ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES

SCHOOL OF INFORMATION SCIENCE

ERP SYSTEM INTEGRATION FRAMEWORK: THE CASE OF BGI ETHIOPIA

By: Sisay Fekadu

ID: GSE/5209/13

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Advisor: Getachew Hailemariam (PhD)

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Name and signature of Members of the Examining Board

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June, 2025

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Declaration

I hereby declare that the work presented in this thesis titled ERP Systems Integration Framework: The case of BGI Ethiopia is my original work and has been carried out under the supervision of Getachew H/Mariam (PhD).

This thesis has not been submitted previously, either wholly or in part, for the award of any degree or diploma in any other university or institution. Any material borrowed from other sources has been acknowledged appropriately. A list of references is appended.

Signature: _____
SISAY FEKADU

This thesis has been submitted for examination with my approval as university advisor.

Advisor's Signature: _____
GETACHEW H/MARIAM (PhD)

Dedication

This thesis is dedicated to my beloved wife Seble Belachew and our beautiful Kids Aron Sisay and Amran Sisay, whose endless support and encouragement made this journey possible.

Acknowledgement

First and Foremost all Praise, honor and glory goes to you, Almighty God!

I would like to express my sincere gratitude to my advisor, Getachew H/Mariam (PhD) for his continuous support, guidance, and patience throughout the duration of this research. His knowledge, follow-up and encouragement have been instrumental in shaping this thesis.

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Finally, I am grateful to all who directly or indirectly contributed to the successful completion of this thesis.

Abstract

Enterprise Resource planning is becoming the choice of many businesses since it unify, streamline and automate core business processes under one integrated platform. Though this fact is true, the dynamic nature of business and the IT industry brought new technologies that require integration with ERP systems. Hence, the issue of integration has become something an organization cannot escape. To this end, a comprehensive integration framework is required to overcome the challenges coming from the Integration process.

This study intends to find out the integration practice exercised in one of big Brew factory in Ethiopia and propose an ERP Integration Framework that enhances the existing undocumented integration practice. Along with the Design Science Research Method, the study use a mixed-method single case approach using semi-structured interview to collect data, and the data collected were analyzed using thematic analysis. Additionally, document review and observation were used to observe user interaction, process alignment and system response.

The study's findings reveal that ERP integration within the company under investigation is being mismanaged, with key issues including the absence of a clear strategy, excessive customization, and lack of governance, inadequate change management, poor control mechanisms, insufficient monitoring, and a failure to address security and compliance requirements. Hence, to solve these issues the study proposed an ERP integration framework that incorporates most of the missing pieces.

The study recommends using the proposed framework to fill the gaps of the integration practice in the organization under study. By utilizing this framework, ERP integration challenges can be more effectively identified and reduced, thereby enhancing organizational performance and supporting enterprise-wide integration. Additionally, the framework extends our understanding of IT-enabled transformation by illustrating how ERP systems drive operational and strategic changes in organizations.

Keywords: IT, ERP, ERP integration, Integration Framework, Integration Challenges, IT-Enabled transformation, Governance, Change Management.

List of Acronyms

ERP: Enterprise Resource Planning

IT: Information Technology

IS: Information Systems

SCM: Supply Chain Management

CRM: Customer Relationship Management

WMS: Warehouse Management Systems

BGI: Brasseries et Glacières Internationales

AX: Microsoft Dynamics AX

HRMS: Human Resource Management Systems

SAP: Systems, Applications, and Products in Data Processing

PR: Purchase Requisition

RQ1: Research Question 1

RQ2: Research Question 2

ETL: Extract, Transform, Load

FTP: File Transfer Protocol

XML: eXtensible Markup Language

BI: Business Intelligence

FDD: Functional Design Document

TOGAF: The Open Group Architecture Framework

EA: Enterprise Architecture

ADM: Architecture Development Method

API: Application Programming Interface

BPO: Business Process Outsourcing

DSR: Design Science Research

SPSS: Statistical Package for the Social Sciences

UML: Unified Modeling Language

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CHAPTER ONE

Introduction

1.1 Background of the Study

According to Singh (2018), ERP is a software package of integrated applications that are extensively utilized in an organization. As such, it is a system as a whole, a completely integrated package that facilitates the automation of all business processes in accordance with the organization's current standards. By sharing a shared and integrated database, the system may provide a comprehensive view of the business operations of the organization. In another perspective, Alshamaila and Papagiannidis, (2023), viewed ERP as a software product that suites integrated application designed to manage and automate various business processes. It is also seen as an organizational framework that maps and integrates all enterprise processes and data, facilitating a holistic approach to business operation.

Today, organizations are increasingly challenged to pursue transformative, 10x improvements rather than incremental 10% changes—an approach that demands innovative tools and a complete rethinking of work structures (Perdoo, 2023). A recent study by Jean Dagher and Laura Fayad (2024) emphasizes the necessity of a revolutionary approach to business performance improvement which can be assisted with the implementation of a technological tool that brings organizational integration. As the study by Alshamaila and Papagiannidis, (2023), underscore, ERP is both technological tool and a strategic framework for organizational integration. In addition to automating various business process in an organization, ERP has also an extended role as the backbone enterprise business suite that connects with customers and business partners (Hvolby and Trienekens, 2010), this insist integration to become an important consideration during the ERP development.

Integration according to Linthicum (2004) is a general term that has various dimensions and meanings in the domain of information systems. He believes it has technical, business process and strategic perspectives and includes data exchange between systems, standardization of business processes and also cooperation and coordination between human actors.

ERP systems integration can be seen from a number of complementary angles, According to Shatat, (2022), ERP technical integration can be achieved using technologies like middleware

and APIs for a smooth data flow. Alshamaila & Papagiannidis, (2023), stated in their study it is crucial to match ERP with organizational workflows to increase efficiency and optimize operation. Data integration consolidate information from various sources, this in turn brings dependability and consistency throughout the company (Tallon & Kraemer, 2021).Finally, organizational culture receive equal importance since it emphasizes on change management, user adoption, and cross departmental corporation to support the ERP's long term performance (Mousa & Othman, 2022).

Even though ERPs are usually adopted to replace numerous legacy systems, ERP does not eliminate the need of other information systems (Lehmann and Gallupe, 2005; Xu, 2011).As more and more companies deploy enterprise systems such as ERP, SCM, and CRM, integration of these systems becomes a top priority (Stedman, 2000).

In numerous business organizations in Ethiopia, the adoption of an ERP system solution is gaining significant attraction. However, Integrating these systems with other enterprise applications and ERP systems presents significant challenges. Nevertheless, organizations implement the system to enhance decision-making, productivity, and efficiency. The focus of this study is to investigate ERP system integration challenges from the perspective of technical, data, and business integration.

1.2. Context of the study

BGI Ethiopia has been operating in Ethiopia since 1998 and is engaged in the production and distribution of beer, wine and beverages. BGI owns six breweries including the iconic St. George Brewery in Addis Ababa, the Kombolcha Brewery, the Hawassa Brewery, Zebidar Brewery, the Meta Brewery and the Maichew Northern Brewery with a combined production capacity of more than 4.0 million Hectoliters of beer (bottle and Draft) annually.

BGI Ethiopia has been using an ERP system called Microsoft Dynamics AX since 2014 to facilitate the day-to-day activities of the organization. The company was using Peachtree as financial management software, locally developed software for Human Resource Management Order follow-up application to follow the status of goods in transit, and optimaint for warehouse management. In addition, the company was using Office suites (WORD, Excel, ACCESS and

PowerPoint) to compile different kinds of reports and interact with the rest of the departments (logistics, production, technique and others).

The company acquired three of the six brew factories (Raya, Zebidar, and Meta) between 2018 and 2022. These three brew companies were using various standalone applications and standard ERP Systems to manage their day-to-day operations. For instance, Raya Brew factory was using Peachtree as finance software, Zebidar Brew factory was using Sage 300 ERP, and Meta is using SAP ERP systems. BGI Ethiopia, which is running Microsoft Dynamics AX, SAP Success Factor, and Business Central ERP systems. These silo systems made the life of the organization very challenging due to duplication of efforts, communication gap between departments, inconsistent data and process which in turn leads to operational inefficiency and poor decision making.

Businesses need to provide better goods and services to their customers to make profits. One of the areas in which they can get a competitive advantage over their rivals is through integrating their business processes with ERP. A company will benefit from a successfully implemented ERP through a seamless interconnection of its internal systems and cross-functional units. According to Davenport (2000), among the business benefits of Enterprise Systems are Cycle time reduction, faster information transactions, better financial management, laying the groundwork for electronic commerce and making tacit process knowledge explicit.

1.3 Research Motivation

Researches are needed to better understand what motivates a researcher to become involved in a research. It's an acceptable standard that research should come out of a desire or motivation to do things better (Singh, 2006). Accordingly, in my more than ten years of experience working in different IT positions, more specifically Enterprise application manager role, I have faced a great challenge due to wrong practices in the area of ERP system integration with other ERP System and non-ERP System.

It is my motivation to assist these areas of malpractice through a well-researched thesis paper. A few of the areas that motivate the researcher are:

- ERP systems were initially conceived as integration of information flows coming from different functional units of the same enterprise. However, as the users get to know the

system very well, they keep asking for more (connecting the system with mobiles apps for instance) which was not initially planned and included in the budget.

- In Ethiopia merger and acquisition is now becoming common, however, the process usually neglect the information system component (ERP systems) which usually play a major role in the daily operation. This research study will assist those parties who intend to acquire a business to have an overall insight on the ERP integration in the process of acquisition or merger.
- Integration of an ERP system with other non ERP systems is customary. However, consolidating two or more ERP systems which have their own pros and cons is challenging. This research will assist the integrators to consider a few factors prior to consolidation.
- The researcher has come to realize there is no standard to be followed in the integration process of an ERP System with other ERP or non ERP System. A tailored framework for the integration process will assist the integrators to minimize the risk.

1.4 Statement of the problem

"A research problem is an educational issue concern or controversy that the researcher investigates" (Creswell, 2012). The importance of implementing a reliable ERP system has long been accepted by business organizations. The core purpose of the current study is to investigate Enterprise Integration practices, models, methodologies that address the prevailing problem in the company under study. This issue of integration can be achieved by identifying barriers in the enterprise integration.

The original goal of ERP was to provide an all-in-one integrated suite for the enterprise. However, in a modern business environment, ERPs are integrated externally with customers, suppliers and business partners and internally with continuously changing system landscape of the enterprise (Kähkönen and Smolander, 2013).

A study conducted by Kähkönen, Maglyas, and Smolander (2015) on ERP Integration: An Inter-organizational Challenge in the Dynamic Business Environment set an empirical ground on all the factors that should be considered during ERP System integration. As a researcher I found this study very helpful and I believe most of the findings can be used to propose the ERP integration framework of the company under study. Additionally, the study will incorporate Enterprise

architecture methodologies to support ERP integration which in turn leads to Enterprise integration.

A study conducted by Ahamed, Musthafa and Marikar (2020) on Challenges and Benefits of ERP System and Non-ERP System Integration in a Developing Country: proposed a hybrid solution of ERP and non-ERP application and integrating those applications for better managerial decisions. However, they didn't stipulate how this integration can be done from business process and strategic point of view. According to Linthicum (2004), integration has technical, business process and strategic perspectives and it includes data exchange between systems, standardization of business processes and also cooperation and coordination between human actors.

In addition to enterprise systems that requires extreme effort to integrated with ERP systems of the same vendor, this study will also identify obstacles on ERP systems of different vendors that require integration decision. Because these systems are very complex and difficult to implement, their integration with different cultures and management styles from merging two companies presents enormous hurdles (Radcliff and LaPlante, 1999; Stedman, 1999). The study will also investigate the various factors that need to be considered in line with the business process and strategic alignment.

Though, various standard business processes, workflows are integrated in the ERP systems to bring organizational success, there are also customized processes integrated into the system to handle various tasks. Due to customizations and release variance, integration of enterprise systems from even the same vendor can be extremely difficult if not impossible (Kubilus, 2003; Stedman, 1999). ERP integration rarely has a static ending point due to the dynamic nature of business processes, and continuous improvement activities are generally required to lengthen the life of these expensive systems. However, the amount of customization required should be at a bare minimum (Monk & Wagner, 2012).

According to Fryling, Meg (2010), There are three options to do various levels of system customization such as rewriting part of the delivered software, writing a homegrown module to work within the ERP system, or interfacing to an external system, with the first being the most invasive and costly to maintain

BGI Ethiopia deployed an ERP System (Microsoft Dynamics Ax) in the year 2014.The company implemented Financial Management, Supply Chain (PR preparation only),and HR and third party Payroll functional modules. During the process of integrating these modules there were a lot of challenges starting from not having a clear implementation strategy, governance standard business process, data management, change management, Security and compliance. In addition, the acquisition process of additional Brew factories brought a more diverse challenge since it required structure change, infrastructure change, and management change. It has been also a challenge to decide which ERP system to keep and which one to drop since the newly acquired factories brought their own standard ERP system. As a result of these ERP systems from different vendors, the company is undertaking expensive and time-consuming projects to integrate the systems. According to Kraemmerand (2003); Vilpola and Heidi (2008), ERP systems are theoretically based on industry best practices and their makers intend that organizations deploy them "as is". ERP vendors do offer customers configuration options that let organizations incorporate their own business rules. However, there have been major customizations by rewriting the delivered software to date due to a continuous business process change and requirement change. Most of the requirements that come from internal sources includes Organizational structure change, Drastic business process reengineering, IT Infrastructure and System Version change, Future Communication and computing technologies integrated to ERP, and Newly acquired factories with their own ERP System.

Despite wide adoption, organizations ERP systems face persistent integration challenges. At BGI Ethiopia, ERP Systems have been implemented, yet integration across functional units remains fragmented, resulting in redundant tasks, inconsistent data, operational inefficiency and poor decision making. While previous studies has extensively addressed ERP implementation and technical architectures, limited scholarly attention has been given to holistic enterprise integration framework tailored to post implementation context in complex organizational environment like BGI Ethiopia. Additionally, existing models often lack adaptability to unique business process and local organization realities creating a research gap in developing a context-specific, scalable and governance aligned ERP integration framework. This study seek to fill the gap by designing a conceptual and architectural ERP integration framework based on practical evidence from the organization under study and a comprehensive review of existing literature.

Additionally, it provides insight into the challenge of ERP system integration and utilizes the proposed framework for their integration intentions.

Research Questions

This research tries to answer the following two questions:

RQ1. How does ERP system integration at BGI need to be carried out?

RQ2. What ERP integration framework is appropriate?

1.5 Objective of the study

The general objective of this research is to Design a conceptual ERP system integration Framework to enhance the existing ERP integration practice of the organization under study.

The specific objective is to focus on providing a comprehensive literature review and asses BGI Ethiopia practice about ERP System integration. Particularly, the study will have the following sub-objectives:

- To investigate the existing ERP integration practice and challenges in the company under study, focusing on technical, business and strategic perspective.
- To identify key challenges and enablers affecting the integration across ERP platforms and enterprise applications.
- To evaluate relevant ERP integration framework, models, Enterprise architecture methodologies and best practices from existing literature.
- To design a customized ERP integration framework that address BGI Ethiopia organizational context, system diversity and strategic goals.
- To evaluate the proposed framework by the expert to ensure its applicability and effectiveness in improving the ERP integration Process.

1.6 Significance of the study

The study benefits different stakeholders. Primarily, BGI Ethiopia which is seeking to enhance ERP efficiency, reduces data inconsistency, and improves interoperability across various platforms. By offering a well-structured integration framework the study supports decision in ERP post implementation integration. Additionally, it supports IT professionals, system architect

and business managers in aligning integration initiatives with organizational goals. Theoretically, the study contributes to the growing body of knowledge of ERP integration by addressing the overlooked challenges of undocumented and fragmented integration practices.

1.7 Scope of the study

The study specifically examines the informal and unstructured integration practices and aim to develop a comprehensive and customized ERP integration framework. The scope includes a review of relevant integration models and framework from literature, a practical assessment of the organization current integration practice, and the design of a tailored integration framework that addresses data, process and system integration. While the proposed framework is derived from generalized models, its design is context specific and validated only within the context of BGI. Technical implementation or post-deployment performance evaluation is beyond the scope of this study.

1.8 Limitation of the study

First, the study is confined in a single organizational context, which limits the generality of the findings. Second, the proposed framework is not yet tested in a real time operational setting which limits its practical effectiveness. Third, due to time and budget constraints the study mainly focuses on qualitative data which is subjected to potential bias.

1.9 Organization of the document

This thesis is organized as follows:

Chapter one: presents an Introduction, statement of the problem, objective of the study, significance, scope and limitations of the study.

Chapter Two: presents a comprehensive review of existing literature related to ERP integration.

Chapter Three: is dedicated to provide details on the research design and methodology

Chapter four: is dedicated to provide details on Data analysis, findings and discussion.

Chapter five: is dedicated to provide details on the Framework Design and Development, demonstration, and evaluation.

Chapter Six: provides the conclusions of the study, and recommendations.

CHAPTER TWO

Literature Review

2.1 Introduction

This chapter review the research conducted on the areas of ERP system integration with the intention of identifying the challenges and factors affecting the integration and related framework designed to improve its successful integration. Hence, in this chapter, international studies have been reviewed and presented. The literature which relates ERP integration with Enterprise integration in terms of its definition, theories, characteristics and types is presented. The literature review also extends to cover the conceptual framework that has been done on ERP integration to bring Enterprise integration.

2.2 Enterprise Resource Planning

Before the Emergency of the ERP system there was a material requirement planning (MRP) system used to plan manufacturing production. Then MRP II emerged with enhanced functionality to improve manufacturing system integration by sharing data from several different functional areas, including sales, production, inventory, finance, and accounting. Today's ERP systems are derived from MRP II though they are different in so many ways, one of them being, the current ERP systems use client/server architectures to efficiently utilize resources instead of MRP II's server-based technology. Markus (2000) notes that modern ERP systems encompasses an even broader range of business processes and functional areas compared to MRP II and now used in a variety of industries such as healthcare, construction, education, retail business etc.

As noted by Callway (1999), a standard ERP package supports cross-functional business processes by integrating the following six primary business functions accounting and controlling, HR management, production and materials management, project management, quality management and plant maintenance and Sales and distribution. Additionally, recent ERP applications include Supply Chain Management (SCM), E-commerce, Customer Relationship Management (CRM) and Business Intelligence (BI) (Callaway, 2000).

Organizations implemented an ERP system with the expectation of getting tangible benefits of improved order management, reduced IT costs, improved responsiveness to customers, standardization of computer platforms, and global sharing of information. As noted by Bingi

(1999), the primary strategic advantage and the ultimate goal of an ERP system is enhanced system integration.

As noted by Beheshti (2006), organization implemented ERP systems to streamline and automate operation and integrate their core business processes to enhance operational efficiency and to improve the business performance. The integration process is both complex and expensive project since it requires a trade-off between customization of ERP system and restructuring existing business processes to fit the package (Law et al., 2010). Albuquerque and Simon, (2007) also noted, ERP projects involve complex socio-technical undertakings that seek the coordination of many stakeholders and technical components in the development or customization of the ERP system. Additionally, this complex socio-technical endeavor tends to change the organizational culture and how people do their work (Liang and Xue, 2004).

While multiple ERP System deployed to replace numerous legacy systems, they do not necisarily eliminate the need of other complimentary information systems (Lehmann and Gallupe, 2005; Xu, 2011). Over the past twenty years, systems boundaries have become unclear as ERP systems extend internal business functions to collaborate with business partners (Hsu, 2013). Given the evolving role of ERP as a core enterprise platform that facilitates interaction with customers and partners, system integration has become a critical aspect of ERP development (Hvolby and Trienekens, 2010).

2.3 Integration

Integration is the bringing together of related components to form a unified whole. It provides the foundation for coordination, collaboration, and synergy, and provides a holistic approach to decision-making, management, and control (Laudon & Laudon, 2020). On a similar definition, Integration involves the coordinated unification of diverse organizational systems such as ion of information systems, manufacturing, engineering, production, management, supply chains, financial and accounting, and human resource into a single, functioning whole. According to Grant (1995), when these components are effectively combined, they operate as one to support and advance the organization overall objective.

