A STRATEGIC DECISION ANALYSIS FRAMEWORK FOR SOFTWARE-AS-A-SERVICE SELECTION

A SYSTEMATIC DATA-DRIVEN APPROACH

MUTHU PRIYADHARSHINI SHANMUGANATHAN

MARCH 2024

UNIVERSITY OF TWENTE.

A Strategic Decision Analysis Framework for Software-as-a-Service Selection

A Systematic Data-Driven Approach

By

Muthu Priyadharshini Shanmuganathan

Department of Business Information Technology

Electrical Engineering, Mathematics and Computer Science

Supervisors

Dr. F.A. Faiza Bukhsh, University of Twente

Dr. A.A.M. Spil, University of Twente

Rajaraman Santhanam, SISAR B.V

Loes Vanhouttem, SISAR B.V

Preface

Pursuing a Master's abroad has always been my dream. But some unexpected event happened in my life that pushed me to focus on my mere survival and I almost gave up on my dream. Yet, a miraculous opportunity came my way. Grabbing it and moving to the Netherlands, which in itself was the toughest decision made so many things simpler and transcended my way forward when life before that pulled me down to hit rock bottom. Though the first year in this new country was quite difficult adapting to the culture shock and people, the second year gave me back the confidence that I had lost for the past 10 years. Thus the two years of my Master's journey gave me a lot of lessons that rejuvenated my life both on an academic level and on a personal level.

My graduation assignment marked the final stage of my master's journey. I had the opportunity to carry out my research with SISAR B.V, Amstelveen for 6 months from September 2023 till February 2024. I want to thank Rajaram Santhanam for taking me under his guidance and for taking time out of his busy schedule to provide support and clarifications whenever I needed it. I would like to thank my supervisor Charu Sharma for guiding me and motivating me all through the journey. I could never forget the days when you used to realize that I was stressed just by reading my face and taking me out to buy me some *chai*. Special thanks to Loes Vanhouttem for extending her support, supervision, and guidance through the last minute of my thesis work.

I would like to sincerely thank my supervisor from the university Faiza Buksh for her feedback, support, and guidance with steps on how to carry out a thesis work. Her constant push helped me complete my thesis at a much faster pace and yet without compromising on the quality of the work. Special thanks to Ton Spil for guiding my project extending support and helping me to produce solid work.

I want to thank my mother for being my biggest support throughout my master's journey and for being there whenever I needed her. I want to extend my gratitude to my brother and cousins for taking care of me. Special mention to Elaiyaraja, and Harish for helping me adjust to a new country.

I want to extend my sincerest and deepest gratitude to Sneha Ramesh. I can never thank you enough and will forever cherish everything you have done for me. And last I would like to thank myself for never giving up when life threw all the reasons to.

Executive Summary

Businesses opt for Software-as-a-Service models as these offer seamless access to resources and services. These models are more flexible to use and reduce deployment and maintenance costs. Recently, the list of services offered to consumers has been extensive, and adoption of these solutions has increased to gain a competitive advantage. However, the process of selecting a suitable one poses challenges to organizations. Choices have to be made to select a service from the available set depending on the requirements of the business. This research aims to propose a framework for software selection considering those choices while addressing several parameters that need to be compared in the decision-making process.

This research identifies the key factors supported by a thorough literature review that influence software selection. These factors include technical and non-technical parameters like functionality, availability, response time, reliability, security, usability, support, and reputation. Moreover, this research also focuses on software selection keeping the business's strategic goals at the center, and explores activities to gain market reach. Furthermore, this thesis delves into analyzing the methodologies in the literature that could be employed by organizations to compare software options and suggests the use of a Muti-Criteria decision-making approach for a quantitative and objective approach to software selection. A hybrid approach of Entropy TOPSIS has been embedded into the framework for the evaluation and ranking of the software alternatives.

Additionally, a case study has been conducted to demonstrate the practicality of the selection framework that can guide organizations to navigate through the selection process to help handle and manipulate data with a structured approach. It has been noted that the reputation of the vendors, the features offered by the software, and the collaboration goals of the organizations with the vendors play important roles in the decision-making process in selecting software. On the other hand, it has been shown that during the phase of preprocessing of data, the decision maker can manipulate the data if they want a certain criterion to have more impact on the decision-making process.

The implementation of the software selection framework outlines the software choice by the identified criteria and choice of the decision analysis technique. In conclusion, the research conducted aligns software selection in a way that can help organizations utilize a data-driven approach to software selection and enhance decision-making processes.

