responses from these organizations were verified from information from other sources. Another limitation is that there are a limited number of energy sector parastatals in Kenya, and they have all implemented proprietary ERPs

making it difficult to get responses from organizations in the process of making a decision on ERP to implement in today's environment and market conditions. These limitations notwithstanding, the study provided useful findings which contribute considerably to expanding knowledge and understanding of factors that limit adoption of open-source ERPs in energy sector parastatals in the energy sector in Kenya.

5.5 Suggestions for further research

This study focused on adoption of open-source ERPs in the energy sector in Kenya. A potential area for future research would be adoption of open-source ERPs in the private sector in Kenya as well as all other public parastatals in Kenya. This research has helped reveal barriers of adoption of open-source ERPs in the energy sector in Kenya but has not provided a strategy that these parastatals can use to implement open-source ERPs and benefit from the low cost of acquisition since there is no license cost. A further study is needed to establish an appropriate strategy, model or framework that could be used to adopt an open-source ERP and reap its benefits.

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APPENDICES

7.1 APPENDIX 1: ORACLE BUSINESS SUITE GLOBAL PRICE LIST

Oracle E-Business Suite Applications Component Global Price List

Prices in USA (Dollar)

	License Price	Software Update License & Support	Metric	Minimum
Product Lifecycle Management				
Agile Product Lifecycle Management				
Agile Product Collaboration	6,545	1,439.90	Application User	20
Agile Product Governance and Compliance	3,995	878.90	Application User	20
Agile Product Cost Management	4,995	1,098.90	Application User	20
Agile Product Quality Management	2,995	658.90	Application User	20
Agile Product Portfolio Management	5,995	1,318.90	Application User	20
AutoVue 2D Professional for Agile	450	99.00	Application User	20
AutoVue Electro-Mechanical Professional for Agile	3,495	768.90	Application User	20
Agile Engineering Data Management	6,995	1,538.90	Application User	10
Option: Agile Product Workbench	4,995	1,098.90	Application User	10
Option: Agile Distributed File Management	75,000	16,500.00	Processor	2
Product Lifecycle Analytics	5,800	1,276.00	Application User	50
Agile Product Lifecycle Management Integration Products				
Agile Engineering Collaboration	75,000	16,500.00	Processor	2
Agile MCAD Connector	4,995	1,098.90	Application User	10
Agile Product Lifecycle Management for Process				
Agile Product Data Management for Process	7,995	1,758.90	Application User	20
Option: Agile Formulation and Compliance for Process	6,995	1,538.90	Application User	20
Option: Agile Product Supplier Collaboration for Process	1,995	438.90	Application User	20
Option: Agile Product Quality Management for Process	2,995	658.90	Application User	20
Agile New Product Development and Introduction for Process	4,995	1,098.90	Application User	20
Enterprise Visualization				
AutoVue Office	115	25.30	Application User	1
AutoVue 2D Professional	450	99.00	Application User	1
AutoVue 3D Professional Advanced	1,725	379.50	Application User	1
AutoVue EDA Professional	1,725	379.50	Application User	1
AutoVue Electro-Mechanical Professional	3,495	768.90	Application User	1
AutoVue VueLink Integration	29,000	6,380.00	Computer	1
Financial				
Financials	4,595	1,010.90	Application User	5
Advanced Collections	1,395	306.90	Application User	10
Internet Expenses	6	1.32	Expense Report	1,000
iReceivables	58	12.76	1K Invoice Line	20
Treasury	28,795	6,334.90	Application User	4
Financials Accounting Hub	175	38.50	Employee	1,000
Human Resources				
Human Resources	185	40.70	Employee	100
Self-Service Human Resources	40	8.80	Employee	100
Advanced Benefits	85	18.70	Employee	500
Compensation Workbench	70	15.40	Employee	100
iRecruitment	75	16.50	Employee	500
Payroll	225	49.50	Employee	500
Performance Management	105	23.10	Employee	100
Time and Labor	110	24.20	Employee	100
Succession Planning	70	15.40	Employee	100

7.2 APPENDIX 2: Data collection methods

Method of data collection	Information being collected	Questions if any
Document analysis	Security and privacy.	
	Reliability and uncertainty.	
	Localization of open-source products.	
	Software availability, difficult discovery, and chaotic release. Also dependent on availability of reliable information.	
Interview IT managers and head or manager of ERP systems.	Lacking financial and skilled human resources to cover switching costs for companies with proprietary solutions.	1. During your ERP implementation, how many consultants/developers did you have? 2. How many ERP specialists do you have? 3. How many software developers have skills in Python/JavaScript/Java/PHP? 4. How many of your database admins have

		skills in Oracle/MySQL/MariaDB/MSSQL/PostgreSQL/IBM DB2 database?
	Vendor lock-in due to lack of interoperability by open-source software.	1. Vendor lock-in due to lack of interoperability by open-source software.
	Lack of people's and organizational awareness about OSS.	2. Do you know any open-source ERPs? 5. Please name open-source ERPs you are aware of?
	Management support and awareness of options and organizational structure are lacking.	1. Would you recommend implementation of open-source ERP? 2. Why? 3. Between open source and proprietary software, which one do you think is prone to failure? 4. If open source, is that a reason to avoid adopting open-source ERPs?

		5. Do you have an OSS champion/sponsor in your organization?
	Lack of government support and public and political pressure	6. Do you have any OSS implemented and being used in the company?
		7. Please specify open-source software being used in the company.
		8. Are there any government regulations you know of encouraging/discouraging your company from implementing OSS?
		9. Please specify these regulations.
		10. Are there any government regulations you know of encouraging/discouraging your company from implementing Open-source ERPs?

	Lack of commercial vendors.	Can you remember any open-source ERP commercial vendor? Could this be a reason why your organization has not adopted open-source ERPs?

7.3 APPENDIX 3: UON RESEARCH AUTHORIZATION

UNIVERSITY OF NAIROBI
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SCHOOL OF COMPUTING AND INFORMATICS

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Our Ref: UON/CBPS/SCI/ MSC/ITM/2019

23rd June 2021

TO WHOM IT MAY CONCERN

Dear Sir/Madam

RE: DATA COLLECTION PERMIT : PAUL ODERO REG. NO. P54/33357/2019

The above named is a bona fide student pursuing an MSc course in Information Systems at the School of Computing and Informatics, University of Nairobi. He is currently carrying out his research on the project entitled *"Barriers of Adoption of Open-source ERPs in Parastatals in Kenya – A case study of the Energy Sector"*. He is under supervision of Ms. Christine A Ronge.

The project involves gathering relevant information from various institutions and he has informed the office that he would wish to carry his research in your organization.

We would be grateful if you could assist Mr. Odero as he gathers data for his research.

If you have any queries about the exercise please do not hesitate to contact us.

Yours sincerely

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PROF. ROBERT O. OBOKO
DIRECTOR
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