To remain competitive in the global market, organizations must achieve a seamless integration across their operations. Without adopting a comprehensive, organization-wide approach, it

becomes difficult to access the timely information necessary to make a quick decision. ERP systems are widely known by their preferred technology for enabling such integration (grant and Tu, 2005).

2.4 System Integration

A seamless integration between systems streamlines operations and brings a quick and unique selling point for business. For example, Apple is aware of the importance of seamless integration between its products (iPhone, iPad, MacBook and others) syncing seamlessly to deliver the ultimate user experience. These days smooth integration between products of technology is becoming a prerequisite for modern society. In other words, societies need products and services that can be used effortlessly in the appropriate context. Examples of the need for integration can be found across different disciplines and industries. One of the disciples that require a seamless integration between its products is IT. According to Azuma (1997), the way that Augmented Reality (AR) is incorporated into human existence through wearable technology, cameras, games, and instructional materials serves as a reminder of the necessity of integrating technology into daily life. Additionally, Rajabalinejad (2018) pointed out that machine learning and artificial intelligence are two more instances of technology being utilized to enable improved performance and greater capabilities through integration.

Achieving seamless integration of products into daily life presents significant challenges, driven by the rapid change of technological innovation and dynamic environment. To remain effective, system must be purpose-driven and capable of adjusting their functions in response to the dynamic change. Effectively integrating emerging technologies with operational systems is gaining critical importance, as there is a growing expectation for robust and resilient service delivery (Wied, Oehmen, & Welo, 2020).

In the context of technology integration, failure to properly connect systems creates significant risks and leads to inefficient use of resources. Incorrect integration of new technologies can incur additional costs, reduce service quality, waste valuable resources, and potentially cause harm to users, infrastructure, or the environment. Often, such integration challenges require expensive redesigns or reengineering of systems, particularly if problems are identified late in the lifecycle, such as during the operational phase or after project completion.

According to Rajabalinejad (2018), Different levels of integration problems might arise, and their effects can go beyond simple technical problems. Rapid technological advancement necessitates solutions that successfully manage data integrity, security, privacy, and system interoperability and dependability in addition to meeting technical needs.

2.5 System of Systems Integration

System of systems integration refers to the integration of two or more systems, or integration at the system of systems level. A system of systems (SoS) consists of a combination of two or more independent systems. According to the SE handbook, SoS is a system whose elements are managerially and/or operationally independent. Therefore, the interoperability of the integrated systems or subsystems is usually not achievable by an individual organization (Jamshidi,2008).

Jamshidi (2008) emphasizes that integration is fundamental to the viability of any system of systems, as it enables the coordination and emergence of new capabilities across independently managed subsystems.

Integration means systems can communicate and interact through different interfaces, which take forms such as hardware and software. In this respect, a system uses services from other systems or delivers services to other systems. This requires collaboration between different organizations. The key factors in delivering optimal results are shared objectives among organizations, the co-creation of desired capabilities and the co-integration of interoperable services (Rajabalinejad & Dongen, 2018).

2.6 Information System Integration

Information system integration has two perspectives, according to Chiang, Lim, and Storey (2000) and Goodhue, Wybo, and Kirsch (1992). The technical perspective contends that integration is a way to illustrate how information technologies are interconnected within an organization and how much a shared conceptual representation of data elements is shared. According to the second viewpoint, integration is the extent to which two or more separate firms have standardized business procedures that are securely connected by computers and telecommunications technologies.

Dechow and Mouritsen (2005) assert that information system integration contributes to the dissemination of standardized information architectures, which in turn influence corporate priorities and practices.

The ultimate goal of these systems is to facilitate the development and manipulation of thorough virtual viewpoints on operations and resource flows, as well as the systematization and coordination of record-keeping, classification, and transaction aggregation structures (Chung & Hsu, 2006).

2.7 ERP Systems Integration

The process of building and managing interfaces and connections between the ERP and other internal and external systems as a joint endeavor by various organizations and development stakeholders is known as ERP system integration (Banaeianjahrom, Kähkönen, Alanne, and Smolander, 2016).

Gulledge (2006) provided clarification on the concept of enterprise system integration by distinguishing between "big I" integration, where a single software application, like ERP, integrates business processes, and "little I" integration, where various approaches, like database-to-database and application server integration, connect enterprise systems. It is possible to conclude that integration is made up of a variety of actions when looking at it from the standpoint of an ERP system. Since the ERP system facilitates data flow between business processes, the aim of an ERP installation is to integrate business functions (Hsu, 2013). Nonetheless, there is still a requirement for many additional information systems, such Manufacturing Execution Systems (MES) and Decision Support Systems (DSS), and it is frequently required to integrate ERP at the application level with these systems (Shafiei et al., 2012; Tao et al., 2004).

According to Watts et al. (2008), bolt-on software like Customer Resource Management (CRM) and Warehouse Management System (WMS) frequently improve an ERP's functionality. External integration with business partners' systems is inevitable since the goal of a modern ERP is to serve as the foundation for business collaboration (Møller, 2005). Providing interfaces for clients and consumers to access the system via the Web or mobile devices is another way to integrate ERP systems. Portal-oriented application integration is the term for this kind of integration, in which an interface is created to show the information that the target user group

needs (Linthicum, 2004). Since ERPs must cohabit with other enterprise applications and systems, their implementation does not ensure organizational integration (Themistocleous, Irani, O'Keefe, & Paul, 2001).

2.8 Enterprise Integration

Organizations implemented several frameworks, tools and standards to improve an enterprise integration process, even though the frameworks individually are not good enough to serve as efficient IT management system. In this particular literature review the researcher tries to show the various EA frameworks and their relation to ERP integration to bring enterprise integration. In the study ERP integration is taken as one the main component to coordinate Enterprise resources in line with other best practices of Enterprise integration. The study uses the framework of ERP integration designed by Gannt and Tue, 2005 (six levels of ERP integration) ,Semantic and ontology integration framework, as well as TOGAF Architectural framework and other best practices to design a conceptual framework for the company under study.

2.8.1 ERP and Enterprise Integration

To make sure that the appropriate people and the right processes have the right information and the right resources at the right time, Brosey et al. (2001) define enterprise integration as the process of connecting and combining people, processes, systems, and technology. In order to facilitate collaborative business processes, enterprise integration is defined as the strategic examination of the procedures, techniques, tools, and technologies related to ensuring interoperability between IT applications both inside and outside the enterprise (Lam and Shankararaman, 2007). Above all, enterprise integration encompasses more than just technological integration. For comprehensive IT integration, it takes into account business processes that span many IT applications.

2.9 Enterprise Architecture

EA is the organization's current and future plan for IT infrastructure and business processes (Jeanne W. Ross, Peter Weill, and David C. Robertson, 2006). A conceptual blueprint that outlines an organization's structure and operations is called enterprise architecture, or EA. Determining how an organization can successfully accomplish its present and future goals is the

aim of enterprise architecture. The process of evaluating, planning, designing, and ultimately putting analysis on an enterprise into reality is known as enterprise architecture.

Because enterprise architecture (EA) focuses on integrating old systems and processes to create a seamless environment, it aids firms undergoing digital transformation. It also aids various departments within a company in expressing difficulties and hazards as well as comprehending the larger business strategy. An organization's departmental procedures can be unified and coordinated with the help of enterprise architecture.

Every business wants to get better, but for that to happen, the way it manages its enterprise resources needs to change. Enterprise architecture is one of the methods or instruments that a company employs to direct a successful transformation. Enterprise architecture should be in line with other procedures in order to properly execute changes (Greefhorst, 2013).On its own, the integration process sets off a complicated series of organizational change processes. Although the EA model is a tool for strategic management, the basic concept can also be applied to integration work (Saukkonen, 2013).

The business viewpoint, application perspective, information perspective, and technology perspective are the four perspectives that make up enterprise architecture, according to Michael Platt, a director in the strategic projects division at Microsoft.

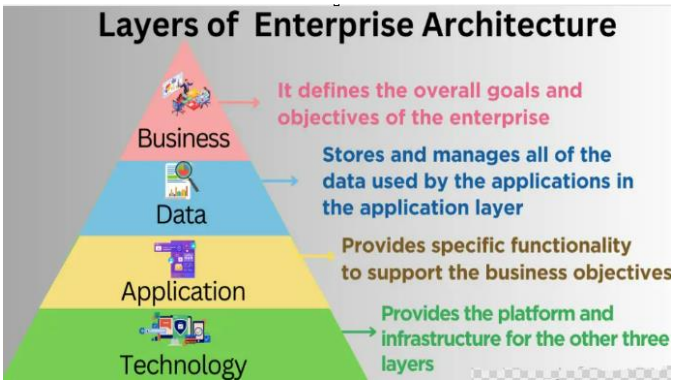

Figure 1 Layers of Enterprise Architecture

2.9.1 ERP and Enterprise Architecture

Information technology governance (IT governance), enterprise architecture (EA), and information system change management are enterprise resource domains, according to Ruta and Grabis (2015). The researcher focuses on corporate Architecture (EA) among these corporate

resource sectors in order to facilitate ERP integration, which in turn facilitates enterprise integration. Because enterprise architecture (EA) is essential to the planning, execution, and administration of ERP systems inside a company, the two fields are closely intertwined. EA basically acts as a guide for ERP system design and implementation.

To guarantee a smooth flow of data and procedures, EA evaluates how ERP modules connect with other programs and systems. ERP, after all, depends on reliable and consistent data, and EA makes sure that data management and governance complement overarching IT plans. Generally speaking, enterprise architecture offers the comprehensive framework and approach that directs the choice, creation, deployment, and administration of ERP systems.

2.10 Enterprise architecture Frameworks

An enterprise architecture framework is a set of guidelines and rules that help to design, plan, and manage an enterprise IT systems.

2.10.1 The Zachman Framework for Enterprise Architecture: offers a framework for arranging data, applications, processes, business, and technological information about an organization. It makes it very evident that there are other parties involved not only architects or developers, but also suppliers, business associates, and clients. (S. Wader, 2002). Business, Data, Process, Application, Infrastructure, and Technology are the six categories into which Zachman's framework separates enterprise architecture. There are sub-domains within each domain.

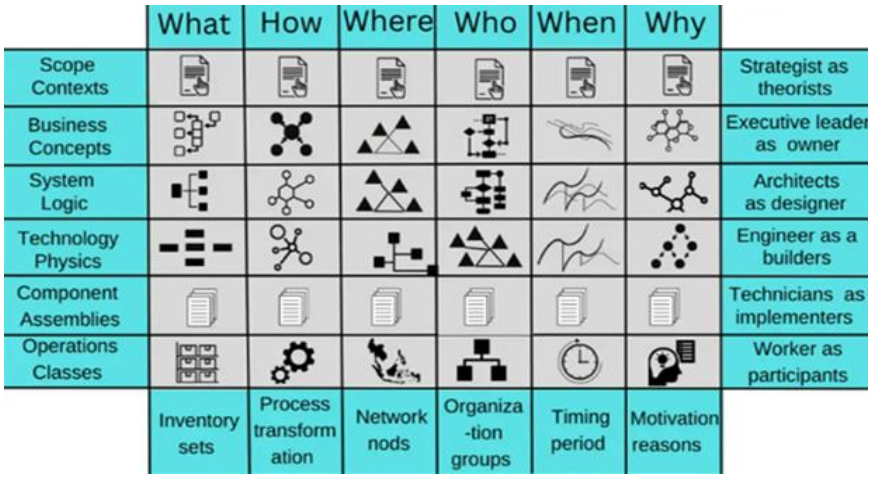

Figure 2 Structure of Zachman Framework

The stakeholders' perspective is represented by the columns, while the framework rows show the perspectives of those participating in the system development process.

Framework columns:

What (data), **How** (function), **Where** (network),**Who** (people), **When** (time), and **Why** (motive).

Framework rows:

• **Scope contexts (Planner's view):** These reflect the strategy and goal of the company.

• **Owners' perspective on business concepts:** These represent the aspects of the company that can be automated.

• **System logic (from the perspective of the designers):** This shows how the system satisfies the information requirements of the company.

• **Technology physics (from the perspective of the implementer):** Describes the system's implementation.

• **Component assemblies (subcontractors view):** These show the specifics of the implementation.

• **Operations classes (Users view):** These show how the system works.

2.10.2 The Open Group Architectural Framework (TOGAF)

The open-source TOGAF framework offers a methodical, conclusive, and tried-and-true approach to creating and managing corporate architecture. It offers a thorough strategy for matching business procedures and IT infrastructure to the strategic objectives of the company. Any firm, regardless of size or industry, can adopt this all-inclusive framework. It assists companies in comprehending their existing situation, determining their goals, and developing a plan of action to reach those goals.

2.10.2.1 Essential Elements of TOGAF

Reference Framework: explains how an organization's enterprise architecture should be organized and structured. It also includes guidelines on how certain TOGAF applications should

be built and run, as well as how they should communicate with one other inside its enterprise architecture development framework.

Architecture Development Method (ADM): The method used by enterprises to plan, organize, and oversee their EA is called ADM. It aids in the development of an organization's architecture; it is a methodical approach to enterprise architecture development that may be modified to meet project specifications.

Figure 3: The Open Groups TOGAF Architecture Development Method

Technical Architecture: outlines the standards and technology that should be used in an organization's IT infrastructure. In order to help enterprises comprehend their options and make well-informed decisions on their IT infrastructure, it also defines various reference models.

Despite the abundance of Enterprise Architecture frameworks, the researcher chose the two mentioned above since they were directly related to the research topic (ERP system integration). By managing the integration and optimization of business processes and IT systems over time through its Architecture Development Method (ADM), TOGAF assists in directing the integration of systems, including ERP. It is a comprehensive enterprise architectural development framework that is process-oriented, customizable to businesses, and covers the entire lifecycle (planning, design, and governance), in contrast to Zachman's framework

2.11 ERP system integration challenges

Because ERP system integration involves multiple parties in its network, it presents a number of obstacles. The following list includes some of the variables influencing ERP system integration.

2.11.1 The Organizational Environment

ERP system integration is based on the organizational landscape, which includes the enterprise architecture (EA), ERP strategy, supporting practices, and the features of integrative systems. Political agendas and structural adjustments may also present new difficulties.

2.11.2 Partners

All parties involved in ERP development work together, and the relationship between the customer and the supplier, the supplier's knowledge, software vendors, consultants, supply chain (SC) partners, and standardization partners all seem to have an effect on how well the ERP system integrates. Any disputes that arise between these partners could cause the integration process to be delayed or altered.

2.11.3 Features of the ERP System

ERP system integration was shown to be significantly impacted by the system design and degree of customization at the system level. Although customizations is unavoidable in a typical ERP system, the degree of customization needs to be carefully considered to avoid significantly affecting performance because of the system's non-scalable architecture. Additionally, the system architecture needed to be adaptable enough to integrate with other systems.

2.11.4 Business process

The degree of system customization was influenced by business processes, which in turn had an impact on ERP system integration.

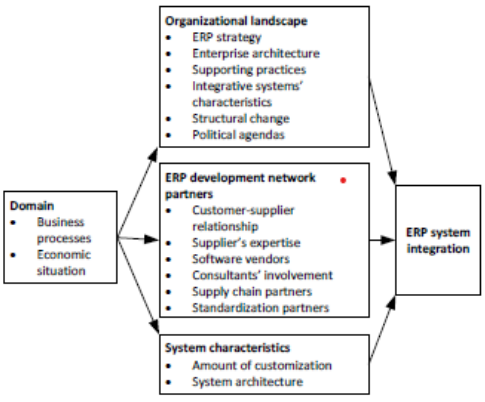

Figure 4 Factors affecting ERP System Integration

2.12 Obstacles of ERP integration

Various academics examined ERP integration challenges in light of the company's size and sector. According to a study on ERP system integration barriers by Banaeianjahrom, Kähkönen, Alanne, and Smolander (2016), the difficulties of integration differ based on the company's size and sector. They divide the challenges into four main groups: organizational, managerial, technical, and environmental.

Cases	Size and Industry
A	Large & global manufacturing enterprise with 30000 Employee
B	Large & global service provider in retail business with 1000 employees
C	Large and global manufacturing enterprise with 20000 employees
D	Large and global manufacturing and service provider enterprise with 5000 employees
E	Large and global manufacturing and service provider enterprise with 1600 employees

Table 1 ***the size and industry of ERP integration Challenge***

Main Theme	Categories of general ERP challenges from the literature	Integration obstacles derived from data	Cases
Environmental obstacles	Intra-organizational environment Issues related to organizational culture as well as organization's experience on ERP projects	Complicated end product	A
		Inexperience on integration projects	A,E
		Heterogeneous operating environment	C
		Different strategic interests of business units	A
	Inter-organizational environment Issues related to external environment such as conflicts between the organizations, poor management of partnerships with these organizations and underperformance of either vendor or consultant	Sanctions in licensing	E
		Competitors taking new technologies into use	A,C, E
		Failing to commit customers in integration projects	A,D
		Discovering a way to satisfy customers by integration	A,E
Technical obstacles	ERP-product selection & implementation strategy Issues regarding selecting and comparing different ERP products	Selecting unsuitable integration technologies	A
		Troublesome management of integration product licenses	A,E
	ERP system characteristics Issues related to the lack of ERP system's quality	Design flaws in ERP system	A
		ERP system's incompatibility	A
	IT-infrastructure & legacy systems Problems in integrating the ERP system with other systems and converting the data between the	Characteristics of integrative systems	A,B

	systems as well as managing the master data	Complex systems landscape	A,D
		Troublesome migration	A,B
	ERP software development & configuration Issues dealing with requirement specifications definition and changes, system configuration, and software development tools and methods. Also, issues related to troubleshooting and functional testing of the software	Poor evaluation of integration requirements	A
		Slow development process	A,B,C
		Inadequate testing of integration	A
		Lack of knowledge on integration	A,E
Managerial obstacles	Business visioning & planning Issues in creation of the business case for the system, setting up business goals and justifying the ERP acquisition financially	Cost cutting hindering integration projects	A
		Insufficient identification of business needs & evaluating the benefits of integration	A
	Organizational management & leadership Issues related to top level management's involvement, capabilities and actions in the project	Top management does not understand integration	A,C,D
		Top management does not support integration	A,D,E
		Lack of company-wide policies for integration	A,D
	Project management Issues regarding the project scope, responsibilities, and resources. Also issues related to crisis and expectations management	Troublesome management of integration projects	A
	Project team & human resources Challenges related to structure and composition, and skills of the people in the project team. Also issues related to empowerment, motivation and incentives	Lack of integration experts	D
		No dedicated persons for integration	D
	Quality management & evaluation Challenges related to measuring the performance and acceptance of the system	Not measuring integration projects	A
Organizational obstacles	Change management Issues related to business process re-engineering, training and education. Also factors related to misunderstanding of the change caused by the system and its implication to organizational culture, personal factors and political issues	The need for comprehensive training	A,C,D
		Personnel change resistance	A
	Communication & coordination Factors related to communication style, coverage and planning. In addition, issues related to knowledge management and unsuitable communication tools	Lack of collaboration	A,D,E

Table 2 Main themes, literature categories and integration obstacles (adopted from Banaeianjahrom, Kähkönen, Alanne and Smolander 2016)

2.13 ERP Integration Frameworks

ERP is the technology of choice for achieving integration. However, the success and failure of ERP depends on how effectively companies use the system to improve integration (Grant and Tu, 2005).

Recent research on integrating ERP systems shows a move toward alternatives that are more flexible, cloud-based, and focused on ecosystems. Companies are still at very different levels of integration maturity, but current ERP systems are becoming better at supporting incremental adoption, modular architecture, and real-time data interchange through APIs and iPaaS platforms (Alshamaila & Papagiannidis, 2023; Xu, 2011). Even though technology has come a long way, failure rates are still high. This is generally because of bad change management, lack of coordinated business processes, and opposition from the company (Bradley, 2008; Schlichter & Kraemmergaard, 2009). To deal with these issues, today's best practices focus on digital process reengineering, ongoing training, and structured change models like Kotter's framework (Kotter, 1996; Lam & Shankararaman, 2007). This is a big improvement from the problems of the early 2000s.