List of Tables

List of Figures

Table of Contents

Chapter I

1 Introduction

1.1 Overview

Cloud Computing(CC) has emerged as a successful paradigm shift for delivering business solutions through products or services. According to NIST(National Institute of Standards and Technologies) "*Cloud Computing is a model that enables ubiquitous, convenient, on-demand access to a shared pool of configurable computing resources that can rapidly be provisioned at any time and from any location via the internet or network*"[38]. Computing, data storage, servers, and software are offered as "as-a-service" over the internet to offer faster resources and innovation. Microsoft defined cloud computing as a platform that drives transformation across hardware and software enabling powerful and efficient hardware at lower costs and developing secure cloud applications with 24/7 management. Sun describes the cloud as a set of services that have API and are available over the network. VMware finds cloud computing has four main attributes – pay for what is used, a lightweight entry, flexible access, and exit service acquisition model. The characteristics of CC include on-demand self-service, wide network access, resource pooling, elasticity and scalability, utility-based pricing, location independence, and multi-tenancy. Cloud Computing is categorized into three types Software-as-service, Platform-as-service, and Infrastructure-as-a-service[37]. The difference in the types is shown in Figure 1.

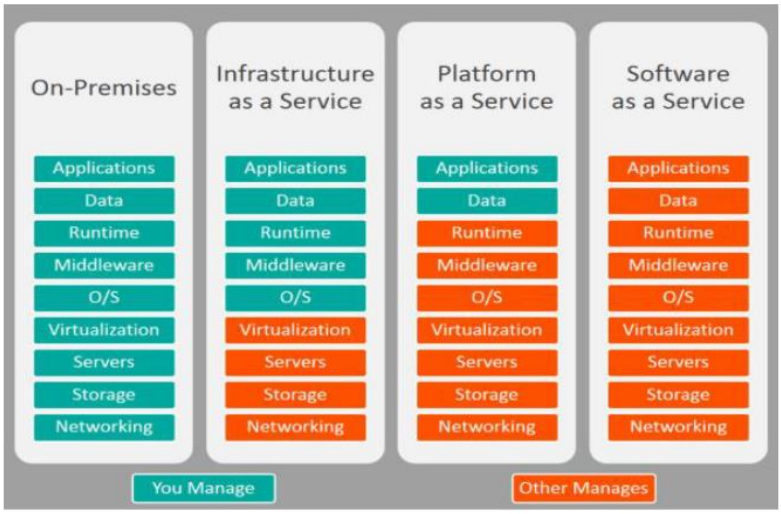


Figure 1. Types of Cloud Services [22]

Software-as-a-Service(SaaS) is a concept in which the data including files, and programs are accessible using a web browser via the internet[4]. Before the cloud computing paradigm, businesses had to have a self-hosted setup where they needed to do both the hardware and the software setup. This includes many disadvantages like higher costs of maintenance[6], disruptions in scalability, difficulties in portability, and upgrades. With SaaS, the service providers provide an instance of the application they have developed to the customer. The provider is responsible for the data, data storage, virtualization, middleware, and user interface. The provider could have several clients with an instance application running on the client's web browser. A client can use the software either through 'subscription-based' payments or 'pay-as-you-go'[31]. There are two ways in which SaaS models are available to clients[4]. The first is for public use, the second is for the business domain both following the subscription model. Businesses started opting for "as-a-service" models as they are more flexible to use and reduce costs of deployment and maintenance. This paved the way for cloud service vendors to provide service models to other businesses.

Several vendors provide software services to solve business problems, but not all are equally built. Choices are made to select a service from the available set depending on the needs of the business. Software Selection is a very crucial, critical investment and an important decision for the strategic benefit of a company or a business. The right procurement of software will enhance the company's competitive advantage and its efficiency[14]. The other things that businesses look for in SaaS products are customizability- whether the product could accommodate new features ensuring access to the latest technologies and interoperability – where the product can integrate with other systems within the organization. On the other hand, the investment could fail if the software doesn't meet the requirements that were promised to be delivered[30]. The risks associated with a software selection outweigh its benefits when it becomes crucial to competitiveness but irrelevant to strategy. So it is important to be sure that obtaining software serves the long-term goal that the product is sustained and that it also improves the efficiency of the business by aligning its services with their strategic goals[14]. In addition to selecting software, it is also crucial to look at the vendor as well. A good relationship with the vendor builds trust and confidence and can build a long-term mutually beneficial partnership, good communication between the stakeholders, better assistance with problems, timely support with updates or new functionalities, and negotiating pricing terms.

Several techniques have been proposed to facilitate cloud service selection based on several factors. It involves a set of steps from choosing what a customer wants in the product/service from the vendor to following a well-defined approach and choosing "the optimal" that fits their needs from a pool of options. Several methodologies and frameworks in the literature are proposed to guide companies in selecting the suitable(or best) software to meet their business needs. Some methodologies can be specifically targeted for certain software. Others give a general framework. Among the methodologies, MCDM has been a popular technique throughout the years for cloud service selection as it can consider multiple criteria to analyze a service[2]. In addition to MCDM other techniques have also followed which are discussed later in Chapter 2. One important aspect to consider during the evaluation process is the client's requirements. The type of software they are looking for, the features, functionalities, and quality of service that it provides, how well the software can sit with the existing setup, and how well it integrates with other applications. Questions are raised about how much the application can be advantageous over the present setup, the benefits that it brings to the organization, the problems that it solves, and the economic boost that the software could bring. Also, since we are talking about cloud computing services, much care needs to be given to the data that is being stored in the vendor's cloud. So careful inspection of the compliance rules and regulations and the data security certificates from the vendors have to be done.

To sum up, software selection is a critical process based on the requirements of the clients from a software and vendor perspective. It is also crucial to make informed decision-making to ensure that the selection aligns with the strategic goals of the client's business. The following section talks about the problem context.

1.2 Research Design

This section discusses the problem context as well as the goals of the company. In the sub-sections that follow, the research questions, the objective of the research, and the research methodology that will be used as guidelines to carry out the research are discussed. The stages of the methodology and the processes carried out in each stage are also discussed. Finally, the outcomes expected for each research question are tabulated.

1.2.1 Problem Statement

Customers of products and services look for SaaS options that are delivered quickly and with high quality. So businesses change their business models accordingly to make sure that their products/services reach their customers with the above requirements and also to make sure that their

services are top players in the market. The same applies to the B2B economy as well. Businesses make use of products delivered by other businesses to solve a business problem/task. The issue now becomes that there are several product/service alternatives available in the market and it's difficult to choose the one from them. The functionalities, features, and service quality attributes are the comparable components to evaluate each alternative.

SISAR B.V is developing an in-house HRMS tool to offer workforce management capabilities including leave management, centralized HR data, employee self-service, hiring application tracking, work scheduling, and data management. The tool offers a platform to integrate other SaaS products with it to enable multiple services. For instance, Salesforce's CRM could be integrated with HRMS. In this context, payroll software has to be integrated with the HRMS tool to facilitate seamless integration between the applications.

The objective is to find and collaborate with a payroll provider in the same country as the client who is going to use the HRMS tool and integrate their payroll software with the HRMS tool. With the choice of many payroll options, it is crucial to evaluate these software based on different factors and eventually compare them to make a selection decision.

1.2.2 Research Objectives

As mentioned in Section 1.2.1, SISAR B.V. is developing an in-house HRMS tool that enables provision to integrate other SaaS products with it. Apart from the previously mentioned aims, the goals have been integrated using the Design Science Research Methodology proposed by Roel J. Wieringa[33]. As mentioned in the paper, a researcher must determine the context of the problem for the study, the artifact that will be utilized to address/treat the problem, the specifications for the solution, and the end goal of addressing the problem. For this, Wieringa's design problem template is used in this study, as indicated below.

improve	*< a problem context >*
by	*< (re)designing an artifact>*
that satisfies	*< some requirements >*
in order to	*< help stakeholders achieve some goal(s) >*

The following design challenge arises when we modify the previously mentioned template to fit the objective of the company mentioned in Section 1.2.1.

improve	*the SaaS selection process*
by	*designing a SaaS selection framework*
that satisfies	*and guides through analyzing the different factors that determine the service quality of the software as well as the vendors*
in order to	*give a combined advantage of selecting software to integrate with their HRMS platform and achieve the organization's strategic business goals through the software vendors*

1.2.3 Research Scope

This research mainly focuses on selecting vendors that provide only payroll solutions and not vendors that provide both HRMS and payroll solutions. The software selection framework designed applies to payroll selection specific to the organization's requirements. The framework that is proposed in this research can be used to find and select payroll software from any country.

1.2.4 Research Questions

The primary research question that will be addressed in this study is as follows, and it will be answered to fulfill the research objective specified in Section 1.2.2

How to approach a software selection process that would meet the organization's strategic requirements?

The above-described primary research question offers the focus and content for the study to create a software selection framework that will encompass the chronological steps to be followed to arrive at a desired result.

SRQ1: What methodologies and approaches have been employed to conduct software selection in a business context?

This research aims to find studies that are related to software selection, the processes involved in choosing software, and the importance of choosing optimal software and analyze the existing techniques for software selection.

SRQ2: What are the principal criteria that influence the choices of stakeholders of an organization when selecting software?

This research goal is to find literature studies to collect and analyze different factors used to evaluate software. This research also aims to choose the factors that apply to software selection from the organization's perspective.

SRQ3: What are the prerequisites an organization needs to consider in choosing software and how to align its business' strategic goals with the technical requirements to develop a framework for the selection process?

This research aims to identify the key requirements and will look into how the business goals could be considered as factors that will determine the selection of software. Also, a study will be carried out to propose a framework for the selection process that could be (re)used for future purposes.

SRQ4: How to put into practice the theoretical selection framework for the software selection practices for the organization?

The framework will be validated and it will be discussed with the stakeholders of the organization. The artifact(the framework) will be verified if it meets the requirements Any areas of improvement in the framework will be considered and updated. The next step will be the implementation of the framework in a real-world case scenario. Research will be done on methods of how to carry out the implementation.

SRQ5: How effective is the proposed selection framework after its application is put into practice?

This question will seek to evaluate the implementation of the selection framework.