According to Main (1990), there is no universally accepted definition and objective measures of integration. Multiple definitions, subjective measures, and their associated interpretations, are testament that integration is neither static nor absolute. Hence, it is required to define some of the components that need to be considered during ERP integration and define different levels of integration. Accordingly, Gannt and Tu (2005) proposed a six level of integration framework. It is a stage growth maturity model for achieving integration using ERP (Holland & Light, 2001).

The below framework of ERP integration (see figure 1.) represents the external environment as a rectangle and the company as a circle. The company is comprised of six interrelated levels of integration connected to the environment via inputs and outputs represented by the heavy arrows. Smaller arrows represent connection between various levels of integration.

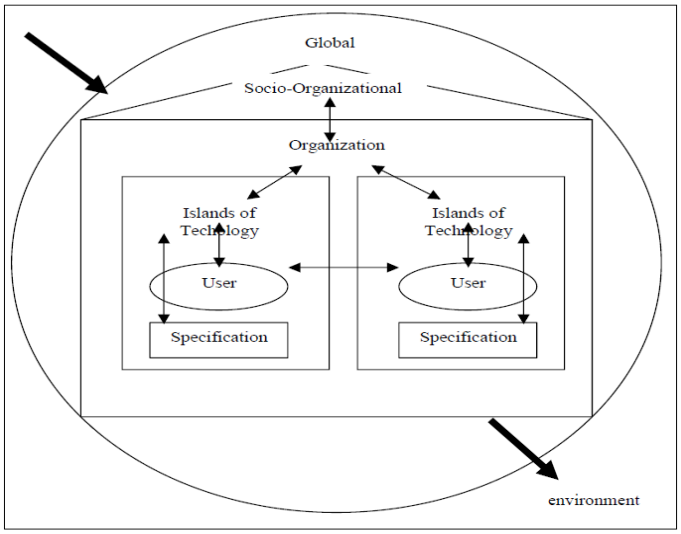

Figure 5 Six levels of ERP Integration (Grant and Tu 2005)

2.13.1 The Six levels of Integration

Level-1: system-specification integration.

The lowest degree of integration is focused on compatibility and specification integration. The technical design specifications of the system at the hardware, software, and application levels of standalone equipment are the main focus of specification integration, while The degree of compatibility among the different parts of the system is the focus of compatibility integration. Application programs and associated software, for instance, need to work with the operating system.All higher levels are built upon this specification, which should also include the effective use of human resources (Rotemberg & Saloner, 1991).

Level-2 system–user integration

Ensuring that users are integrated with the environment and technology is the focus of system–user integration**.** Two forms of integration are involved: cognitive integration guarantees that the information, error messages, and other communications between the system and the user are understandable, practical, and in line with the user's frame of reference, while ergonomic integration guarantees that the system and the surroundings are ergonomically designed.

Level-3: islands of technology integration

Technological islands Integration connects the company's geographically separated technological islands. At this level of integration, communication between these islands is a concern. ERP is frequently the answer to this issue since this kind of integration is the outcome of ad hoc

development that lacked enterprise-wide integration (Mathew, 2006; Themistocleus, 2002) (Truman, 2000).

Level-4: organization integration

The capacity to support the company's overall business goals and objectives is known as organization integration. Internal vertical integration, internal horizontal integration, strategic integration, and internal temporal integration are the four forms of integration that are involved in value chain integration, which oversees the efforts of different functions throughout the value chain (Rockart & Sbort, 1989; Sheu et al., 2003). Information flow from strategic management to non-management and vice versa is known as internal vertical integration. The degree to which an organization's information systems support its strategic goals, objectives, and critical success factors (CSFs) is measured by strategic integration. The efficiency and cooperation of departments, groups, functions, and individuals are measured by internal temporal integration. Business process reengineering, a challenging and disruptive technology (Davenport, 1998; Kumar et al., 2000; Markus & Tanis, 2000), is necessary for Level-4 integration (Bhatt, 2000).

Level-5: socio-organizational integration

Connecting the business to suppliers, customers, strategic partners, the government, and civic organizations is known as level-5 integration. It coordinates the task environment (Truman, 2000) and incorporates supply chain management (SCM) and customer relationship management (Mendoza, Perez, & Griman, 2006; Scheer & Habermann, 2000; Sheu et al., 2003; Zheng, Yen, & Tarn, 2000). Four different forms of integration are involved: shared-vision integration, external horizontal integration, external vertical integration, and external temporal integration. The relationship with clients, suppliers, and other business partners is the main indicator of external horizontal integration. The degree to which businesses are integrated with external control agencies, such as local, state, and federal organizations, is measured by external vertical integration. The degree to which businesses are able to promptly coordinate their operations with external institutions is a measure of external temporal integration. When corporate partners have a common vision, this is known as shared-vision integration.

Level-6: global integration

Businesses must be seen as worldwide with a domestic component and function as a single global entity rather than separate geographic entities (Ein-Dor & Segev, 1993; Fiderio, 1990). The highest level of integration, level 6, focuses on integrating across national and cultural

boundaries (Rochester & Douglass, 1992). In addition to the needs of the global economy (Barker, 1993; McGowan, 1989), it addresses language, time, culture, politics, customs, and management style (Hofstede, 1983; Simchi-Levi, Kaminsky, & Simchi-Levi, 2000; Trompenaars & Hampden_turner, 1998). International horizontal integration, international temporal integration, and cultural integration are the three forms of integration that make up level-6 integration. The efficiency of conducting business across national borders is the focus of international horizontal integration, which encompasses all information and data that go across borders. Businesses operating in multiple nations with disparate time zones are associated with international temporal integration. Businesses are compelled by cultural integration to acknowledge the subtleties and distinctions of different cultures. Linguistic, cultural, legal, economic, and political issues are specific to different civilizations.

Table 3 ***Summarizes types of integration at each of the six levels***

Levels of Integration	Types of integration	Related studies
Level-6 Global Integration	Internal horizontal, Internal Temporal and Cultural	International supply chain integration (Sheu et al., 2003); international environment (Phatak, 1989)
Level-5 Socio Organizational Integration	External horizontal, External Vertical, External Temporal, and shared vision	Interface integration (Truman, 2000); Total Information Solution or External Information Management (Li, 1999); EDI (Cash, Eccles, Nohria, & Nolan, 1994; Choudhury, 1997; Emmelhainz, 1993; Hart & Estrin, 1991; Iacovou, Benbasat, & Dexter, 1995; Nygaard-Andersen & Bjorn-Andersen, 1994; Ramamurthy, Premkumar, & Crum, 1999); internet (Scheer & Habermann, 2000)
Level-4 Organization Integration	Internal Vertical, Internal horizontal, and Internal temporal strategic	Functional integration (Al-Mashari & Zairi, 2000; Burbidge et al., 1987; Hammer & Stanton, 1999; Yates & Benjamin, 1991); electronic exchange environments (Truman, 2000); and Level-4 integration (Meredith & Hill, 1990); and interrelatedness (Rotemberg & Saloner, 1991)
Level-3 Ice lands of Technology integration	Horizontal and vertical	Internal integration (Truman, 2000); Level-2 integration (Meredith & Hill, 1990); functional integration (Burbidge et al., 1987); horizontal integration (Bullers & Reid, 1990); data integration (Bhatt, 2000); enterprise integration (Hasselbring, 2000; Mendoza et al., 2006; Rotemberg & Saloner, 1991); system integration (Rockart, 1989)
Level-2 System-User Integration	Ergonomic, cognitive and Human computer interaction	Compatibility integration (Rotemberg & Saloner, 1991); technology adoption (Hwang, 2005)
Level-1 System-Specification Integration	Specification and compatibility	Middleware integration by Hasselbring (2000); Level-1 integration by Meredith and Hill (1990); and internal integration by Truman (2000)

2.13.2 A Semantic ERP Integration Framework (Naglaa, Emad, and Hatem, 2016)

The researchers in this particular study employ a semantic-based framework to make ERP integration easier by adding a semantic logic layer, which transforms ERP into a knowledge-centric ERP system that is semantically complete. Semantic process modeling has been included into enterprise applications like ERP. When businesses attempt to integrate ERP with other current programs, they encounter significant integration challenges.

Interoperability must be achieved during the computer system integration process (Semerhanov, Vargin, and Muromtsev, 2012).There are two aspects of interoperability: syntactic and semantic. The capacity to control the structure of system elements is known as interoperability. Syntactic interoperability is used when two or more systems can exchange data and communicate in any way. Semantic interoperability, on the other hand, looks for ways to meaningfully and accurately identify correspondence between varied cooperative functions in separate systems in order to provide outcomes that are helpful according to the end users of both systems.
In order to facilitate effective integration with other legacy systems and enterprise applications, the suggested framework seeks to enable semantic interoperability for data and process models that are present in ERP systems.

In order to facilitate process knowledge management, Lin and Krogstie (2010) proposed a paradigm based on semantic annotation of process models. To offer a general solution for the workflow as well as for the data and relations throughout the entire system, the framework incorporates a semantic business process layer. It aids in describing how the system behaves, what its objects do, and how the interaction between them changes. As a result, the suggested framework is regarded as a process-and data-driven paradigm. Additionally, the model is made to provide smooth system connection, whether it is with CRM, ERP, or another system.

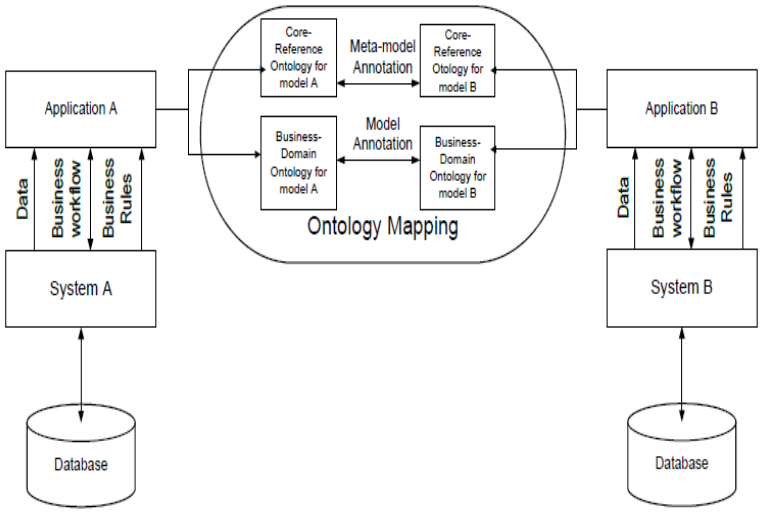

Figure 6 Conceptual models for the proposed framework *(Naglaa, Emad, and Hatem, 2016)*

In order to do the ontology mapping, the conceptual model for the suggested framework includes both model annotation and meta-model annotation. The interpretation of meta-data for each system, as represented by modeling languages such as Event Process Chain (EBC) and Business Process Modeling Notation (BPMN), is the responsibility of meta-model annotation. However, by annotating business process models, objects, and rules to domain ontology, semantic model annotation aids in achieving this goal. The difficulty of computer system integration is reduced to the problem of mapping between the conceptual domain models, since each model is a subset of the ontology.

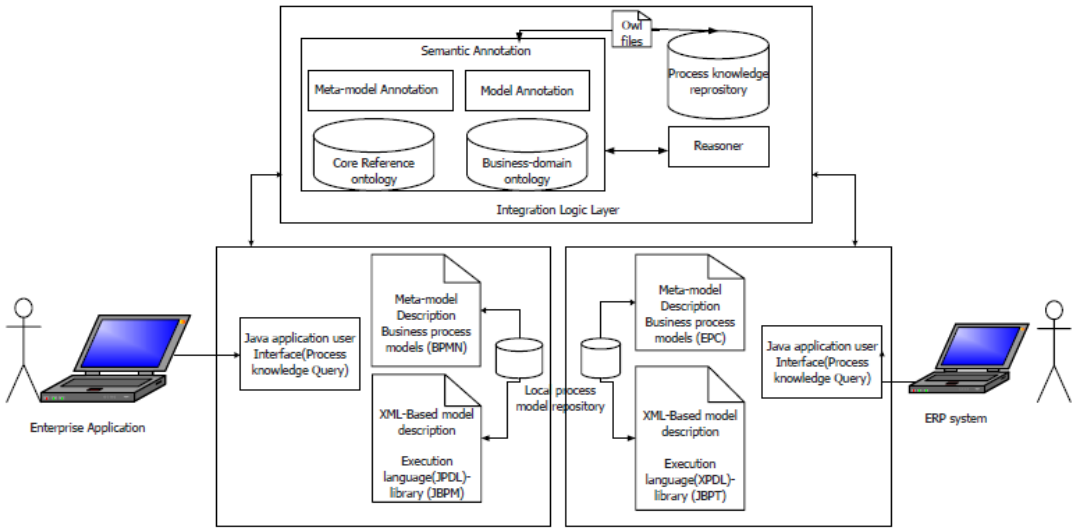

Figure 7 Architecture of the proposed framework *(Naglaa, Emad, and Hatem, 2016)*

The software solution in the above architecture of the proposed framework is a Java application that will deal with two types of modeling languages EPC and BPMN. EPC is used for ERP, and any enterprise application has models built in EPC. The framework proposed software will be developed for the integration of information systems based on ontology. The metadata and ontology description (Domain, Core Reference) will be based on XML technologies and models of OWL built-in protégé.

2.13.3 Legacy ERP Systems Integration Framework based on Ontology learning

Brodi (1993) defined legacy information systems as a class of information systems that were created a few years ago and have less advanced technology, but they nonetheless function regularly in companies to assist management and decision-making today. Distinct departments or sub-organizations within the company have distinct legacy ERP systems. The bulk of legacy ERP systems are heterogeneous, meaning they may have been created by various software companies using different development frameworks. This makes it difficult for organizations to create and deploy centralized and integrated management systems based on their current legacy ERP systems in order to react quickly to the changing business environment. Therefore, developing a broad framework that directs the integration of these ERP systems has become essential. As a result, the researchers suggested ontology learning as a useful tool for combining data from several disparate sources.

Ontologies have been used to address the issues of data heterogeneity since they are seen to be an efficient technique for integrating various data from several heterogeneous sources (Das, M., et al, 2015).

Maedche (2001), suggested the Ontology Learning Framework (OLF) to accomplish the integration of different data for the semantic Web and to offer a (semi-)automated tools and approach for ontology modeling. In order to successfully and efficiently integrate the different legacy ERP systems, the researchers in this particular literature review suggested an ontology-learning-based framework for legacy ERP system integration.

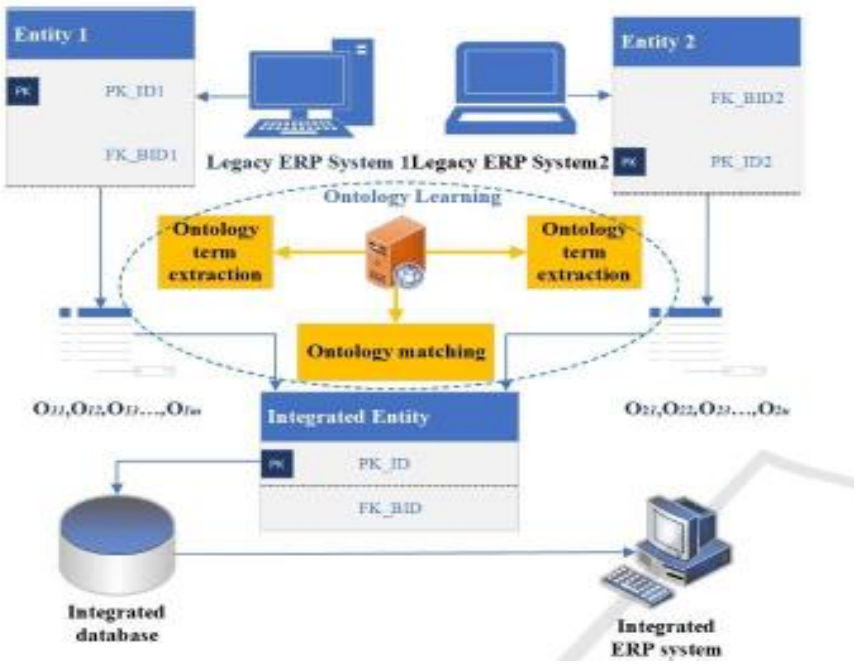

Figure 8 A Legacy ERP Systems Integration Framework based on Ontology learning *(Chuangtao and Bálint 2019)*

The following are the crucial ontology learning processes for integrating older ERP systems, according to Chuangtao and Bálint (2019).

Step 1: Pre-process of Entities Text Document: The framework suggests pre-processing of entities text documents using the methods of clustering, dimension reduction, and linguistic processing at the initial phase of ontology learning in order to achieve the ontology construction and mapping. This is because different entities have different formats and naming conventions among text documents, such as date formats, fields names, and so on, which create a significant barrier for ontology learning.

Step 2: Extract Ontology Terms from the Text Document: This step involves extracting terms from text documents and database scripts to represent knowledge and concepts using natural language processing techniques like semantic analysis, co-occurrence analysis, and hyponymy detection.

Step 3: Identify and Extract the Relationships among Ontology Terms: Ontology mapping and matching depend on relationships between ontology terms. To identify and extract these relationships, all ontology terms will be examined using the domain ontology and the association

rule-base.

Step 4: Use Relationships to Match Ontology Terms: Integrating the various historical ERP systems at the data integration level is made easier by matching the various ontology words based on their relationships. Prior to matching ontology terms according to their relationships, inductive logic programming should be used to extract the axioms pertaining to the relationships between the ontology terms. Subsequently, sets of ontology term relationships will be gathered; these relationships will serve as a foundation and source of helpful guidance to enable the integration process of the many database entities within the various historical ERP systems.

Step 5: Assess the Outcomes of Ontology Terms: Matching Prior to merging the various database entities within heterogeneous historical ERP systems, it is vital to verify that ontology words are consistent and then assess the outcomes of ontology term matching. There are four different sorts of methods for evaluating the results of matching ontology terms: manual evaluation, data-driven evaluation, application-based evaluation, and gold standard-based evaluation.

2.14 Related Works

Numerous scholars, practitioners, and researchers have tackled the integration issue during the past thirty years. As a result, numerous frameworks, methods, and resources were put forth. The researcher has chosen relevant publications that highlight the advantages and disadvantages of the integration approach.

Table 4 ***Strength and weakness of integration***

Models of integration	Strengths of the model	Weaknesses of the model
Towards a framework for integrated information systems Mathew (1986)	Focuses on MIS, CAD, CAM, and integrated DB	Ignores integration between functions, integration between firms, global integration, user integration, temporal integration; shared vision; strategic integration
Production flow analysis for planning group technology Burbidge (1987)	Focuses on inter-business function and intra-business function integration	Ignores integration between firms, global integration, user integration, temporal integration; shared vision; strategic integration
On the integration of information systems Bullers et al. (1990)	Focuses on EDP, MIS, DSS, ES, CMS, horizontal, vertical, temporal and physical integration	Ignores integration between firms, global integration, user integration; shared vision; strategic integration

Alternative research paradigms in operations Meredith et al. (1990)	Focuses on integration of standalone hardware and linking islands of technology	Ignores integration between firms, global integration, user integration, temporal integration; shared vision; strategic integration
Integration in electronic exchange environments Truman (2000)	Focuses on B2B-EDI, interface integration, and internal integration	Ignores integration between firms, global integration, user integration, temporal integration; shared vision; strategic integration
Enterprise Integration Methodology Lam& Shankararaman, (2007)	Focus on a structured step by step process and Facilitates project control and governance and best works on premise systems	Less responsive to agile/cloud environments integration and requires heavy initial planning and resource commitment
Empirical Integration Models Kähkönen (2014; 2015)	Focus on analysis of ERP integration challenges and Useful for diagnostics	Lacks a prescriptive integration framework, provide limited actionable guidance.
Strategic Data Governance Model Tallon & Kraemer, (2021)	Focus on alignment between integration intiatives and organization strategy	focus more on conceptual and governance aspects than on technical integration mechanisms
Lifecycle Integration Framework Shatat, (2022)	Comprehensive and structured framework for ERP integration and implementation.	Too generic for organization with legacy systems with limited empirical validation

Mathew (1986) started in manufacturing and used an integrated database to connect computer-aided design (CAD), management information systems, and computer-aided manufacturing (CAM). Because it just concentrates on the three information systems, this integration is constrained. Other information system components like CRM, ERP, DSS, SMS, and others are not included in the study. Additionally, the analysis ignores non-manufacturing industries and solely focuses on the manufacturing sector.