1.2.5 Research Process

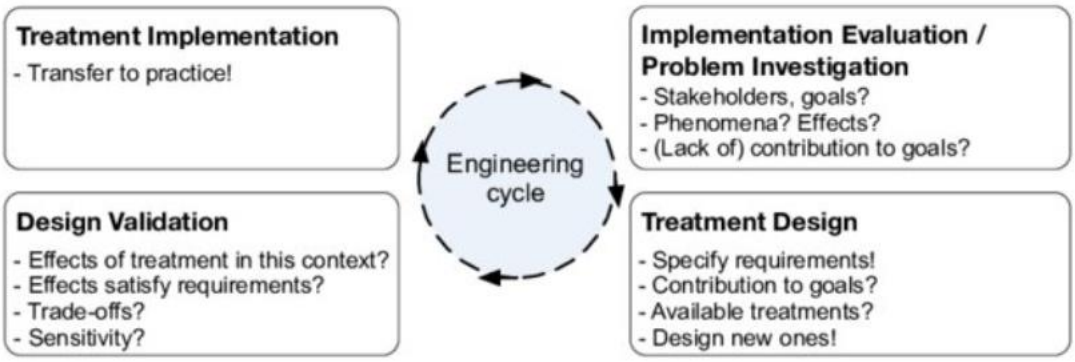


Figure 2. Wieringa's Design Cycle [33]

The research questions presented in Section 1.2.4 will form the base for designing the framework for the software selection process. The design and evaluation of the framework for the software selection process will use the Design Science Research Methodology(DSRM) proposed by Wieringa as guidelines. Figure 2 shows the engineering cycle proposed by Wieringa[33]. This methodology facilitates an iterative approach to design science research works through the steps of design, development, validation, implementation, and evaluation of the framework. In this research process, all the steps in this methodology including Problem Investigation, Treatment Design, Design Validation, and Treatment Implementation and Implementation Evaluation will be carried out. The steps are detailed below following the research project.

Problem Investigation

This phase deals with the question of *"What phenomena need to be improved? Why?"* [33]. At this point, the goal is to comprehend better the problem that has to be solved to prepare for treatment design. The above question prompts us to deal with research questions SRQ1 and SRQ2 of Section 1.2.4. The Systematic Literature Review answers these questions carried out as the preliminary step for the research.

Treatment Design

The next phase of the engineering cycle is the Treatment design. Here the output of the Investigation step is fed as the input and the framework as the treatment for the software selection process is designed according to the requirements of the organization. This treatment/artifact attempts to answer the research question SRQ3. The Literature Review provides a foundation to understand how the selection processes have been carried out in the recent past, the methodologies used, and the factors/criteria that influence the process. The literature provides several treatment ideas and so research needs to be done to choose the one fit for the context. In this stage, requirements are gathered from the internal stakeholders of their expectations that align with what they are looking for in software and the vendor. In addition, as a proposed new ideology, the treatment artifact is redesigned to fit the business's strategic goals.

Treatment Validation

This stage pertains to a component of SRQ4. In the third phase of the engineering cycle, the proposed framework will be validated. For this qualitative interviews will be conducted with the internal stakeholders of the organization. The framework will be discussed and an analysis of the impact of its impact on the company, the HRMS tool integrations, and software selection will be examined.

Treatment Implementation and Evaluation

This stage handles the remaining SRQ4 and SRQ5. The theoretically designed treatment is put to practical application in a real-time scenario. The objective in this stage is to operationalize the treatment to address the problem. During this phase, it is required that essential planning and preparation are needed. Establishing timeliness is important because the implementation process requires the input of stakeholders participating in the research. It is also important to adapt to suit specific needs and constraints as the implementation might not always be what was imagined.

After the framework is put into practice, it must be evaluated to gauge its effectiveness, impact, and performance. Monitoring includes keeping an eye on the small building blocks that comprise the framework, getting feedback from the stakeholders, and pinpointing areas in need of tweaking or streamlining. Evaluation procedures support deployment success and provide insights for upcoming revisions or improvements.

One crucial point to keep under consideration during the entire engineering cycle is to check the ability of the treatment to accommodate and adapt to future requirements and its capability to sustain those requirements. The stages of Wieringa's engineering cycle mapped to the research questions have been outlined in Figure 3.