Integration is the connection of internal company functions across functional boundaries, such as marketing, production, and manufacturing, according to Burbidge, Falster, Riis, and Svendsen (1987). The necessity to facilitate communication and consultation, as well as to share information and goals, gave rise to their idea of integration. The study, however, ignores global and external integration, including supply chain, customer relationship, and strategic integration. According to Bullers and Reid's (1990) research, integration is the process of connecting Computerized Manufacturing Systems (CMSs) with four main categories of information systems (ISs): Electronic Data Processing (EDP), MIS, decision support systems (DSSs), and expert systems (ESs).

According to the researchers, connecting these four main categories of information systems necessitates four different forms of integration: vertical integration allows access to information for decision-making, while horizontal integration facilitates coordination among manufacturing functions. The physical integration connects geographically separated facilities, whereas the temporal integration allows the utilization of historical data for upcoming planning initiatives. Additionally, this study fails to consider external integrations like supply chain management (SCM) and customer relationship management (CRM), as well as user and worldwide integrations. Different levels of integration are included in Meredith and Hill's (1990) study to justify the cost of manufacturing equipment.level-1 integration to manage standalone computers by programmable controllers, level-2 coupling level-1 equipment's in a cellular structure to carry out various functions,level-3 manufacturing cells of Level-2 integration are connected to computerized information networks and finally level-4 which uses vast networks to connect the production function and all of its interfaces. The non-manufacturing sectors and external integration features like SCM, CRM, global integration, and strategic integrations are disregarded in the study, though.

Integration is associated with electronic exchange contexts, namely business-to-business and Electronic Data Interchange (EDI) system environments, according to Truman (2000). Interface integration and internal integration are the two forms of integration that are examined in this study. Interface integration is the process of integrating EDI with an organization's internal systems. The integration of an organization's internal systems is known as internal integration. This perspective is constrained since it ignores all other aspects of internal and external integration in favor of concentrating only on EDI.

It is evident from the above table (Table 4) that several studies have been conducted on the integration of an information system's various components. When the elements work together in the best possible way, they promote a company's mission and help it achieve its goals and objectives (Grant, 1995). Information system integration is still rarely studied, though, and we typically assume that ERP integration leads to enterprise integration. Integrating all business operations inside an organization is one of the main goals of enterprise systems (Schlichter & Kraemmergaard, 2009). An enterprise system does not ensure a comprehensive integration that facilitates easy communication between internal and external components.

Several ERP integration frameworks offer various perspectives to ensure a comprehensive integration, though each has its own limitations. Lam and Shankararaman (2007) propose a structured, step-by-step methodology that supports governance and is well-suited for traditional on-premise systems, but it is less adaptable to agile or cloud-based environments. Kähkönen (2014; 2015) provides valuable insights into ERP integration challenges and serves as a diagnostic tool, though it lacks actionable framework. Tallon and Kraemer (2021) emphasize on strategic alignment, offering strong governance insight but limited technical implementation guidance. Shatat (2022) presents a comprehensive and structured integration model, yet its broad scope may not adequately address the specific needs of organizations operating with legacy systems, and its practical application is constrained by limited empirical validation.

The idea of ERP integration taking into account different stakeholders and factors is extremely important in the case of developing nations like Ethiopia, particularly at the stage where the successful adoption of ERP systems is still in its infancy. Therefore, the purpose of this study is to examine the internal and external problems associated with ERP System integration and to suggest a conceptual framework in the context of BGI Ethiopia.

CHAPTER THREE

Research Design and Methodology

According to Kothari (2004), research methodology is a way to systematically solve the research problem. In this regard, this chapter deals with the research methodologies used to conduct the study and solve the research problem, along with a brief explanation why we use the specific design, method or approach. The chapter starts by explaining Design science research method, along with qualitative and quantitative methods used in the study, it then explain the approaches (case study approach) used to determine the logical reasoning. Additionally, it explained the research design, sampling, data collection methods (interview, observation and Document analysis) and Data Analysis method used in the study.

3.1 Design Science Research Methodology

Design-science research (DSR) supports a pragmatic research paradigm promoting the creation of artifacts to solve real-life problems (Hevner et al., 2004; Simon, 1996). It is fundamentally a problem-solving paradigm. DSR seeks to enhance human knowledge with the creation of innovative artifacts and the generation of design knowledge (DK) via innovative solutions to real-world problems (Hevner, March, Park, & Ram 2004).

In Design science research there are two commonly cited frameworks that provides guideline to researchers namely Peffers and Hevner DSR frameworks. Both frameworks ensure rigor in research process with their own perspective of design and evaluation process. In this study Peffers DSR framework is chosen due to its strength on problem and solution alignment with a well-defined evaluation process. Additionally, the framework is clear with detailed sequence of steps for conducting DSR (See figure 9).

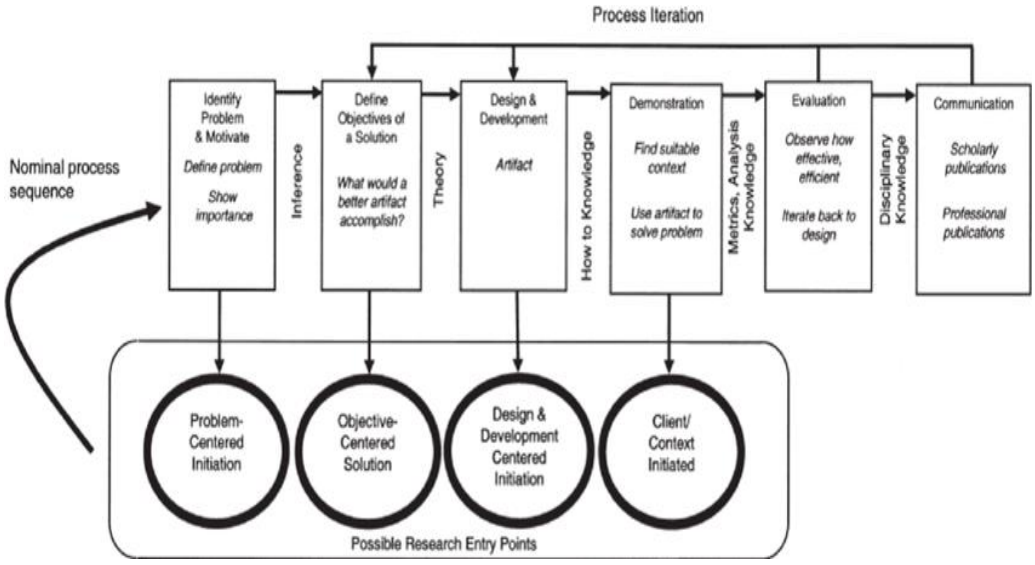

Figure 9 DSR Methodology Process Model (Adapted from Peffers et al. (2008))

In general, the DSR process consists of two basic processes: building and then evaluating the IT artefact (Baskerville et al., 2009; Hevner and March, 2003; March and Smith, 1995). In the building process, sequences of activities are conducted such as **Problem identification and motivation**, **objective of the solution**, **design and development** and **demonstration**. Then in the **evaluation** process, the artifact undergoes evaluation using various evaluation metrics to measure how it supports the solution to the problem. Finally, the conceptual design is communicated to all stakeholders to generate new knowledge about the problem using a formal communication. The newly generated insights serve to improve the quality of the IT artefact and the design process itself (Hevner, 2004).

3.1.1 Problem identification and Solution objective

According to Kähkönen and Smolander (2013), the original goal of ERP was to provide an all-in-one integrated suite for the enterprise. However, in a modern business environment, ERPs are integrated externally with customers, suppliers and business partners and internally with continuously changing system landscape of the enterprise.

Given the information provided by Kahkonen and Smolander, implementing ERP is crucial to improving operational efficiency through corporate integration. However, integrating internal business operations is not the only outcome of this integration process. As technology advances integration with other tools and platforms such as (AI, BI, IoT, E-commerce, etc), in addition to,

customer, supplier, and manufacturing systems is becoming increasingly necessary. However, these integration procedures provide a considerable difficulty, particularly in a dynamic and multi-vendor setting. The actual implementation of ERP systems necessitates a defined implementation strategy, governance, data management and migration, security and compliance, change management, customization, and organizational adaptation, despite the fact that these systems are designed to offer an integrated suite of processes.

Because of structural, technical, and managerial difficulties, BGI Ethiopia has faced significant challenges when integrating its ERP systems with other enterprise applications. The difficulties have also been worsened by the acquisition of new breweries, each of which has its own unique ERP system, resulting in a fragmented, costly, and challenging IT environment. The operational effectiveness of the organization is directly impacted by these integration issues, which lead to inaccurate and inconsistent data, inadequate security, poor reporting and decision-making, and a lack of coordination and cooperation.

This study aims to address the challenges hindering effective ERP integration by identifying key barriers and developing a practical framework designed to achieve targeted outcomes. Accordingly, the proposed framework is structured to fulfill the following specific objectives:

- Align the organization strategic objectives with the ERP integration strategy.
- Ensure sensitive data protection while transmitted between systems
- Improve interaction with external stakeholders or partners
- Ensure compliance with industry standards, best practices and internal policies
- Achieve Scalability and flexibility
- Ensure better communication and data sharing between departments
- Improve real-time decision making
- Enhance operational efficiency by reducing manual intervention and automating workflows.
- Ensure that data across different systems is consistent and accurate.

3.2 Research Approach

Along with the design science research process the study used a mixed (qualitative and quantitative) method to provide a more comprehensive understanding of the research problem.

According to Creswell and Plano (2011), mixed methods' is a research approach whereby researchers collect and analyze both quantitative and qualitative data within the same study. A qualitative method with exploratory nature is used in order to gain deep, detailed understanding of the integration process practiced in the company. Additionally, a quantitative method is also used to evaluate the framework via evaluation metrics.

3.3 Case approach

In line with qualitative research method, there are different types of research strategies: narrative, phenomenology, grounded theory, ethnography and case study. As a strategy of inquiry this study adopts case study. Case study observes a specific event or an activity in a limited environment and uses the data collected from the observations. This study is considering complex IT-business phenomenon which is ERP integration in a specific company, accordingly a qualitative case study is certainly the most fitting procedure for the case.

Yin suggested three types of case studies: exploratory, explanatory, and descriptive. In this study the researcher use an exploratory case study in discovering the key characteristics, relationships, and meanings between cases.

According to Yin (2014), case studies are appropriate when asking "how," "why," "what," and "who" questions. In the exploratory case study, the questions answered are "how" and "what." Accordingly, the study focuses on how an ERP integration process can be assisted via a convenient conceptual integration framework by identifying the challenges that hinder smooth integration.

According to Yin there are four types of designs for case studies based on a 2 × 2 matrix: These are (Type 1) single-case (holistic) designs, (Type 2) single-case (embedded) designs, (Type 3) multiple-case (holistic) designs, and (Type 4) multiple-case (embedded) designs. This Study falls under holistic (single unit of analysis) within single-case design.

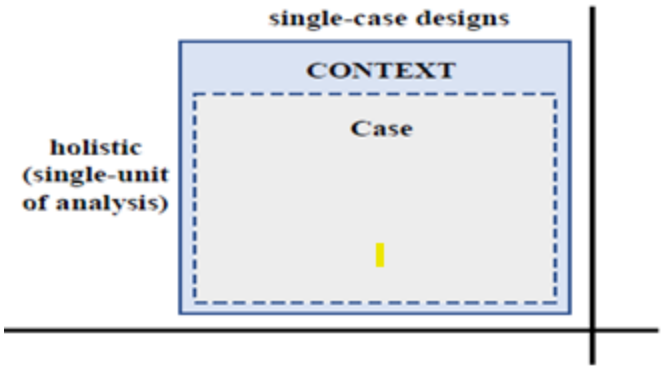

Figure 10 Single case design for case studies (Adopted with modification from yin, 2009 p.46)

The rationales for choosing the suiting design for the company under study are uniqueness, representativeness, typical nature and researcher experience.

The justifications for choosing BGI Ethiopia for a single case are stated below:

- It is one of the largest Brew industries in the country with six sub-Sideris that is struggling to connect with other affiliates abroad through Enterprise integration process.
- The company is strongly associated with complex ERP integration issues and challenges due to technical environment incompatibility, acquisition of additional factories with their own ERP systems (multiple vendors), upgrade issue due major customization, continuous business process and requirement change.
- The market demands for such a big company to smoothly integrate all the enterprise applications to make a sound decision.
- Finally, since the researcher used to work for the company under study as Enterprise Application Manager with the role of managing all enterprises applications, his observations of and insights into the problems of ERP integration formed a significant revelatory case.

  In addition,
- Access to available data
- Willingness of individuals to participate in the study

3.4 Method of Data Collection

The study uses different methods of data collection: semi-structured interviews, observation and existing documents review to reduce the likelihood of misinterpretation, biases, and inconsistency. These methods also assist the researcher to triangulate facts gained from one method with the other. According to yin (2009) triangulation technique is a process of using multiple perceptions to clarify meaning.

3.4.1 Semi-structured Interview

According to Denscombe (2014), interviewing is the most appropriate research method for exploring complex and subtle phenomena like opinions, feelings and experiences, complex issues that call for a detailed understanding of how things work or privileged information based on someone's experience or position. Accordingly, a semi-structured interview is used in the study due to its flexibility or the freedom to probe the interviewee to elaborate or follow the new line of inquiry. Additionally, it gives the interviewee a freedom of expressing an event or idea in their own terms. Burgess (1984), pointed out a semi-structured interview has been referred to as a 'conversation with a purpose.

In a semi-structured interview the researcher prepared an interview guide questions extracted from literature review that is well designed for the interviewees. The researcher used a mental framework of study questions, but the specifically verbalized questions as posed to any given participant will differ according to the context and setting of the interviews (Yin, 2009).

Prior to preparing the interview guide questions the researcher made a review of the company's overall strategy, environment, and technologies used to develop a good understanding of the topic of interest necessary for developing relevant and meaningful semi-structured questions. After understanding the organization overall integration objective, the researcher prepared an interview guide questions to understand the context of the company, ERP integration strategy, Data management, Technical aspect of Integration, challenges of integration etc. In each category the researcher chose relevant and understandable question to make the interview flow naturally. These questions were open ended questions that allow an interviewee to go back and forth while answering questions. Additionally, the researcher involved in the explanation of

topics or questions that were not clear for the participants. The questions were well designed following the logical order of the concepts and ensuring one question follows the other.

The interviews were conducted face-to face with the participants at their work place (BGI Ethiopia) in order to get a better understanding of the existing ERP Integration Practice.

3.4.2 Sampling

To explore the challenges and critical success factors in ERP integration the study use a qualitative approach. Based on their level of experience and involvement in the ERP integration the participants pool includes a diverse group of stakeholders, namely IT Managers, Programmers, BPO personnel, Support Team members, and End Users. To get a true representation of various functional areas and considering the diversity of roles and perspectives, participants for the study were selected using purposive sampling. Creswell and Poth (2018) stated 5 to 25 participants for qualitative case studies are considered sufficient. Accordingly, the researcher set a target of 10 participants to capture a rich understanding of ERP integration challenges and to identify recurring themes across different stakeholder groups.

Category of Participants	Number of Respondents
Managers	3
Programmers	1
BPO	2
Support	2
End User	2
Total	**10**

Table 5 Distribution of interview across their Hierarchy

The interview process began by reaching out to the chosen participants and providing a brief overview of the interview's purpose and procedure. Prior to the interview process the interview guide questions were shared through their e-mail address. The researcher asked the participants if it is ok to record the interview session after assuring the anonymity of their identities and responses. The interviewees were further informed that they were not bound to answer all the questions and could reserve their comments in answering to any question they may have felt uncomfortable. Given the time constraints of the participants, each interview lasted 45 minutes or more.

3.4.3 Observation

In addition to Interview, the researcher used observation to witness the integration process practiced in the organization**.** The researcher was part of the company under study with the role of managing enterprise applications. This gave him the opportunity to better understand the practical realities of ERP integration at BGI Ethiopia. The researcher observed routine business process and ERP systems interaction such as procurement, inventory and finance department as part of his job. A structured observation guide was used to record specific events such as data entry delays, module switching inefficiency (budgeting___ procurement___ inventory) and system-user interaction. Findings were documented through field notes and categorized under predefined themes (e.g. integration challenges, Technical approach, data inconsistency, Security etc.) to support triangulation with interview and document analysis.

3.4.4 Document Analysis

Finally, the researcher used document review to support interview and observation by analyzing the company's available documents such as IT policies and Strategy, business strategy, Information system architecture, reports, Work flows, FDD, training and workshop sessions. The document analysis enabled the researcher to double-check regarding particular issues that participants had difficulty remembering during the interviews. According to Zohrabi (2013), multiple ways of gathering information can supplement each other and hence boost the validity and dependability of the result.

3.5 Data Analysis Technique

This study used an Exploratory Sequential Design. This method of analyzing data lets the researcher look closely at the qualitative data gathered from interviews, observations, and document analysis before turning it into quantifiable numbers during the evaluation step of the framework design. The researcher employed case studies and thematic analysis in particular. These two data analysis methods are suitable due to the in-depth and detail exploration requirement of the study. A researcher used a case study analysis to evaluate the artifact in a real world setting as well as to gain a detailed, in-depth exploration of the context, application, and effectiveness of the artifact.

CHAPTER FOUR

Analysis, Findings and Discussion

The general data analysis technique used for this study is Exploratory Sequential Design; In particular, the researcher used a case study and thematic analysis. Using these data analysis techniques the researcher explores the qualitative data collected from interview, observation and document analysis in depth before quantifying the results gained from the evaluation stage of the framework design. The study uses a single case analysis to answer the research questions and attain the objective of designing ERP integration framework.

Identifying existing Integration practice in the organization under study is important to give special attention to ERP integration components that needs to be managed through the developed framework. Accordingly, the study focus on the technical challenges of ERP integration by identifying the key areas such as change management, data security, data consistency, system architecture etc.

BGI Ethiopia implemented ERP systems that undertake integration with other enterprise application. The researcher attempted to assess the various steps taken to undergo the integration by interviewing experts and users that participated in the process.

4.1 Profiles of Interviewees

The researcher used participants from different section of IT department, Project team, End-users to get an insight on the overall ERP integration practice. Each user has its own perspective of understanding the integration process depending on their experience and knowledge. There are six Users from IT department, two from project and two from end user with a total of ten candidates. Out of the six IT department members 3 of them are managers, one senior programmer and the rest two are support team. In order to preserve the anonymity of these employees, their names were replaced by pseudonyms (See table 6).

Category of participants	Role	Pseudonym	No of Participants
Managers	IT Service Delivery Manager	Manager 1	3
	Business Relationship Manager	Manager 2	
	IT security and Database Manager	Manager 3	
Programmers	Senior application programmer	Tech 1	1
Project team	Finance Project Manager	Project 1	2

	Supply chain Project Manager	Project 2	
Support	IT Support	Support 1	2
	ERP Support	Support 2	
End-users	Finance	Staff 1	2
	HR	Staff 2	
Total Number of participants			**10**

Table 6 Profiles of interviewees

4.2 Theme Generation

According to Ashley and Amanda (2018), thematic analysis (TA) is a data analysis strategy that is a commonly used approach across all qualitative designs. It is used to identify, analyze and interpret patterns or themes from different data source (Interview, document review, observation etc). Data analysis was conducted after the interviews were completed and the researcher follows the following steps to organize the data into key themes that reflect the integration process, challenges and success factors in BGI Ethiopia's ERP integration practice.