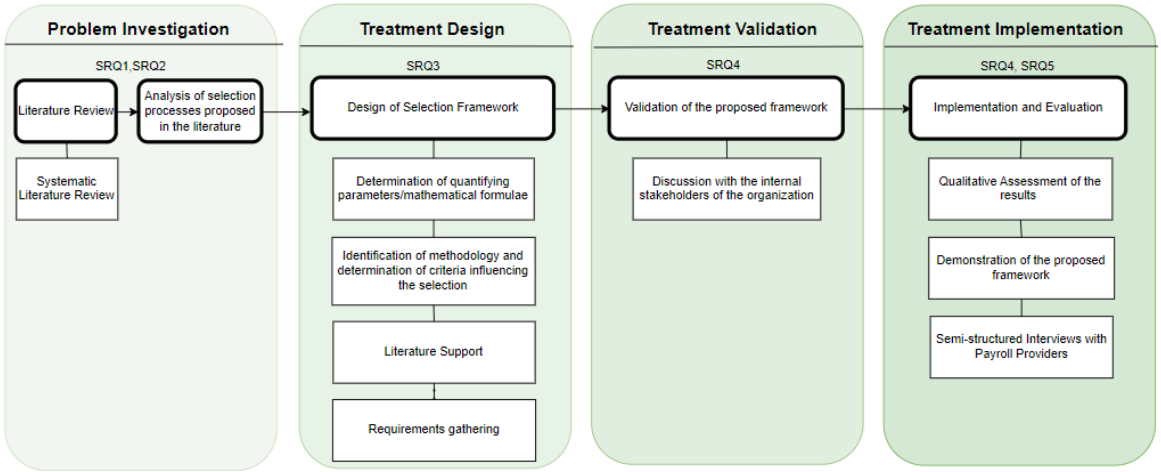


Figure 3. Stages of DSRM Mapped to Research Questions

1.2.6 Research Overview

Table 1 gives an overview of the chapters in which the answers to the research are answered and also the method by which the questions are answered.

S No	Research Question	Chapter	Method	Outcome
1.	What methodologies and approaches have been employed to conduct software selection in a business context?	Chapter 2	Literature Review	An overview of software selection and the general steps that are followed to arrive at a selection and the selection techniques.
2.	What are the principal criteria that influence the choices of stakeholders of	Chapter 2	Literature Review and Interview with	A shortlist of factors that predominantly influence the evaluation of software

	an organization when selecting software?		Internal Stakeholders	
3.	What are the prerequisites an organization needs to consider in choosing software and how to align its business' strategic goals with the technical requirements to develop a framework for the selection process?	Chapters 2, 3	Literature Review, Interview with Internal Stakeholders, and Design of Framework	Set of requirements taken into account to apply through the selection process A framework that incorporates the selection technique, both the technical parameters and the business strategic goals converted to factors
4.	How to put into practice the framework for the software selection practices for the organization?	Chapters 4, 5	Semi-structured Interviews with external/internal stakeholders and demonstration	Validation of the framework, and use of it in a real-world example.
5.	How effective is the proposed framework after its application is put into practice?	Chapter 5	Discussions with Internal Stakeholders	Evaluation of the results.

Table 1. Overview of the Research

1.2.7 Report Outline and Structure

The sections are organized as follows. Chapter 2 gives a comprehensive view of the literature review carried out for the research. It discusses the different existing literature studies used so far for software selection. Additionally, it provides reports to which the current research can contribute and the analysis carried out as part of the research gap. Chapter 3 details the treatment design. In this chapter the software selection process framework will be proposed and how each step of the process is being developed. Chapter 4 will discuss the qualitative validation of the proposed framework and the refinement implemented in the framework and Chapter 5 demonstrates a case study. Chapter 6 answers the research questions of Section 1.2.4 and Chapter 7 concludes the research project with contributions to Academia.

1.3 Chapter Summary

This chapter gives a view of the introduction to SaaS selection and the problem context that applies to the research project. The subsections of this chapter discuss the research objectives, the research questions, and the relevance of carrying out the research. In addition, the chapter presents the research methodology proposed by Wieringa[33] that will be used as guidelines for the. It also discusses the phases of the methodology and its influence on the research project. The next chapter discusses the Systematic Literature Review.

Chapter II

2 Literature Review

This chapter discusses the Systematic Literature Review conducted to serve as background knowledge to answer the research questions SRQ1 and SRQ2 mentioned in Section 1.2.4. To carry out the literature review a research methodology is employed to search, identify, select, and analyze work on similar topics relevant to software selection. The guidelines of Kitchenham[1] have been followed for the systematic literature review. The steps included in the guidelines start with formulating the research questions, selecting the database/databases for the search, choosing query keywords, and selecting the relevant work considering a set of inclusion and exclusion criteria followed by a quality assessment of the studies.

2.1 Search Strategy

The studies for this literature review were obtained from databases accessible through the University of Twente and are available via open-access policy. Some popular ones included the Web of Science, Scopus, Google Scholar, and IEEE Xplore. For this research purpose, the search was restricted to Scopus as it covers an extensive range and also gives studies that cover most of the query keywords.

The following keywords were used to build a search string after the database was chosen. Various keyword combinations were tried out until the most appropriate one that yielded accurate and inclusive results was identified. Necessary filters and limitations were applied to find the most applicable studies. Following several iterations, the primary search query that was used was as follows.

TITLE-ABS-KEY (saas) AND TITLE-ABS-KEY ((vendor OR product)) AND TITLE-ABS-KEY ((selection OR comparison OR evaluation)))

The above query fed into the Scopus search gave 142 results. To extend the search a different set of keywords was fed as the secondary search string as given below:

TITLE-ABS-KEY (cloud OR saas) AND TITLE-ABS-KEY (evaluation OR selection OR ranking) AND TITLE-ABS-KEY (criteria OR indicator OR factor) AND TITLE-ABS-KEY (vendor OR supplier) AND NOT TITLE-ABS-KEY (cloud AND service AND provider))

The above query gave 150 research papers giving out a total of 292 in addition to the previous results. With further conditions limiting the criteria to papers published from 2009 till 2023, 282 papers. The subject areas that are excluded: are Earth and Planetary Sciences, Biochemistry, genetics, and Molecular Biology resulting in 272. Again limiting the search to papers without defined authors refined the search to give 241 papers.