The researcher repetitively listens to the recorded interview to get a general sense of the data. While doing so a note is taken on ideas that require further elaboration as well as writing down recurring words or statements such as (data quality issues, resistance to change etc,) then categorize each recurring words in a commonly used ERP integration themes which were initially identified from literature. The identified themes from literature are well reviewed prior to incorporating the recurring statements or words from interview to ensure they capture the key aspects of ERP integration. Finally, key insights are generated from each theme that uncover systemic challenges or suggest possible improvements.

Thematic approach allowed the researcher to cover all aspects of the integration practices, from strategy to technical implementation to user adoption and future plan. Accordingly, the researcher structure the respondents reply with the following theme.

- **Theme 1:** understand the overall context and goals of the ERP integration
- **Theme 2:** Integration Strategy and Planning
- **Theme 3:** Technical Approach to ERP Integration

- **Theme 4:** Data management and accuracy
- **Theme 5:** Integration Challenges
- **Theme 6:** User Adoption and Experience
- **Theme 7:** Operational Efficiency and Process Improvements
- **Theme 8:** Monitoring, Maintenance, and Support
- **Theme 9:** Business Outcomes and Impact
- **Theme 10:** Future Plans and Improvements

4.2.1 Theme 1: understand the overall context and goals of the ERP integration

In order to understand the overall context and goal of ERP integration in the company under study, the researcher devised a question that identifies the ERP system and its integrated applications.

Accordingly, **Manager-1 and 2** replied**,** when asked to describe the company's ERP system and its integrated systems:

"There are about three ERP systems that are currently running in the organization namely Microsoft Dynamics AX (the first legacy ERP system acquired on 2014), customized Business central (Drinkit), and SAP success factor. These ERP systems are used to manage different functional units for instance, SAP success factor for HR management, business central for Finance, supply chain, marketing and production and Microsoft Dynamics currently running financial modules.
Further, the respondents said these ERP systems are integrated using an interface with other industry side applications such as Dimomaint which is used for warehouse management system and Eleader which is used for Customer relationship management."

When asked about the beginning of the integration process and the objective to it **Manger-1** said:

"The organization implemented ERP integration since 2016 with the objective of getting a full view of the organization business transactions."

Project-1 also added*:*

"Getting a consistent financial report from one source was very challenging; we were looking for data everywhere, for example: there is a budget data coming from Excel, other financial data from Peachtree, stock consumption from Dimomaint application and payroll from HR third party application."

These

According to Manager-2 the objective of implementing ERP integration is:

" Internal factors such as isolated systems, inconsistent data and other competitive marketing strategy forced the company to have an ERP system that integrates all business functions (Finance, HR, Sales and marketing, Supply chain, Production, CRM etc).Unfortunately, the first ERP system implemented in the company utilize only a few functional modules (Finance and procurement)."

The above reply from the interviewees shows there is an ERP system that is struggling to coordinate all the resources available to bring a more coherent and consistent output. The isolated data coming from various applications hinder operational efficiency, decision making, data consistency and waste lots of time. This kind of setup could imply challenges related to system interoperability, data consistency, and overall system efficiency.

4.2.2 Theme 2: Integration Strategy and Planning

In addition to understanding the overall context and objective of the integration process, the researcher attempted to find out how the integration was planned and the strategic consideration behind the process.

Manager-1 said:

"In the first ERP System there was no holistic view; most of the ERP integration projects or customizations were disintegrated." The researcher also noticed such a challenge when he was part of the first ERP Implementation project team."

At the beginning, the company was using a formal procedure to execute its ERP implementation. However, users request entertained unplanned after going live. For instance: A finance manager

may come and request a change in a certain process or field in the ERP system; this had a domino effect on related tables and on the entire integration process.

When **Manager-2** asked on how the integration strategy is developed and the approach used for integration. He explained:

"*There is no specifically articulated ERP integration strategy that enforces the team to understand the business needs. However, there is a general strategy orally communicated to gather requirement from different departments, to do feasibility study, master data cleansing, etc. In line with the general strategy the company is using a phased approach to implement the integration."*

The company is using multiple systems with multiple platform and technologies. These systems need a well suited integration method to bring operational efficiency, data consistency and quick decision making. However,

"The company currently using an ETL method to extract, transforms, and load data between ERP systems and enterprise applications. This method of Integration involves user intervention to manage the data before loading. However, it will be replaced with an API technology for second phase" Said **Manager-2**.This brings one of the biggest challenges of data security which is data manipulation.

"In the process of ERP integration a lot of stakeholders involved one of them being the External consultants with the role of feasibility study, FDD, designing and development, testing and user training" said **Manager-2 and 1**.

Manager-1 commented on the type of integration methods used.

"A secured FTP is used to transfer data from SAP to Dynamics AX with only authenticated users can have access to check its accuracy. However, Power platforms are used to manage the data coming from locally developed invoice management system. Both systems are from the same vendor (Microsoft) with internal ability to communicate.

He also added: *"An interface is used to communicate a stock management system with ERP systems by extracting data in CSV format and check the data accuracy and manually import it into the ERP Systems."*

With regard to the external consultants involved and the role assigned, **Project-1** Said*:" Many consultants involved in the ERP customization and integration process since the start of the project. These skilled personnel used their own coding procedures and data pulling mechanizes which leads to substandard customization or integration"*

The company under study is using a general integration strategy to understand the business needs and challenges. However, this strategy must be a specific ERP integration strategy that clearly identifies an integration that adds value to the organization. Further, even though there are many convenient integration methods available the company is using an ETL approach with user intervention. This shows interface or middleware is developed but not used end to end to bring a more consistent and reliable data. One of the goals of the ERP integration is to provide a more consistent and accurate data flow between systems.

4.2.3 Theme 3: Technical Approach to ERP Integration

In the technical aspects of ERP integration the interviewer attempted to identify the technical challenges and solutions related to integrating the ERP system. Accordingly, the types of systems integrated with company's ERP systems are identified. Additionally the technologies, tools and data management between the integrated systems were pointed out.

In connection to the platform and technologies used **Manager-2** explained:
"Two of the ERP systems are cloud based and one is on premises. Hence, the platform used is a challenging factor to transfer data via a secured line. Business central and SAP success factor are using cloud platform while MS-Dynamics Ax is on premises. The company is using a secured FTP server owned by the group Castel to manage the ETL."
The respondent also added, *all sites (RAYA, ZEBIDAR, HAWASA, KOMBOLCHA, and ADDIS) load their uniquely identifiable HR .XML data once in a month to an independent location on the FTP server while the other end awaits for all data to be batched for extraction and processing. Additionally, the company integrates a real time processing concerning daily sales, daily cash position, stock etc. using BI tools.*

Tech-1 added:

"In-house developed applications such as Dimomaint use a middleware to extract data from stock management system and load it to a specific location. This application has no validation rules set for data quality. Further, no controlling mechanism when data moves between applications. The respondent also added there is an on-premises Legacy system with outdated codes which create a loop holes for any security breach."

Manager-1 informed the type of system integrated with the current ERP system*: He said: "in addition to the standard types of systems such as CRM,SCM,HRMS, and Finance, a production and marketing modules are integrated in the new business central ERP System."*

In the technical aspect of ERP integration most respondents raise the issue of security with regard to the integrated systems and tools used. No IS security audit has been done on the overall infrastructure as well as on the integrated systems said the respondents, this in turn leads to a high vulnerability to any security breach. Further, since there is no controlling, data integrity is also a major concern.

4.2.4 Theme 4: Data management and accuracy

Data is a critical aspect of ERP integration, and the following interview session assesses the data handling mechanisms across the systems. Specifically, the researcher raised an issue of data synchronization, migration and measures taken to ensure data quality. Additionally, the validation mapping and transformation techniques used are brought to discussion.

The interviewees were requested regarding the data handling mechanism in place to ensure data quality. **Manager-2** mentioned: *"A team of people organized to create and manage the master data in the new ERP System. Before any migration these team of people are supposed to cleanse the master data and make it ready for migration or synchronization. Despite, the consistency and integrity issues are still there."*

Support-1 added: *there were a lot of data errors coming from the older ERP system which created a challenge on the data migration and synchronization. Those data took a lot of time to clean.*

In the data migration and synchronization process of the ERP systems the researcher also witnessed a lot of data entry errors due to no standard data recording format are available.

With regard to Data mapping and transformation **Manager-1** *and* **Tech-1** *replied: in the interface integration we extracted the required tables from both ERP systems and map the fields.*

One of the challenges of data migration is data duplication, inconsistency, outdated records etc **Support-2 explained***: there were a lot of data duplication especially on customer and supplier master data with different vendor or customer account. Additionally, a lot of outdated customer, supplier, and product records were deleted during the data cleansing process.*

The researcher used to witness lack of monitoring on master data creation. Many people were given permission to create a master data such as customer, product, or supplier with no standard format .These way of handing a master data cost the company a great deal with poor data quality.

4.2.5 Theme 5: Integration Challenges

Questions raised at this section helped the researcher to identify specific challenges and problems faced during the integration process. Accordingly, most respondents raised the challenges of data quality, data security, data governance etc. in addition to the following technical challenges.

In a dynamic business environment business requirement changes are expected with a few customizations to be incorporated and documented, however **Manager-1** Stated: *there is major documentation issue on how customizations and integration of ERP system has been done which lead to an integration issue with other system and Upgrade to a new release.*

With regard to down time challenge during integration **Support-1** said*: "though off hours are used to implement the integration on live system, there usually was a service interruption after integration." We usually restart the ERP service to bring the system back to live* said **Support-2**

When managing multiple systems integration complexity is imminent. **Manager-1** said: *finance users are asked to do technical IT works due to the ETL integration method used. For example: A finance user is asked to login to a server where the .csv file from an interface is loaded and extract it to its workstation and load it to ERP system after manipulation.*

One of the factors that determine the success of ERP integration believed to be a stakeholder's alignment and communication. In this regard **Project-2** and **Manager-1** said: *the new Integration project leader organized a team of seven (Project manager, Deputy, BPO from five departments) with a specific responsibility. These teams daily communicate with one another and with their respective department heads once in a week and with BOD once in a month. Any integration change will be communicated to staff members too.*

In connection with the infrastructure that supports the ERP system **Manager-1** and **Manager-3** reported: *The Company is using a state of the art technology to support the entire IT infrastructure such as Nutanix hyper convergent failover cluster Lenovo servers with SSD are currently used to manage the ERP Systems.*

The general output of this theme shows, though the company is using a state of the Art technology to support the ERP system and its integration, most of the integration involves human intervention and lack documentation on how each operation is executed.

4.2.6 Theme 6: User Adoption and Experience

One of the key factors to successfully rate integration is the end-users experience and adoption.

When the interviewees are asked to give thoughts in the ERP integration process in the organization, one respondent said, "*Since there is a good sign in user's attitude to adapt to the integration process, the organization must work towards boosting user's involvement in the process."*

One of the contractual agreements with the external consultants is to give training and support to the end users. *Training and support structure are in place to help employees navigate the integrated systems* said **Project-2**. There is a training server where key users login and train themselves and their respective end-users during the project launch. However, *user training is not something that should be done once and forget after project go-live* said **Support-2**.

The researcher raised a question to respondents about integrated system functionality, accessibility and responsiveness. Most respondent said: "*though system functionality and accessibility is attractive, they witnessed slow systems responsiveness during the reporting period which is usually the end of the month."* It is believed the over customization made on business process tend to have an impact on the overall performance and system responsiveness.

We usually restart the entire ERP system service to refresh the report generation Said **Manager-1 and Support-2**.

In general, most respondents believed *there is an improvement in terms of ease of use and effectiveness when we compare it with the legacy ERP system*. The new ERP system brings new user friendly interface where you get everything easily by simply putting a search word. *Everything is available in the front-end with the right parameter request* Said **Manager-2.**

Finally the participants were asked how they access data from the integrated system.**Tech-1** replied: *there is an in-house customized Business intelligence dashboard where users get consolidated data.* **Manager-2** Added: *Data about daily sales, cash position, and available stock are available on real time basis.*

The researcher strongly believes all concerned individuals in the organization should be involved in the integration process, while the organization creates an environment or platform where co-workers share their ideas. For the ERP integration process to succeed users must own the process.

4.2.7 Theme 7: Operational Efficiency and Process Improvements

One of the reasons why organizations integrate their silo systems is to bring an enterprise integration, which in turn expected to bring operational efficiency and process improvement. Hence, it is important to assess how the integration practice in the organization under study affected the business process.

Accordingly, the researcher raised questions like improvement in operational efficiency such as speed, accuracy, consistency and cost reduction due to ERP integration.

Manager-2 said: *previously we used to gather data from different sources to do financial budget which is taking too much time and usually not error free. After the integration of all the functional units, the process of budgeting becomes a one click away. However, even though all the data are available in one place users are still in doubt of the data accuracy and integrity and preferred to use their Excel to manage it.*

There were tasks executed multiple times by different systems. For instance: invoicing is done in the ERP system as well as in the stock management system. *Due to the integration this repetitive*

task is now done only once Said **Manager-2**. Additionally, *two important business functions (production and marketing) are streamlined as a result of ERP integration, which reduce the Excel data transfer from production and marketing to the rest of the departments.*

Most respondents believe *there is better data access and integration which leads to quick decision makings plus the integrated BI tools are helping the managers to get a real time reporting. However, there should be a strong access control mechanism in place to manage individuals access rights* said **Manager-3.**

The general outcome of this set of theme depicted there are improved integrated processes that enhance speed, accuracy and consistency, though they lack controlling and monitoring.

4.2.8 Theme 8: Monitoring, Maintenance and Support

Understanding how the integrated systems in the company are monitored and maintained is essential for ongoing success. Hence, the researcher assesses the monitoring, maintenance and support practice in the organization under study. Accordingly, the researcher tries to investigate the mechanism used to monitor performance of the ERP system and its integration, how maintenance is handled, troubleshooting and specific challenges during patching, feature integration or updates.

Support-1 pointed out that: *there is no performance monitoring in place apart from the ERP Database Disk Size monitoring. However, there is an assessment or status update weekly on the enterprise applications that gives a tip on the overall issues.*

In connection with the way system maintenance, updates or patches for integrated systems handled **Manage-1** said: *it is very challenging due to lots of customization in the legacy ERP system and with a support contract ended long time ago. On the other hand, the other ERP systems (SAP and Business Central) are on-cloud; it is the host that manages all the patch updates and maintenance.*

The researcher asked who is responsible to troubleshoot any integration related issues **Tech -1** and **Support-2** replied: *Internal IT team in collaboration with third-party support for on-premises systems. However, for those that run in the cloud the consultants is handling any integration issues.*

Support-1 commented: *we are unable to change computer name or Operating system upgrade due to application compatibility issue,* **Manager-1** supported the idea by stating *lots of customization has been done on the legacy ERP system that complicates the maintenance and upgrade program.*

These maintenance and support issues forced the company under study to look for other options (SAP or Business central) following the best practices of system integration.

Accordingly, the company owns the two strong ERP systems for financial, supply chain, production, marketing and HR modules. *Along with their enormous benefits these ERP systems show alerts with red flag when error happens with specific details which in turn assist the troubleshooter to identify the problem easily said* **Tech-1.** Since these systems are hosted on cloud, Performance monitoring and ongoing maintenance is done by the third party. *Most importantly, Standard process and best practice are followed during the integration process* said **Manager-1**

In this section the general outcome can be considered as lack of monitoring on performance of ERP systems and its integration. Further, a lot of customization that has been made on the legacy ERP system hinders the integration as well as the maintenance, upgrade, and features inclusion. It is important to point out that a support contract with partners is crucial to sustain the business process.

4.2.9 Theme 9: Business outcome and Impact

This section intends to find out the tangible results and outcomes of the ERP integration. In this set of theme the researcher tries to investigate the impact of ERP integration on business objective, customer satisfaction, revenue generation, competitive advantage over its rivals, and impact on company growth, scalability, or ability to adapt to market change.

When asked about the organizations achievement of its initial business objective due to ERP integration, **Manager-1** replied *there are processes that are becoming more efficient than before though it lacks follow up. For example: the process of production and marketing. Further, there is a good progress with data visibility though it requires more work in terms of monitoring and analysis.*

Other responses from employees indicated that *better improvement are seen in almost every corner of the integration process that enhance customer satisfaction, revenue generation and get a competitive advantage, however, these integrations are not well compressive to bring an Enterprise integration to lead to an end to end process management.*

With regard to Scalability of the organization the researcher pointed out. BGI Ethiopia started the road to ERP integration with three factories via Microsoft dynamics AX ERP system. After two years the company owns three more factories with their own ERP system. This acquisition brought a challenge on the overall scalability of the ERP system which leads to struggle to cope and perform under expanding load.

4.2.10 Theme 10: Future Plan and Improvement

Understanding the future plan and areas of improvement can guide ongoing optimization efforts. To investigate the organization future plan and improvement areas, the researcher raised the following questions.

Manager-2 replied when asked about the improvement or enhancement plan to the ERP integration.

"*There is a phase 2 that will be coming soon to change the manual ETL method to API so that automatic data synchronization carried out smoothly". Additionally, planning module will be integrated in phase 2.*

"There is also a phase 3 that rollout integration between POS system with the ERP system"

In the next five years the company will migrate all of its business data to the cloud where data volumes, integration complexity, business requirement handled by the third party following the standard Said **Project-1**.

In connection with lesson learned during the integration process, **Manager-2** said*: "rather than bringing the ERP system to your business process, take your business process and integrate it to the ERP system of your choice following best practices* ."

Finally, when the respondents are asked their overall evaluation of the integration practice most reported that "*there is implementation governance issue in the existing ERP integration practice."*

4.3 Discussion

In this section, the researcher offers a comprehensive analysis grounded in the findings of the preceding case study, contextualized within the ERP integration framework and supported by relevant literature. The discussion synthesizes insights derived from interviews with employees, document reviews, and observational data. These insights are then aligned with the study's main research questions and objectives as outlined in Chapter One, providing a structured evaluation of ERP integration practices and challenges.

The analysis revealed the gaps on the existing ERP integration practice in the organization under study. The company is using various enterprise applications and ERP systems to maintain and support its daily operation. The organization implemented an on-premises legacy ERP system in 2014 (MS Dynamics) which works at basic functional module level. The ERP system in use has undergone extensive report customizations that deviate from established best practices. As a result, the system experiences performance issues during report generation. Moreover, the non-standard customization approach has made system upgrades and patching significantly more difficult and complex.

The organization currently employs a broad integration strategy to assess business requirements and challenges. However, this approach should evolve into a more targeted ERP integration strategy that explicitly defines value-adding integration points aligned with organizational objectives. Despite the availability of more efficient integration methods, the company relies on an ETL process that requires manual user involvement. This indicates that while an interface or middleware solution has been developed, it is not fully leveraged to enable seamless, end-to-end data integration. One of the key objectives of ERP integration is to ensure a consistent and accurate flow of data across systems, which remains partially unfulfilled in the current setup.

Within the technical dimension of the BGI Ethiopia ERP integration framework, several respondents highlighted security concerns related to the systems and tools involved in the integration process. Their advice indicates that the firm is extremely vulnerable to possible security breaches because no thorough information systems (IS) security audit has been carried out, neither on the interconnected systems nor on the entire infrastructure.

Additionally, the absence of robust control mechanisms raises significant concerns regarding data integrity across integrated platforms.

Within the context of the BGI Ethiopia ERP integration practice, particularly regarding data quality and consistency, the researcher observed a lack of proper monitoring and control in the creation of master data. Multiple users were granted access to create critical master data—such as customer, product, and supplier records—without adherence to standardized formats or validation rules. This unstructured approach to master data management has significantly impacted the organization, resulting in poor data quality and inconsistencies across systems.

Under the integration practice in use, the organization has achieved enhanced process integration, resulting in improved speed, accuracy, and data consistency. However, these gains are undermined by the absence of sufficient control and monitoring mechanisms, which are critical for sustaining integration effectiveness and ensuring data reliability.

Within the BGI Ethiopia ERP integration practice, the middleware-based integration between the legacy ERP system and the stock management system has revealed significant inconsistencies. Common issues include data duplication, manipulation, and inadequate validation, all of which compromise the reliability of the integrated environment. To address these challenges, the organization has initiated a transition by implementing two modern ERP solutions: SAP Success Factors for human resource management and Drinkit (a customized version of Microsoft Dynamics 365 Business Central) for other operational areas. Unlike the on-premises MS Dynamics AX, these new systems operate on a cloud-based architecture, introducing a new set of integration complexities related to compliance, data synchronization, latency, system performance, and protocol compatibility. A notable example involves the use of secure FTP for transferring data between the local server and the cloud systems. However, allowing users to manually access and upload data via the FTP server introduces significant risks to data integrity and increases the potential for unauthorized manipulation.

In general, these enterprise applications and ERP systems are not well integrated leading to data inconsistency, operational inefficiency, duplication of efforts and unable the management to make quick decision. Accordingly, the researcher attempted to address the organization ERP integration challenges mentioned during the interview and observation by designing an ERP integration framework that enhance the current integration practice.

CHAPTER FIVE

Framework Design and Development

The organization under study adopted Integration practices in a way that doesn't bring change to it. Even though, the exercises of the integration practices are there, the process is not well organized and collaborative.

In designing a convenient ERP integration framework for the company under study an extensive review of literature on Integration, Information System integration, System integration, ERP integration and Integration Frameworks are attempted with the point to distinguish commonalities and inadequacies within the available undocumented ERP Integration practice. Additionally, an assessment on the organization integration practice is done using multiple data collection methods to gather data relevant to the designing of the integration framework. The data are also analyzed to reveal the gap in the integration practice of the organization under study. Some of the revealed facts include data inconsistency, data insecurity, platform incompatibility, slow performance, standardization, lack of controlling and monitoring.

In this section of the DSR process, a lot of effort has been put to design a comprehensive ERP integration framework that will enhance the organization's ERP integration Processes. Hence, the proposed integration framework primarily supposed to ensures real-time synchronization between ERP systems and enterprise applications with minimal data inconsistencies. It is also designed to handle different data formats and protocols, ensuring a smooth flow of data between systems. Along with the data management and accuracy the integration framework ensures data security, controlling and monitoring of the entire process.

The researcher has done a few customizations on the framework that has been looked in the literature review section to make it suitable for the organization under study. Additionally, the researcher identifies the features to be integrated, the overall architecture of the integration process, the flow and connections of the attributes, models, and constructs.

5.1 Proposing a framework

The researcher reviewed three ERP System integration frameworks for the purpose of proposing a customized ERP system Integration Framework. These ERPIF are assessed based on the three aspects (Data integration, Process integration and system integration) that have been identified by different authors. According to Huang (2013), ERP system integration could be achieved by

the integration framework based on data integration. According to Kobayashi (2003), ERP integration can be achieved through the business process integration which is strongly connected to workflow integration and system integration.

The main objective of the proposed framework is to enhance the existing Undocumented ERP Integration Process exercised in the organization under study. Accordingly, the Framework helps the organization to smoothly automate workflows, improve efficiency, data consistency, and enhance collaboration between functional units and quick decision making. It also encourages communication between co-workers and adds great value to have a common understanding on ERP integration process, and serves as a blueprint for the detailing ERP integration processes.

5.1.1 Conceptual View of the Proposed Framework

The proposed framework incorporates the three components of integration (Data integration, Process integration, and System Integration) that are depicted in the Designed conceptual framework. The framework is a hybrid of the frameworks gathered from a systematic Literature review and from gap assessment made on ERP integration practice in the organization under study. Figure 11 shows an ERP System Integration framework designed for BGI Ethiopia (Conceptual view).

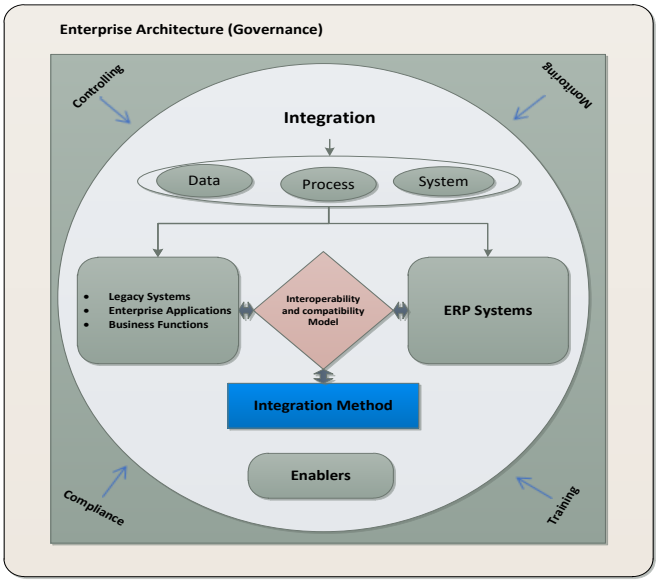

Figure 11 Customized ERP System Integration framework designed for BGI Ethiopia (Conceptual view)

(Source:** Gannt and Tue 2005 (six level of integration), TOGAF (Implementation Governance), and Interoperability from Semantic and ontology ERP integration**)

5.1.2 Architectural View of the Framework

The researcher suggested the following architectural approach, which illustrates the layers, components, and their relationships, in addition to the more general one shown above. The ERP system and other corporate systems of the organization under study can integrate seamlessly with this architecture.

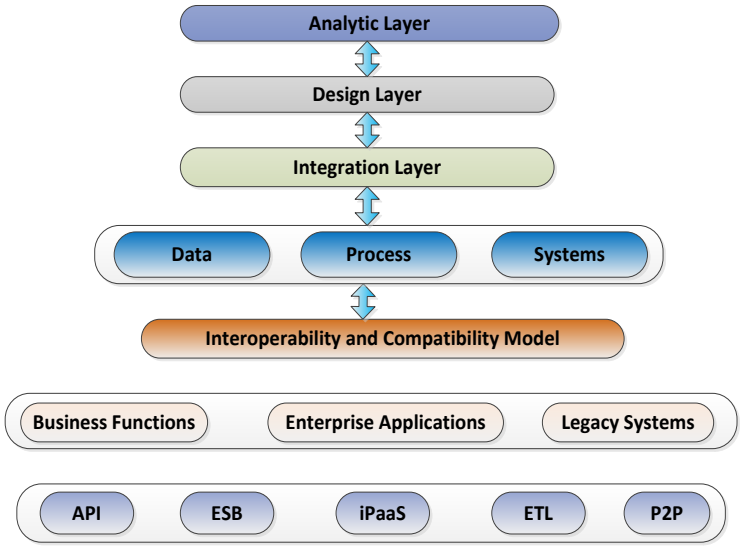

Figure 12 Customized ERP Integration framework for BGI Ethiopia (Architectural view) (Source: *DATA WAREHOUSE ARCHITECTURE FOR ETHIOPIAN HEALTH SECTOR by Wondwossen Mulugeta (PhD))*

5.2 Components of the Proposed Framework

The designed framework intends to enhance ERP integration Process of the organization under study. The framework ought to incorporate and clarify the major ERP integration components, their relationships, and the principles that characterize how these components interact. Based on the systematic literature review, the following components are integrated into the framework and the components are discussed below:

Enterprise Architecture

An architectural layer is the governing layer that is considered to manage the changes that is going to be executed in the organization. The organization runs various enterprise applications and multiple ERP systems in its headquarters premises and outside of its headquarters premises. These applications require integration across the company domain due to their heterogeneity; hence, a change in the current organization structure, workflow, and system is imminent. To

make these changes and manage the outcomes there must be a governing tool or technique. Accordingly, Enterprise architecture helps the businesses going through digital transformation, since EA focuses on bringing both legacy applications and processes together in an attempt to form a seamless environment. To implement changes successfully enterprise architecture should align with other processes (Greefhorst, 2013).

Enterprise Archtecture ERP integration strategy ensures the communication and cooperation of all enterprise applications in such a way that brings enterprise coherence. This comprehensive plan helps the organization to maintain data consistency, operational efficiency, and make informed decision. The organization under study doesn't have a clear integration strategy that aligns with the overarching organizational strategy and objectives. Hence, the proposed framework incorporate an EA layer that encompass an ERP integration strategy to understand specific business needs and challenges, mapping out the existing technology landscape and identify the key areas where integration will add more value. This specific layer assists the organization not only in identifying the key areas but also in outlining the best method of integration for each unique application that exist in the company. These integration methods could range from using P2P, ESB, API, ETL and iPaas. In order to protect sensitive data as it moves between apps, the plan also takes data governance and security into account.

The rapid advancement of technology necessitates strategies that successfully address issues related to data integrity, security, privacy, and system interoperability and dependability in addition to meeting technical requirements (Rajabalinejad, 2018a).

Level of Integration

The entire structure, which includes data, process, and system integration, is centered on this layer. The integration process will center on these three fundamental integration items (data, process, and system) following the proposal of an ERP integration strategy that includes all the necessary details. ERP integration includes business process integration as well as technology integration.

Data integration: as the organization being studied has a number of enterprise systems with diverse data, there needs to be a method for managing this data to ensure correctness, consistency, and completeness. In order to provide a uniform data environment, the data integration layer implements an integration platform that links diverse systems. Additionally,

data governance guidelines will be developed that specify requirements for precision, neatness, and maintenance.

Process integration: Workflow integration and process integration are closely and consistently linked. Everyday transactions are carried out by organizations using processes, whether they are documented or not. Standard ERP workflows do not fully meet the numerous unique workflows of the firm under investigation. Therefore, workflows must be customized and integrated to the unique demands of the business in order to increase efficiency and production by reducing errors and manual involvement.

Systems integration: As the need for robust services grows, it is becoming more and more crucial to integrate new technology with existing systems as efficiently as possible (Wied, Oehmen, & Welo, 2020).Inadequate integration results in hazards and wastes important resources. When new systems are not integrated properly, stakeholders may incur extra expenses, receive poor services, waste limited resources, or even harm other systems or the environment. It is essential to have several systems with their own business processes because the organization under consideration underwent numerous merger and acquisition operations. These corporate apps and legacy systems must function as a single ERP system, which in turn triggers the process of system of systems integration.

Interoperability and compatibility layer

The interoperability of the diverse data originating from many enterprise apps and older systems is defined by this layer. This layer also syntactically structures the data format that will be shared. The company being studied has data from a variety of sources. For these data to be transferred between systems, it must be organized in a format that is interoperable. Technical, semantic, syntactic, and ontology interoperability will therefore be used to test the data's compatibility. Compatibility testing will also be done between old ERP systems, ERP systems that are currently in use, and different corporate applications.

Interoperability must be achieved during the computer system integration process (Semerhanov, I., Vargin, G., and Muromtsev, D, 2012).There are two aspects of interoperability: syntactic and semantic. The syntactic The capacity to control the structure of system elements is known as interoperability. Syntactic interoperability is used when two or more systems can exchange data and communicate in any way. Semantic interoperability, on the other hand, looks for ways to meaningfully and accurately identify correspondence between varied cooperative functions in

separate systems in order to provide outcomes that are helpful according to the end users of both systems. Furthermore, ontologies have been used to address the issues of data heterogeneity since they are thought to be a useful tool for integrating various data from several heterogeneous sources (Das, M., et al, 2015).

The interoperability layer considers the entire system in addition to data and workflow. It aids in describing how the system behaves, what its objects do, and how the interaction between them changes in tandem.

Business Functions

Finance and accounting, manufacturing, supply chain management, inventory management, order management, warehouse management, workforce management, and customer relationship management (CRM) are examples of business functions. Enterprise resource planning effectively integrates these business processes. Initially, the organization under investigation merely included the base package while implementing an ERP system at the foundational level. However, in order to facilitate client relationships, the firm requires other modules, such as CRM. The company experienced significant customizations and integration challenges as a result of this requirement change.

Enterprise Application

An enterprise application (EA) is a sizable software system platform that is usually made to function in a corporate setting, such a government or business. Additional application software with specialized functions is referred to in this context as enterprise applications. To provide enterprise integration, these apps are not yet connected to the ERP system.

Legacy Systems

According to Brodi, M.L. (1993), legacy information systems are a type of information system that was created a few years ago and has less advanced technology, but they nevertheless function regularly in businesses to support management and decision-making today. After making a backup of their master data, these legacy systems may eventually be eliminated or incorporated with contemporary technology. In order to achieve enterprise integration, the corporation plans to combine these old systems with the ERP system that is currently in use.

Integration Methods

These are the various methods used to integrate an ERP system with other ERP and non-ERP systems.

Point-to-Point Integrations (P2P): P2P integrations establish a connection between two software programs.

The Enterprise Service Bus (ESB) is an on-premises software architecture that facilitates data sharing and communication between various applications. There are adapters that sit between the bus and the other software (like the ERP) that convert data to and from XML (or another language) and the format they need. Data enters the bus in a specified format, usually XML.

Integration Platform as a Service (iPaaS)

Platforms that provide a cloud-based method of integration, known as Integration Platform as a Service (iPaaS), allow companies to sync programs more quickly and easily.

Application Programming Interfaces, or APIs, enable real-time communication across various systems by transmitting and receiving data using established protocols.

Extract, Transform, and Load (ETL)

The process of taking data from one system (such as legacy systems), converting it into the appropriate format, and then feeding it into the ERP system for processing is known as ETL (Extract, Transform, and Load).

Enablers

The information infrastructure that makes integration within the company easier is referred to as an enabler. It encompasses people, partners, information technology infrastructure, Trainings organizational culture and structure.

Organizational Culture

"The process of construction and interpretation of an organization's social reality in the symbolic and linguistic activities of an individual in a group" is one definition of organization culture (Sułkowski, 2008: 12). Employee perceptions and interactions with ERP systems are greatly influenced by an organization's culture, which is made up of its common values, beliefs, and behaviors.

Organization Structure

An organization's structure describes how its members are arranged and who they report to. Due to mergers and acquisitions, the firm under investigation has undergone several structural changes. The way the IT department operates has been significantly impacted by these changes to the organizational structure.

People

These are individuals who work for the company to accomplish a purpose, and they have varying degrees of competence. The organization succeeds when the right individuals are at the right places. Lack of experienced or well-trained staff can be quite costly, particularly when enterprise integration is involved.

Technology Infrastructure

The technologies that allow a firm to create and operate the enterprise applications that support its operations are known as technology infrastructure. In addition to servers, data centers, and accompanying tools, it also consists of a modern architecture that combines cloud environments, on premise data centers, and edge computing devices, all of which are connected by enterprise networks.

Partners

Consultants or companies that participate in the integration process are known as partners. They oversee the project, give advice on best practices, and teach the staff so they can operate the new system efficiently.

Training

Though technical integration is critical, user resistance remains a significant challenge to a successful ERP integration. To address this, structured user adoption and training strategy is mandatory. To this end ADKAR change model with a tiered training approach enhance the integration process. This model promotes awareness, knowledge, and reinforcement through continuous engagement. This component's objective is to guarantee early user involvement and post-training performance measurement to ensure sustainable adoption and minimize resistance.

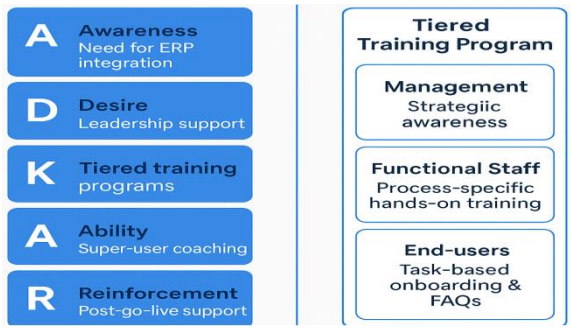

Figure 13 User Adoption strategy overview *(Source: ADKAR: A model for change in business, government and our community by Hiatt, J.)*

5.3 Framework Demonstration

In this section of the Design Science research process the researcher shows the efficacy of the framework designed to solve the problem. It uses a case study to demonstrate its effectiveness. The demonstration started by defining the environment; challenges occurred and problem faced. Under BGI Ethiopia there are six brew industries with their own ERP systems and non ERP Systems. These systems don't interact seamlessly since they are not well integrated. Due to this the company is facing a lot of challenges such as no clear and standard business process, data governance issues, data and business process interoperability, deduplications, and change management issues. In the proposed framework the researcher shows how the challenges are minimized and how it enhances the ERP integration Process in the organization under study, which is the main objective of the study. The researcher used a face-to face demonstration by selecting the same team of experts involved during the interview session.

The broader view framework consists of three major sections that start with a bigger square which shows the Enterprise Architecture that governs the entire process. Then, the second small Square contains attributes such as access control, training, monitoring, partners, strategy etc that are expected to contribute much to the integration process. Finally, there is a big circle that shows the entire integration process by identifying the integration components (data, process, or system), interoperability and compatibility models, methods of integration, and enablers. The demonstration for each component and the relationship between the attributes and constructs are discussed below.

One of the major components of the proposed ERP Integration framework is an Enterprise Architecture which is used to govern the entire integration process. This Governing architecture enables enterprise resources to work together in a cohesive and efficient manner, providing seamless integration to be embedded within disintegrated systems. It is one of the major ways to enforce effective utilization of enterprise resources. Enterprise Architecture gives an end to end view of business process and Information systems within the company. During the interview session one respondent said

"There was no holistic view; most of the ERP customizations or integration projects were disintegrated. A finance manager may come and request a change in a certain process or field in the ERP system; this has a domino effect on related tables and on the entire integration process" ***Said One Respondent.***

Another respondent said," Many consultants involved in the ERP customization and integration process since the start of the project. These skilled personnel used their own coding procedures and data pulling mechanizes.

Additionally, most respondent reported there is no IT governance that manages and controls the integration process."

These replies show lack of standard procedures to execute the ERP integration. Enterprise architecture assists standardization of processes and technologies. Most importantly, Enterprise architecture facilitates interoperability between systems by establishing layers that promote better communication between systems (e.g., data, application, and business process layers).

Even though, the company has overwhelming Enterprise Architecture, without the right strategy and leadership we cannot touch every corner of the organization. The strategy and leadership component of the framework assists the organization under study to align its vision, mission and goals with the Enterprise Architecture. Having the Architecture and strategy and leadership with a well-defined roadmap and active engagement of stakeholders, the next step will be identification of the Integration resources such as data, process and system. In the organization there are various integration requirements that are categorized as data, process or system. The organization under study is using Microsoft Dynamics AX ERP system to manage its daily operation. Along with this ERP system there are many applications that interact with the system. These applications interconnect with legacy systems and cloud ERP systems through the process of extracting, transform and loading data after ensuring their quality and integrity through the process of interoperability.

Additionally, there are workflows that require automation within an ERP system and between other systems. For example, sales and customer service workflows needs integration for better customer handling. Data and process integration address different challenges and require different strategies. The framework assists the organization under study by identifying these integration components and uses a different strategy to manage them.

In addition to data and process integration, the organization should treat system integration separately. The organization has multiple enterprise application and ERP systems; some of these disintegrated systems require integration at system level to facilitate access to information. For example, the company is using a middleware to interconnect an ERP System with Warehouse management System. This system of system integration requires a different approach and tool.

Once the integration components are identified the process of interoperability and compatibility ensures these different systems to communicate, understand, and utilize each other's data, regardless of their underlying technologies. The framework depicts arrows pointing from integration circle to both rectangular boxes. The one on the left side showing various enterprise applications interact with ERP systems through the process of interoperability. There are various interoperability types that can be utilized considering the type of technology to be integrated. Technical Interoperability ensures systems to connect physically using various protocols or interfaces. The organization under study use an interface and an FTP protocol for system integration and data integration respectively. Syntactic interoperability ensures systems to communicate using common data format XML or csv. These formats are commonly used in the organization. Semantic interoperability is another way of ensuring data is interpreted the same way between systems. For instance, date format are interpreted the same between applications and ERP systems.

In addition to interoperability, system compatibility is an important factor to consider during the integration process. System compatibility ensures systems or applications to work with one another in terms of technical aspects such as Hardware, software and protocols. In this regard, the organization is facing a challenge of compatibility between Software. For instance, the operating system where ERP software resides is outdated. This is due to the change in the OS version may have an impact on the ERP system function.

Once Interoperability and compatibility between the existing systems are ensured the integration method can be selected. Hence, the proposed integration framework establishes a link between interoperability and compatibility model and integration method. There are various integration methods that can be used considering data or business process interoperability and system compatibility. For instance, technical interoperability leads the organization to integrate SAP with Microsoft Dynamics AX using XML on a secured cloud FTP server. In addition API is used to create an interface between two disintegrated application services since they use different platform.