2.2 Literature Selection Process
A list of inclusion and exclusion criteria is considered to screen the number of papers that were obtained from section 2.1.

The inclusion criteria cover the following

IC1: The papers are downloadable.

IC2: The papers are in English.

IC3: Include only papers that discusses about cloud vendor selection that is limited to software selection.

IC4: The papers are not restricted to only payroll software selection. Papers that discuss any software like ERP, or CRM are also included.

The Exclusion criteria cover the following

EC1: Since two search strings are used to collect papers, the duplicates are removed.

EC2: Papers that do not talk about software evaluation and talk about evaluating other domain services.

EC3: Papers that talk about cloud technologies or cloud services for introduction purposes for a different context/topic but do not give a broader perspective of software/vendor selection

EC4:Papers that talk about the selection of cloud services but no focus on SaaS.

EC5: Papers that talk about Sustainability/Green Index evaluation.

From 241 papers, going through the title of the research study and the abstract, skimming through the rest of the paper for relevant keywords, and analyzing a pattern through how the papers are structured around the proposed methodologies helped in narrowing down the results. Applying the inclusion and exclusion criteria, the results narrowed down to 27. The overview of the search and selection of literature is shown in Figure 4.

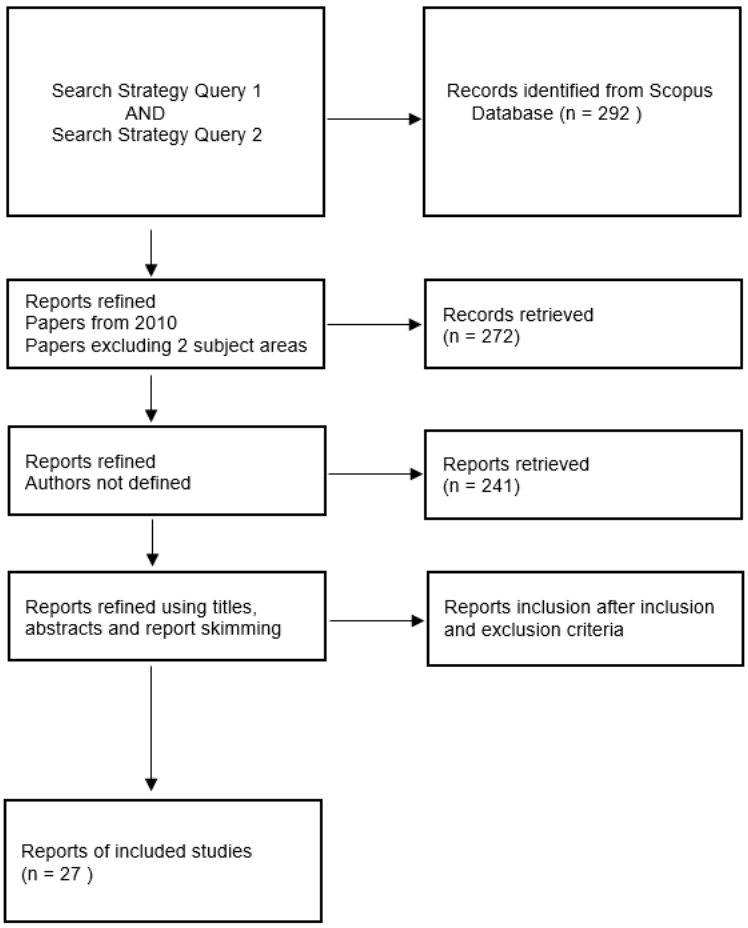


Figure 4. Literature Selection Process

2.3. Data Extraction

The studies are analyzed and reviewed to collect data to answer the research questions mentioned in Section 1.2.4 and the results are discussed in Section 2.4.

2.4 Results

2.4.1 Software-as-a-service selection:

Cloud Computing is often referred to as "Everything-as-a-service". It is based on two concepts, SOA(Service-oriented Architecture) and Virtualization. The major classification of the services include Infrastructure-as-a-service(IaaS), Platform-as-a-service(PaaS) and Software-as-a-service(SaaS)[26]. SaaS is a third form of cloud computing model[4] that deploys software applications on the cloud and allows users to use it over the internet. The users either pay or use a basic/trial/free version of the application to carry out specific functionalities. In addition to this, the end users are responsible for choosing a better application from the available lot. There are some principles that they need to follow[25].