Even though, we device the right Enterprise Architecture, strategy and leadership style and followed best integration practice, it will be very challenging to facilitate the integration process without having the right Enablers in place. Hence, the organization must invest on a good infrastructure in order to facilitate the ERP integration process. Though all activities of

integration requires a good infra, organization structure, and organization culture, the framework give due emphasis to manage skilled personnel very well. Further, controlling, monitoring, compliance and training are also important pillars for the success of the ERP integration process. The organization have to involve partners on how, when, what to integrate, following the guiding Enterprise Architecture. Additionally, how to effectively and efficiently use the integrated system should also be communicated for all stakeholders.

The Architectural Framework depicts the integration steps to be followed once the assessment on the entire IT landscape has done. The analytic layer focuses on processing and analyzing data coming from various applications and ERP systems. These raw data will be aggregated, cleaned and transformed to be used by the interconnected systems. The Design layer on the other hand is responsible for the architectural design, system modeling, and the blueprint of how different systems, data, and processes interact. It also sets how the organization's business requirement aligns with technical design. Finally, the integration layer is responsible for seamless communication between different enterprise applications or ERP systems running in the organization under study. It is through this layer the company's entire IT ecosystem unified. This layer encompasses data, process and system integration. It ensures the implementation of the design asper the blueprint to facilitate data synchronization and communication. The integration layer works in collaboration with interoperability and compatibility layer to ensure different systems can communicate smoothly even if they are under different technologies, platforms or data formats. In the organization under study, there are various systems that use different technologies and platform such as ETL, API, Middleware, cloud based etc.

5.4 Framework Evaluation

In this evaluation process the researcher compare the objectives of a solution, which is designing an Integration Framework that assist a smooth integration process between ERP and non ERP Systems, to actual observed results from use of the framework in the demonstration. A researcher used a case study analysis to evaluate the artifact in a real world setting as well as to gain a detailed, in-depth exploration of the context, application, and effectiveness of the artifact.

According to (Venable, Pries-Heje, & Baskerville (2016), IT artifact Evaluation can be done through various methods depending on the type of research conducted. These methods can be analytical method, observational, experimental, expert validation and descriptive methods.

Accordingly, the tailored framework generated for BGI Ethiopia is evaluated though expert validation and a descriptive method. The evaluation process ensures the designed framework best suit the organization under study through the process of running various variables such as Performance and scalability, Flexibility, Security, Data quality and consistency suitability, ease of use, reliability, usefulness etc.

Evaluation achieved after demonstrating the designed ERP integration framework with domain experts to confirm that the framework is true representation of the organization ERP integration practice. In this study the proposed framework is evaluated by five key experts from the ERP team. Most of the participants in the evaluation process were also part of the integration practice assessment interview sessions. Two technical managers, one Security and database team member, one support team leader and the researcher with a total of five key experts were used to evaluate the framework. The researcher used SPSS as a tool to analyses the data collected and descriptive statistics to summarize the characteristics of the data set. The evaluation criteria for this framework are usefulness Performance and scalability, Flexibility, Security, Data quality and consistency suitability, ease of use, reliability, usefulness etc.

The evaluation is captured by using questionnaires that use five-level of rating scale, where 1: stands for strongly disagree, 2: for disagree, 3: for neutral 4: stands for agree and lastly 5: stands for strongly agree. Further, the researcher used APA-style report to explain the results and their implications in the context of an ERP integration framework evaluation.

5.4.1 Evaluation of ERP Integration Framework Using Descriptive Statistics

5.4.1.1 Abstract

This is a report generated using various ERP integration dimensions to evaluates the frameworks capability to entertain system's performance and scalability, flexibility and customizations, security and compliance, and other important factors. The report use descriptive statistics to assess the ERP integration framework. The results are shown as minimum, maximum, mean, standard deviation and other relevant statistical metrics. The data were gathered through expert review. The purpose of the study is to gather information about the overall efficacy of the framework considering various dimensions.

5.4.1.2 Introduction

Enterprise Resource Planning (ERP) Systems are systems that are used to integrate internal business functions as well as other enterprise application to improve operational efficiency. The integration process of these systems with other ERP and Non-ERP system requires a framework that enhances the current practice in the organization under study. Accordingly, the researcher design and develop an ERP integration framework to enhance the integration practice. This framework needs to be evaluated by experts using comprehensive metrics to assess performance, usability, applicability, security, ease of use and other important factors. These metrics are analyzed using descriptive statistics that offers a simple yet powerful way to summarize the central tendencies and variability of these metrics, which collectively determine the frameworks' effectiveness.

5.4.1.3 Methodology

Several key measurements were used to evaluate the integration framework through expert's feedback. SPSS, as a tool, was used to analyze the data collected and descriptive statistics to summarize the characteristics of the dataset. The evaluation metrics are categorized under a theme of ten with valid and relevant questions. These categories are added into SPSS considering the average results gained from the total of each questions. The evaluation is captured using questionnaires with various statements that rate experts' agreement using a rating scale, from 1 (strongly disagree) to 5 (strongly agree). The descriptive statistics were calculated based on these ratings to summarize the overall performance of the integration framework across different categories.

5.4.1.4 Descriptive Statistics

The descriptive statistics of the dataset summary of the ERP integration framework evaluation across multiple dimensions are displayed in the table below. These consist of each category's mean, standard deviation, minimum, and maximum values.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Performance and Scalability	5	2.00	4.25	3.4500	.89093
Flexibility and Customization	5	4.00	4.60	4.1860	.27199

Security and Compliance	5	4.00	4.75	4.3500	.33541
Data Quality and Consistency	5	4.00	4.33	4.2640	.14758
Ease of Use	5	3.60	4.60	3.9400	.47749
Reliability and Fault Tolerance	5	3.00	4.00	3.7000	.44721
Integration Option	5	4.00	4.66	4.3300	.23335
Support and Documentation	5	3.00	5.00	4.0000	.70711
Change Management	5	3.60	5.00	4.1000	.58310
Monitoring and Reporting	5	3.50	5.00	4.0000	.61237
Overall Evaluation	5	4.00	5.00	4.3200	.46043
Valid N (list wise)	5				

Table 7 Descriptive statistics of ERP integration Framework Evaluation

5.4.1.5 Results

Table 7 summarizes the expert evaluations of the ERP integration framework across various categories. Key observations from the descriptive statistics include:

- **Performance and Scalability**: Moderate performance and scalability is indicated due to high standard deviation (0.89) with the mean score of (3.45).This is a result of some experts rating the integration framework lower with the ability to handle large-scale operations.
- **Flexibility and Customization**: High flexibility and customizable is shown with a high mean score of 4.19 and low standard deviation (0.27). This suggests the framework can be adapted to various industries that wish to integrate their ERP system.
- **Security and Compliance**: This metrics indicates high support with a mean of 4.35 and a standard deviation of 0.34. With a proper regulation in place the integration framework support security and compliance, this is essential for handling sensitive business data.
- **Data Quality and Consistency**: a low standard deviation (0.15) with a mean score of 4.26 reflects that the framework is effective in ensuring data consistency across integrated platforms.
- **Ease of Use**: The score received on framework ease of use shows a mean score of 3.94, and a standard deviation of 0.48. This means there is a slight challenge for some users to understand the framework, though most believe it is user-friendly.

- **Reliability and Fault Tolerance**: in this category moderate reliability is seen as the mean score of 3.70 and a standard deviation 0.45, indicating that the framework could benefit from further enhancements in fault tolerance.
- **Integration Option**: The framework integration capability rated highly with a mean of 4.33 and a low standard deviation of 0.23, indicating strong integration features with other systems.
- **Support and Documentation**: This dimension reflects there should be a room for improvement in support and documentation clarity and accessibility since the score received shows a mean of 4.00 and a standard deviation of 0.71.
- **Change Management**: This category score shows although there is variability in the level of satisfaction, change management processes are well-supported. A mean of 4.10, with a standard deviation of 0.58 are scored in this category.
- **Monitoring and Reporting**: The framework's monitoring and reporting functionalities were evaluated as effective with a mean score of 4.00 and a standard deviation of 0.61, but could benefit from enhancements in user-friendliness.
- **Overall Evaluation**: In general most experts show positive perception of the integration framework, though minor areas of improvement are identified. The overall evaluations mean score is 4.32, with a standard deviation of 0.46.

5.4.1.6 Discussion

The general outcome of the descriptive statistics analysis process shows positive feedback in almost all dimensions of the evaluation metrics. The envisioned framework shows promising result in areas such as security, data quality, flexibility, customization, and integration capabilities with other systems. However, performance and scalability and user-friendliness are some of the weak areas identified during the evaluation process. In addition, fault tolerance and reliability shows moderate results which indicate the framework should extend its integration to incorporate these factors. Most importantly, support and documentation are also considered as improvement areas with the focus on clarity and accessibility.

This result could have been more interesting had it been done in a large sample of users with a broader perspective on the framework's effectiveness. Moreover, additional statistical analysis,

such as inferential statistics, could assist in the determination of the variation observed in experts' ratings by identifying their significance.

5.4.1.7 Conclusion

While the integration framework evaluation is conducted on various metrics, the result gives strong feedback with Reporting, security, flexibility, customization and framework integration with other system. Though, the integration framework shows better support in areas mentioned above, due attention should be given to performance under high loads and the ease of use for non-technical users. Furthermore, documentation and support access should also be given equal attention. By addressing these areas, the frameworks overall effectiveness, applicability, usefulness and ease of use can be further improved.

5.5 Validity and Reliability

In Qualitative validity means that the researcher checks for the accuracy of the findings by employing certain procedures, while qualitative reliability indicates that the researcher's approach is consistent across different researchers and different projects (Gibbs, 2007).Validity and Reliability are conceptualized as trustworthiness, rigor and quality in qualitative paradigm.

Since the researcher use multiple data source such as systematic literature review, interview, observation, expert validation and the researcher own experience, it allows him to use triangulation. It is through the use of triangulation the researcher eliminates bias and increases the researcher's truthfulness of the findings. According to Creswell and Miller (2000), triangulation is defined to be "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study"

Additionally, the researcher uses the same case group at both initial interviews for assessing the integration practice and during the evaluation stage of the framework; this ensures the reliability of the findings.

In addition to the qualitative reliability and validity, the researcher used factor analysis to validate the constructs in the ERP integration framework and ensure that the evaluation metrics are effectively measuring what it intend to assess. Further, reliability test has been conducted on the items to measure performance and scalability of the ERP integration framework.

5.5.1 Validity Test

Factor Analysis

Component Matrix

	Component 1:Performance and Scalability
Can the framework handle an increasing volume of data very well?	.968
Can the framework scale horizontally and vertically as the business grows?	.968
Is the average response time for integration processes quick?	.867
Does the system perform well under peak loads?	.908

Extraction Method: Principal Component Analysis.

Table 8 Factor Analysis using component matrix

All four items (variables) have strong loadings on Component 1, with loadings ranging from 0.867 to 0.968. This means that Component 1 represents a cohesive set of variables related to the ERP integration framework's performance and scalability.

The Component Matrix reveals that all four variables in the ERP integration framework evaluation load strongly on Component **1**, which likely represents performance and scalability. The high loadings suggest that this component is a valid and meaningful representation of how the ERP integration framework handles growth, performance, and peak loads. This insight can help guide further analysis and validation of the ERP framework's effectiveness.

5.5.2 Reliability Test

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	5	100.0
	Excluded[a]	0	.0
	Total	5	100.0

a. List wise deletion based on all variables in the procedure.

Table 9 Case processing

Reliability Statistics	
Cronbach's Alpha	N of Items
.934	4

Table 10 Reliability Statistics

Since the Cronbach's Alpha is 0.934, it falls within the "Excellent" range, indicating that the 4 items used in the ERP integration framework evaluation have strong internal consistency and are reliable in measuring the construct of performance and scalability. This strong reliability suggests that the measurement instrument is sound and the results can be trusted for further analysis and interpretation.

5.6 Communication and Experts Feedback

After experts evaluates the ERP integration framework using quantitative methods (such as questionnaires distributed to experts) based on various dimensions such as Performance and Scalability, Usefulness, Data Consistency, Flexibility, Security, and Compliance, experts typically provide valuable feedback. Based on their responses, here are some potential areas for improvement or additions that experts suggest:

- Moving the Training component to Enablers Category to reflect its supporting role
- Inclusion of Alerts, notifications and audit logs to support traceability
- Enhance Documentation and Reporting
- Security and Authentication
- Detail Naming of Integration methods
- The components relationship and arrow direction should be amended

5.6.1 Updated Conceptual Framework

The updated ERP integration framework incorporates these suggested improvements and additional components based on expert feedback see figure 13. This process ensures that the framework is comprehensive, addresses key business needs, and aligns with best practices in ERP integration. With this iterative feedback loop, the framework can evolve to be more effective, secure, user-friendly, and aligned with the organization's strategic goals and industry demands.

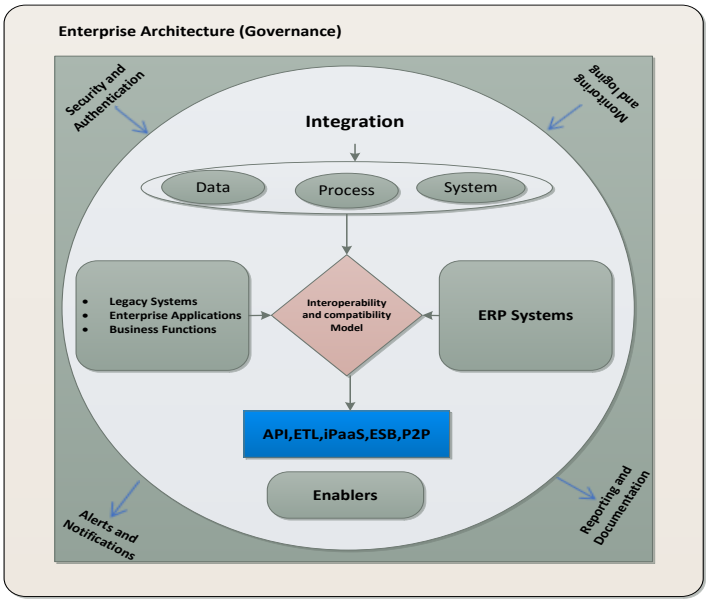

Figure 14 Customized ERP System Integration framework designed for BGI Ethiopia (Updated Conceptual view)
(Source: *Gannt and Tue 2005 (six level of integration), TOGAF (Implementation Governance), Interoperability from Semantic and ontology ERP integration****)***

5.6.2 Updated Architectural Framework

In addition to integration Framework broader view feedbacks, the experts also suggested additional components to be incorporated in the Architectural layer view which includes:

- Security and Governance layer to be cross cutting on the top of the integration framework
- Deployment environment foundational level
- Interoperability and compatibility to be cross cutting between the integration process and integration methods and deployment environment
- Architectural layer relationship amendments
- Presentation Layer inclusion

After incorporating the suggested components the framework design becomes as follows:

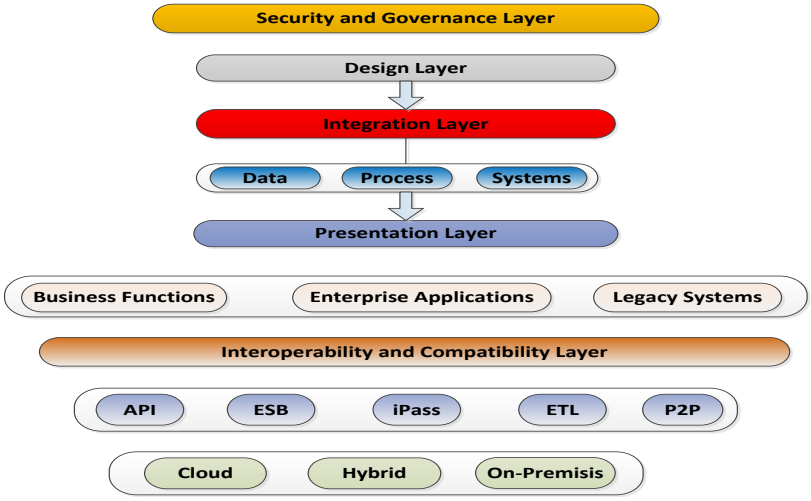

Figure 15 Customized ERP Integrations framework for BGI Ethiopia (*Updated Architectural View)*
(Source: DATA WAREHOUSE ARCHITECTURE FOR ETHIOPIAN HEALTH SECTOR by Wondwossen Mulugeta (PhD))

5.6.3 Updated Framework Component

Security and Governance: acts as a control shield for everything underneath. It defines security policies, authentication/authorization, data privacy, and compliance standards. It is also responsible for role-based access control, data encryption, audit trails and logs and compliance.

Presentation Layer: Focuses on how information is delivered to users or external systems. This layer includes Dashboards, User interfaces, Portals and reporting tools that ensure integrated data is consumable and visualized properly.

Deployment Environment: refers to the underlying infrastructure or hosting model where the ERP system and its integrated components are deployed and operated.

5.6.4 Updated Framework Demonstration

The security and governance component are added to layered view to enhance the entire framework capability to function securely, effectively and align with the organizational objectives. Security was one of the concerns of most respondents, having a security component as part of the integration process is not an option. Some of the security features include data encryption, authentication and authorization, audit logs, and security patches. Additionally, governance is also mentioned by most respondents as one of the missing link between the

organization objective and ERP integration. Some of the governance mechanisms include integration policies, standard operating procedures, change management controls, performance monitoring etc. These components ensure other components to function under their oversight and minimize technical and operational risks.

Further, the presentation layer is also included in the updated version of the framework to enhance data visibility to all stakeholders. This layer is a user interface through which users, managers and other stakeholders interact with the ERP system. It presents data from ERP system and other integrated application, enabling users to record data, report, and workflow approval.

Putting the interoperability and compatibility layer across integration methods, processes, and deployment environments shows that it doesn't just support data, systems, or processes alone—it plays a vital role in making the whole integration work together smoothly. Finally, deployment environment are included as a foundation layer for the entire integration process since the placement of this environment determine the integration success, security, scalability, and performance.

5.7 Linking Empirical findings to the designed framework

The architectural layered framework was directly connected with empirical findings gathered from the case study at BGI Ethiopia. Specifically, the observed paper based PR preparation, the delayed approval workflows, and redundant data entry in finance modules highlighted the lack of end to end integration approach. Additionally, the findings (such as absence of unified strategy, weak change management, fragmented project ownership, data inconsistency etc) from the interview session shaped the framework components. Accordingly, Table 11 shows the empirical finding mapping with the designed framework evidencing each element of the proposed model is grounded in practical issues experienced on-site, ensuring the framework is both context-specific and actionable.

Empirical Findings	Mapped Framework Component	Justification
Absence of unified integration strategy	Design Layer	Reveals the lack of strategic alignment and blueprinting at the architectural level.
Weak change management practices	Security and Governance Layer	Governance includes user training, compliance, change management, and

		communication.
Fragmented project ownership	Security and Governance Layer	Includes role clarity, authority, and coordination across units.
Data Inconsistency	Integration Layer	End to end workflows across systems.
Data Insecurity	Security and Governance Layer	Involves access control, compliance, and audit mechanisms.
Platform Incompatibility	Interoperability and Compatibility Layer	Solve the challenge of connecting diverse platforms through middleware tools.
Slow Performance	Integration Layer and deployment Layer	Performance may suffer due to poor integration logic or inappropriate deployment models.
Lack of Monitoring & Control	Security and Governance Layer and Interoperability Layer	Weak oversight is typically due to poor governance and absence of centralized monitoring tools (e.g., ESB logs, API tracking).

Table 11 mapped empirical findings to designed Architectural framework

5.8 Technical Feasibility of the proposed framework

Though architectural framework is provided in the proposed integration framework, it is acknowledged the need for annotated, step-by-step visuals to clarify the integration process across ERP systems and Enterprise applications. Accordingly, figure 16 shows how a typical transaction from initiation of one module through API or middleware to synchronize with other module.