- They need to be fully aware of the process that the application will contribute to the business's goals
- The application can provide high-quality service over a long time

2.4.2 SaaS Selection Methodologies

Several approaches could help a customer to choose a provider. [19] classified the cloud service selection into three broad categories namely content-based filtering, collaborative filtering, and multi-criteria decision-making methods. Content-based filtering is where a ranked list of services is given based on the nearness of the user's preferences to the preferences in the marketplace. Examples of content-based filtering include[29, 30]. Collaborative filtering is where a product is suggested based on the preferences of similar users. It is similar to a recommendation system that recommends a service based on past users' data. The third approach is the Multi-criteria decision analysis method which is used to rank the services when the number of choices is less. Other approaches have also been proposed that could be used to select an option[4, 5, 17, 19]. Some approaches have taken a further step to automate the proposed methods as software applications for quick and easy responses[5, 15]. Below are the techniques and models followed for the evaluation/selection of an alternative.

2.4.2.1 MCDM techniques

The following query string was fed into Scopus to analyze how many documents use MCDM in the cloud service domain. Figure 5 shows the trend of usage of MCDM.

(TITLE-ABS-KEY (mcdm OR mcda) AND TITLE-ABS-KEY (cloud AND service))

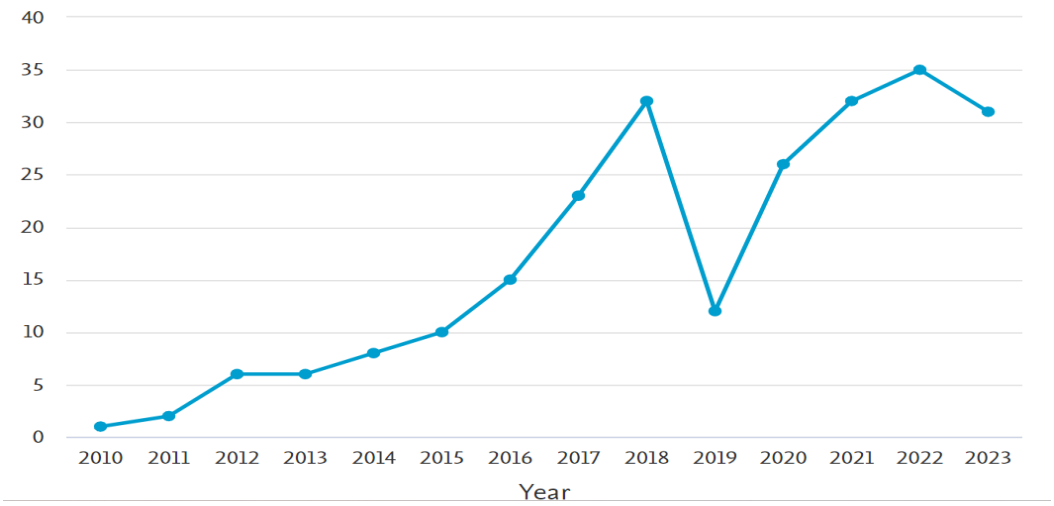


Figure 5. Number of Studies that Cite MCDM Techniques

In [2] the researchers proposed a technique called IF-MARCOS (intuitionistic fuzzy measurement of alternatives and ranking according to compromise solution), which is a utility-based MCDM problem for the selection of ERP systems. The utility models are used when a large number of experts and criteria are involved in decision-making.

[3] proposed Analytical Network Process(ANP) to evaluate the trial version of SaaS products available in the market. It is an MCDM technique which is a generalized version of AHP. The study follows a quality-based evaluation and selection of SaaS. The quality model proposed by[34] was used in the study. In ANP, criteria, sub-criteria, and alternatives are treated equally as nodes in a network unlike in AHP where local priorities are calculated among the sub-criteria, criteria, and alternatives to arrive at global priorities that will be used to compare the alternatives based on the criteria. In ANP, each node can be compared with any other node in the network as long as there is a relationship between them.

[7] used the AHP technique to compare and rank CRM services. The technique is based on three key dimensions – Benefits, Cost, and Risks. It is a much more straightforward application of the technique.

The steps involved are building hierarchies into the software, performing pairwise comparisons, collecting relative weights, and finally calculating the BCR ratio as proposed in the paper.

[8] introduced a new technique CORE(Customer Oriented Reliability Evaluation) to perform customer perspective based on reliability evaluation of a product. The authors state that reliability, an important QoS factor should be user-oriented and not developer-oriented. This paper has proposed a quantitative way to quantify the qualitative metrics. Also, the metrics measurement are categorized into three types, type I, type II, and type III where data is collected from past customers' feedback, prospective customer requirements, and quality standards respectively. The framework is divided into three layers – the repository layer, the user preference layer, and the reliability evaluation layer. The repository layer is the data storage layer that has all the data required to be sent to the reliability evaluation layer when needed. The data includes feedback collected from consumers. This layer stores time-stamped product and attribute data, quality and compliance standards that need to be checked, and also the feasibility of updating the standards data. The user preference layer has a user interface product lists, and user preferences attributes. This layer accepts details from the customers that need to be evaluated. The factor preferences are input in a user-friendly interface and are fed to the reliability evaluation layer. This layer provides a list of SaaS products, a list of factors/attributes, and also a factor preference template for various business needs. In the reliability evaluation layer, the data collected from the repository layer and the user preference layer are used to evaluate the reliability ranking of the factors and the reliability ranking of the SaaS products.