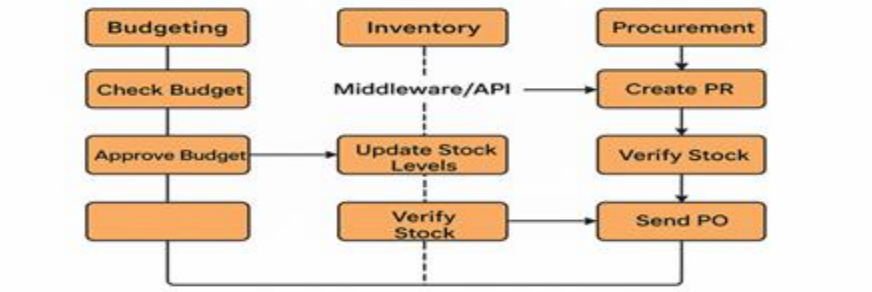

Figure16 Integration in a PR Transaction using middleware

The integration workflow described (PR, PO, GR to Finance, and budget validation) are based on common ERP implementation pattern supported in literature (Magal & Word, 2011; Hohpe & Woolf, 2003; Sharma, 2020).

UML Sequence Steps:

1. Employee → Procurement Module: createPR(PR_data)
2. Procurement Module → Budgeting Service: checkBudget(PR_data)
3. Budgeting Service → Procurement Module: budgetStatus(approved/rejected)
4. If approved:
   -Procurement Module → Inventory Module: checkStock(item_code)
   - Inventory Module → Procurement Module: stockStatus(available/short)
5. If stock is short:
   - Procurement Module → Finance Module: createPO(PR_data)
   - Finance Module → Middleware: processPayment(PO_data)
6. Middleware logs the transaction and routes it to the external payment system (if needed).
7. Finance Module → Employee: paymentStatus(success/failure)

A bunch of integration tools and standards were considered to assess the technical feasibility of the proposed ERP integration framework and for potential prototyping. These include:

- **API-based integration** for real-time data exchange between ERP modules (e.g., Procurement ↔Inventory , and payroll ↔ Finance)
- **Enterprise Service Bus (ESB)** to mediate communications among distributed applications (payroll and HR and Finance)
- **ETL tools** for batch data transformation across legacy ERP systems and Warehouse Management System using .CSV files.

As a proof-of-concept, sample data exchange workflows were outlined for:

- Generating and routing Purchase Requisitions (PR)
- Updating inventory records in real-time
- Budget approval feedback loops via API

In addition to the internal module integration, integration between various enterprise applications and ERP systems with different platforms are taken into consideration. The selected integration technologies such as **APIs**, **ESB and ETL** are aligned with the architecture's interoperability and deployment layers. Further prototyping in a sandbox/test environment is proposed to validate system behavior, latency, and data consistency in practice.

CHAPTER SIX
Conclusion and Recommendation

6.1 Conclusion

In today's dynamic world of IT, new technologies are emerging with the intention of helping an organization to make strategic decision. These new technologies as they bring new features to advance the operations of an organization they also bring a challenge of integration with the existing information system. There are many initiators for calling integration such as business process change, acquisition of new technologies, obsolete systems, government laws etc. These initiators come with a challenge of data format mismatch, compatibility issue, workflow change, extensive customization etc. In order to alleviate these integration challenges and bring a smooth communication between its enterprise applications and ERP systems BGI Ethiopia implemented various integration techniques.

In this study, BGI Ethiopia is used as a case organization to explore the ERP integration practices. The aim of the research was to examine the challenges within the current ERP integration practice at BGI Ethiopia and develop a framework to address these issues, ensuring the successful integration of ERP systems.

The study also reviewed various frameworks from different enterprise resource areas that align with ERP integration. To effectively address the research questions and meet the objectives, a mixed case study approach was utilized, incorporating multiple data collection methods. This allowed for an in-depth investigation and understanding of ERP integration practices at BGI Ethiopia. Information on ERP integration process at BGI Ethiopia was gathered from multiple participants, offering diverse perspectives, opinions, and experiences. Additionally, a comprehensive literature review and document analysis were carried out to gather further insights into the mentioned constructs, which helped to triangulate the findings and improve the quality of the results. The researcher's extensive experience in ERP integration also made a significant contribution to the organization's understanding and application of ERP systems.

On the basis of the study findings, it is possible to draw several conclusions about BGI Ethiopia's ERP integration practice, particularly through interviews that helped assess employees'

understanding of integration and the integration framework. The use of interviews as a data collection method provided valuable insights into the company's ERP integration process and the challenges faced by employees in adapting to the system. Additionally, much of the literature on ERP integration reveals that companies often face significant challenges when integrating ERP systems. These challenges typically include issues like inadequate planning, insufficient stakeholder involvement, resistance to change, lack of proper training, and difficulties with system customization. Additionally, integration between different ERP systems and legacy applications often results in data inconsistency and workflow disruptions, which can further complicate the process.

In summary, by way of answering the research questions, the study has been able to: identify the core issues and challenges of ERP system integration at BGI Ethiopia and (2) propose a comprehensive integration framework to address those issues and challenges.

Based on the analysis and the findings, the following conclusions are drawn from the study:

- Change was not properly planned
- Extensive customization not following best practice
- Weak Data Security and compliance
- Weak monitoring of integrated system performance
- Lack of overall IT Governance
- Lack of proper Documentation, Support and training

Addressing these complicated issues by strengthening change management, improving user training, following best practice, implementing proper governance and monitoring tool, and ensuring robust system integration frameworks can significantly enhance the success of ERP integration efforts in organizations like BGI Ethiopia.

Accordingly, the study followed a Design Science research process in order to build and evaluate an ERP systems integration framework for BGI Ethiopia that provides a comprehensive approach to managing the complexity of integrating multiple ERP systems across various functional areas within the organization. Given the current multi-ERP landscape, with systems such as Microsoft Dynamics AX, customized Business Central (Drinkit), and SAP

SuccessFactors in use, the framework offers a structured way to streamline integration, improve data consistency, and enhance overall operational efficiency.

In addition, the ERP systems integration framework for BGI Ethiopia offers an invaluable approach to streamlining operations and aligning IT with business strategy. By addressing the customization, training, change management, and security needs specific to BGI Ethiopia, the framework provides a structured methodology for successful ERP integration.

The company's focus should be on ensuring that ERP systems integration aligns with its broader business goals, scalable for future growth, and employees are well-prepared to adopt the newly integrated system. Additionally, by integrating emerging technologies such as AI, cloud computing, business analytics and adapting the framework to the local Ethiopian context, BGI Ethiopia can position itself for operational excellence and competitive advantage in the long term. This research lays the foundation for further investigation into ERP integration in developing markets, offering insights that can be useful to other organizations in similar contexts.

6.2 Recommendation

The result of this study is believed to provide guidance to managers and IT professionals concerning the main activities of ERP systems integration and realize the intended business benefits. This study provides some useful insight for BGI Ethiopia IT managers who often need to take decisions with regard to integration changes. The proposed framework also provides general guidelines and controls for ERP integration change initiators to structure an effective ERP integration process.

BGI Ethiopia should carefully evaluate the need for ERP customization to ensure it aligns with its business processes and goals while balancing it with standardization to avoid unnecessary complexity. A thorough analysis of business processes is essential for aligning the ERP system with the company's strategic objectives. Additionally, the company must focus on effective change management and employee training to ensure smooth adoption of the system and minimize resistance.

BGI Ethiopia should establish clear, measurable integration goals and milestones to track progress and address any issues early on. Leveraging ERP data for decision-making and optimization will enhance operational efficiency and performance. The integration framework should also incorporate emerging technologies like cloud computing, AI, and data analytics to improve ERP capabilities. Lastly, the framework should be adapted to the local Ethiopian context, considering challenges such as infrastructure limitations, Government laws, and cultural factors for a successful ERP integration.

Further, the following recommendations are forwarded on how to execute and practice the proposed framework considering the major issues that this study addressed:

6.2.1 Recommendation for practice

The ERP integration framework helps organizations effectively implement and integrate ERP systems, ensuring they maximize their investment. Key practical implications include:

- The replies gained from the respondents shows there is a major governance issue. Hence, the framework offers structured guidance using enterprise architecture, helping organizations avoid common issues like poor planning, lack of stakeholder involvement, or inadequate training, leading to better implementation outcomes.
- The framework not only supports the integration of various ERP systems and Enterprise application but also supports the streamlining of internal processes to enhance core business functions such as finance, logistics, and procurement.
- The study suggests BGI Ethiopia to use their current BI tools in a more efficient way in addition to cloud computing. Accordingly, the framework aids in making informed decisions about ERP tools and technologies, ensuring they align with long-term business goals and organizational needs.
- The study suggests due emphasis should be given to Change Management and Training. It emphasizes the importance of managing cultural and organizational change through effective strategies, stakeholder engagement, and staff training, helping overcome resistance and ensuring employees can effectively use the ERP system.

- The study also suggests the organization under study to use a cloud deployment environment to get the best advantage of performance, scalability, security, patches and updates.

6.2.2 Recommendation for research

As part of further future researches, the following are the researcher's suggestions for research opportunities:

- Research could explore industry-specific ERP integration models, tailoring frameworks to sectors like Telecom, Banking, and Aviation.
- Future studies could examine the trade-offs between customizing ERP systems and using standard modules, considering cost, complexity, and scalability.
- Research could investigate how cloud computing, AI, and block chain impact ERP integration and how frameworks need to adapt to these technologies.
- Future evaluations could incorporate more detailed feedback from a larger sample of users to provide a broader perspective on the frameworks effectiveness.
- There is potential to explore ERP integration in broader business ecosystems, focusing on collaboration across organizations.
- Studies could explore how cultural and organizational factors influence ERP integration success, particularly in global or diverse settings.

6.2.3 Recommendations for theory

The envisioned ERP integration framework influences organizational theory by improving our understanding of Governance, change management, workflow redesign, and business process reengineering. It highlights how aligning business goals with IT systems enhances information flow across departments. Additionally, the framework extends our understanding of IT-enabled transformation by illustrating how ERP systems drive operational and strategic changes in organizations.

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Appendix-A: Semi-structured Interview Outline

Source: Adopted with modification and addition from literature and AI

1. Can you briefly describe your company's ERP system and the systems it integrates with?
2. What were the main objectives behind implementing ERP integration in your organization?
3. How long has the company been using ERP, and when did the integration with other systems begin?
4. Which departments or business functions are involved in the ERP integration (e.g., finance, HR, sales, supply chain)?
5. How was the ERP integration strategy developed and what were the key drivers for it?
6. Was there a formal roadmap or phased approach for integration, and how was it executed?
7. What integration methods were used (e.g., direct API integration, middleware, custom development, third-party connectors)?
8. Were any external consultants or vendors involved in the integration process? If so, what role did they play?
9. What types of systems (e.g., CRM, SCM, HRMS, financial software) are integrated with your ERP system?
10. Can you describe the technologies or platforms used for integration (e.g., APIs, ESB, EDI, cloud-based solutions)?
11. How are data flows managed between the ERP system and other integrated systems? Are they real-time or batch processes?
12. What tools or middleware are used to facilitate integration? Are there any specific issues or challenges related to these tools?
13. Have you encountered compatibility issues with any existing systems or technologies during the integration? If so, how were they resolved?
14. How is data migrated and synchronized between your ERP system and other integrated systems?
15. What measures are in place to ensure data accuracy, consistency, and integrity across all systems?
16. How do you handle data validation, mapping, and transformation between different systems?
17. Are there any challenges related to data duplication, inconsistency, or loss during the integration process?
18. What have been the most significant challenges or obstacles faced during the ERP integration?
19. Were there any issues related to system downtime or disruption of business operations during integration?
20. How well did the company's infrastructure (e.g., hardware, network, etc.) support the integration process?
21. Have there been any problems with managing integration complexity, especially when dealing with multiple systems?
22. Were there any issues with stakeholder alignment or communication during the integration process?
23. How easy or difficult was it for end-users to adapt to the integrated ERP system?

24. Were there any training programs or support structures in place to help employees navigate the integrated system?
25. How would you rate the user experience in terms of system responsiveness, functionality, and accessibility?
26. What feedback have you received from employees about the ERP integration in terms of ease of use and effectiveness?
27. How do users access integrated data from various systems (e.g., through dashboards, reports, alerts)?
28. Has the ERP integration led to any improvements in operational efficiency? If so, can you provide examples?
29. How has the integration impacted your business processes in terms of speed, accuracy, and consistency?
30. What manual processes were automated or streamlined as a result of the ERP integration?
31. Have there been any measurable improvements in decision-making or reporting due to better data access and integration?
32. Can you quantify any operational cost reductions or efficiency gains from the integration?
33. What mechanisms are in place to monitor the performance of the ERP system and its integrations?
34. How do you handle system maintenance, updates, or patches for integrated systems?
35. Who is responsible for troubleshooting and resolving integration-related issues (e.g., internal IT team, third-party support)?
36. Are there any challenges with ongoing system maintenance, especially when adding new features or updates to integrated systems?
37. Has the ERP integration achieved its initial business objectives (e.g., improved data visibility, process efficiency)?
38. Has the integration led to any competitive advantages for the company (e.g., better decision-making, faster product delivery)?
39. What overall impact has the ERP integration had on your company's growth, scalability, or ability to adapt to market changes?
40. What improvements or enhancements do you plan to make to the ERP integration in the future?
41. Are there any systems or processes that are currently not integrated but are planned for future integration?
42. How do you plan to handle future growth in terms of data volume, system complexity, or business requirements?
43. Are there any lessons learned from the current ERP integration that would inform future integration projects?
44. Overall, how successful do you think the ERP integration has been in meeting the company's goals?
45. What would you consider the most important takeaway or lesson from the ERP integration experience?
46. Do you have any final thoughts or recommendations for improving ERP integration practices within the company?

Appendix-B: Expert Evaluation Questionnaires outlined

Source: Adopted from literature and AI with modification and addition

1. Can the ERP integration framework handle an increasing volume of data very well?
2. Can the framework scale horizontally and vertically as the business grows?
3. Is the average response time for integration processes quick (data transfer, synchronization)?
4. Does the system perform well under peak loads or during business-critical periods?
5. Can the framework be customized to suit the unique needs of the business?
6. Can the framework support future changes in business processes without requiring extensive rework?
7. Does the framework allow for easy modifications to integrate with other systems as needed?
8. Does the framework adhere to industry-specific security standards?
9. Are data encryption, user authentication, and authorization handled within the framework?
10. Does the framework assist for maintaining audit logs for all integration activities for compliance purposes?
11. Is the framework place a mechanism to ensure data integrity and prevent unauthorized access during integration?
12. Does the integration framework handle data validation and error management?
13. Does it provide features for data cleansing and deduplication before integration?
14. Does the framework ensure consistency between different data sources (ERP, CRM, etc.)?
15. Is the framework user friendly for technical and non-technical users?
16. Does the framework include the level of expertise required to implement and manage the integration?
17. Does the framework handle retries, data recovery, and error alerts?
18. Is the framework including built-in redundancy or failover to ensure continuous service?
19. Does the framework assist the integration with other critical business systems (e.g., CRM, HRM, and SCM)?
20. Does the framework support modern integration technologies like APIs, web services, and middleware?
21. Can the framework assist integration with both cloud-based and on-premises systems?
22. Does the framework offer comprehensive technical documentation and user guides?
23. Does the framework handle changes to the integration (e.g., updates, patches)?
24. Does the framework have version control capabilities to manage updates and maintain compatibility?
25. Does the framework assist changes communication and testing to minimize disruptions to ongoing operations?
26. Does the framework provide real-time monitoring of integration processes and data flow?
27. Does the framework allow for proactive alerts and notifications based on system performance or data anomalies?
28. Does the framework have strong potential to guide ERP integration successfully?
29. Would you consider this framework a valuable resource for organizations embarking on ERP integration?

Appendix-C: Framework Demonstration Session

Friday April 04, 2025

Organizer: Sisay Fekadu

Participants: (Experts at BGI Ethiopia)

1. Samuel Nigussie: IT Service Delivery Manager

2. Yilekal Mitiku: Business Relationship manager/Programmer

3. Sintayehu Diriba: IT support Manager

4. Sinodos Amaha: Security and Database Administrator

5. Sisay Fekadu: Former Enterprise Application Manger

Demonstration setup

The objective of the case group discussion was to demonstrate the proposed ERP integration Framework with experts, with regard to performance and scalability, data management, Security and compliance, Monitoring and Documentation etc. Furthermore, the purpose was to gather improvement areas originated from the discussion.

Agenda

Presentation on the problem statement, objective, and research design of the study, and discussion on the contents of the framework with the participants comments

Venue

BGI Office

Appendix-D: Sample Data Exchange Workflows for ERP Integration (Source: ERP integration literature)

1. Purchase Requisition (PR) to Purchase Order (PO) Workflow

Modules Involved: Procurement → Budgeting → Inventory → Finance
Technology: REST API + Middleware (e.g., MuleSoft or SAP PI)

Workflow Steps:
1. User creates PR in Procurement module.
2. System triggers API to Budgeting module → checks for fund availability.
3. If approved, API sends PR to Inventory to verify stock.
4. If stock is insufficient, system auto-generates PO.
5. PO is forwarded to Finance for commitment recording and supplier payment scheduling.

Integration Tools: REST API, Webhooks, Event-Driven Messaging

2. Inventory Update After Goods Receipt

Modules Involved: Inventory → Procurement → Finance
Technology: ETL (for batch) or API (for real-time)

Workflow Steps:
1. Warehouse receives goods → user logs GRN (Goods Receipt Note).
2. Inventory module sends event or data packet to Procurement to update order status.
3. System also updates Finance module to trigger invoice matching and payment scheduling.

Integration Tools: API Gateway, ETL job, Event broker (e.g., Apache Kafka)

3. Budget Adjustment and Real-Time Validation

Modules Involved: Budgeting ↔ Finance ↔ Procurement
Technology: ESB or API orchestration

Workflow Steps:
1. Finance adjusts annual departmental budgets.
2. Budget update is broadcast via ESB to Procurement and other dependent modules.
3. When user tries to raise PR, system validates in real-time against updated budget.
4. If limit is exceeded, request is flagged and approval escalates via workflow.

Integration Tools: ESB (e.g., WSO2, BizTalk), Synchronous APIs

Appendix-E: UML Software-Level sample Models for ERP Integration

(Source: *ERP integration literature*)

1. UML Sequence Diagram: PR to Payment Workflow

Purpose:
Illustrates the step-by-step message flow between system components during a Purchase Requisition (PR) to Payment transaction.

Actors / Objects:
- Employee
- Procurement Module
- Budgeting Service
- Inventory Module
- Finance Module
- Middleware/API Gateway

Sequence Steps:
1. Employee → Procurement Module: createPR(PR_data)
2. Procurement Module → Budgeting Service: checkBudget(PR_data)
3. Budgeting Service → Procurement Module: budgetStatus(approved/rejected)
4. If approved:
   - Procurement Module → Inventory Module: checkStock(item_code)
   - Inventory Module → Procurement Module: stockStatus(available/short)
5. If stock is short:
   - Procurement Module → Finance Module: createPO(PR_data)
   - Finance Module → Middleware: processPayment(PO_data)
6. Middleware logs the transaction and routes it to the external payment system (if needed).
7. Finance Module → Employee: paymentStatus(success/failure)

2. UML Component Diagram: ERP Integration Architecture

Purpose:
Shows the structural breakdown of the ERP system components and their dependencies.

Main Components:
- ERP Core Modules:
  - Procurement Component
  - Inventory Component
  - Finance Component
  - Budgeting Component
- Integration Layer:
  - API Gateway
  - Enterprise Service Bus (ESB)
- External Systems:
  - Supplier Portal
  - Banking System

- Governance & Security Layer:
  - Access Control Module
  - Audit Logger

Connectors / Interfaces:
- Each core ERP module interfaces with the Integration Layer.
- The API Gateway exposes services like getBudgetStatus(), postPO(), etc.
- The ESB handles message transformation and routing.
- External Systems communicate via APIs exposed by the Integration Layer.
- The Governance & Security Layer monitors all communication via audit trails and role-based access.