[11]proposed a framework where virtual teams(VT) are combined with the Benefits, Cost, Opportunities, and Risks model(BOCR) of ANP. The VT-BOCR model has three stages. In the first stage, the VT is constructed with 4 members. Each member is responsible for each of the first levels of BOCR. The virtual teams are talented experts geographically dispersed each responsible for a certain task, in such a way that they could evaluate the software using high-performance computing resources. In the second and the third stage, each team brings out a list of factors and sub-factors that impact the selection process. ANP is performed using these factors and the alternatives considered follow a sensitivity analysis to analyze the best option.

[14] proposes a 4 stage strategic decision-making framework “E4-arrowhead” for the selection of an ERP system in Original Equipment Manufacturers. The four E’s are Explore Examine Evaluate and Eliminate. In the Explore stage, the need for understanding the functionalities of ERP vendors and solutions is addressed. In the Examine stage, the list of vendors is shortlisted, in the evaluate stage the vendors are evaluated and in the eliminating stage, the choice of ERP is made. In the eliminating stage, AHP is used to compare the alternatives for the selection. The company’s Business Scorecard approach is linked to the selection for the pursuit of the company’s strategic goals. This will pave the way to take into consideration vision, mission values, and emphasizing technology sustainability to adopt ERP to give a competitive edge to the customer. In the proposed framework the IT strategic fit, business strategic fit, and technology sustainability are ensured for the recommendation of ERP software.

The objective of [15] is to reduce cognitive overload when choosing an application from an E-marketplace like AppExchange and Google Playstore. For this purpose, the paper uses fuzzy set theory(FST) and an information visualization approach. Using GUI(Graphical User Interface) the QoS requirements are input by the user. In the fuzzy visualization-driven framework the QoS aspirations are considered and the fuzziness is treated using linguistic variables. Finally, the framework uses Euclidean distance metrics to estimate the proximity of the alternatives to the QoS aspirations.

[18] used fuzzy logic and TOPSIS to evaluate an application from the customer’s perspective. For this QoE factors have been analyzed carefully. A customer evaluation handler is used to register customer feedback. Two linguistic variables namely quality priority and quality evaluation are considered to arrive at a final quality evaluation score. The linguistic values proposed for quality priority are extremely important, very important, somewhat important, not important, not very important, not

important at all. The quality evaluation variable's proposed values are very low, low, medium, high, very high, and extremely high. The final quality evaluation score is obtained by aggregating priority and evaluation scores. Finally, TOPSIS is used to rank and choose the best alternative under a fuzzy environment.

[21] applies fuzzy ELECTRE-IV to select an ERP provider from the ERP provider's perspective. It has been cited that this perspective means that the providers are choosing an ERP for themselves which will channel the best selection. [24] proposes a framework called "Find SaaS" for the selection process based on the consumer's perspective. The framework uses TOPSIS(Technique for Order of Preference by Similarity to Ideal Solution). The framework has three components – Preference Processor, Services Registry Repository, and SaaS Selection processor. The preference processor collects preferences on functional and non-functional factors. The non-functional factors are determined by QoS by comparing the qualitative criteria with the others and quantitative using real data. The second component has the list of services that are available to the consumers. In this part, the metrics are set to the factors, both Qos(qualitative and quantitative) and the functional factors. The last component is the selection processor which sorts and ranks the alternatives. To rank the alternatives, TOPSIS has been slightly modified to rank based on similarity to consumer preference.

[25, 27] uses conventional AHP for SaaS vendor selection. It uses a 9-point scale. [26] proposes the Primitive Cognitive Network Process(P-CNP) which is a rectified AHP approach. The steps involved in P-CNP are problem cognition processes where the problem in the context is formulated with a set of alternatives. The process uses a set of 9 linguistic values for which interval scales are given. The next step is the assessment step where decision makers rate the factors using pairwise opposite matrix. The next step is the prioritization process in which the matrix is prioritized by Primitive Least Square. The fourth step is the multiple information fusion process where a list of results is obtained. The final step is the decision volition process where the final decision is made.

[4] proposed a competency model integrated with AHP to bring out the best software product. For factor selection they used AHP. Five levels have been introduced- None, Low, Medium, High, and Very High. None is denoted if a product has the attribute. Low means the product offers the attribute but with a low qualification level and goes on to the 5 levels. Using levels the weights of the alternatives are calculated against the factors and are ranked accordingly. A case study has been done to select a CRM system from three options.

Selection of Weighting Methods

In [2], suggests that the experts' judgment must be assessed systematically to mitigate subjective randomness. It proposes two approaches to calculate the weights of criteria to denote importance. Thus the weights of decision-makers are calculated with an extended variance approach. The concepts of mean, variance, and confidence factor are used to compute the weight of the experts. The other approach involves the estimation of the weights by the cross-entropy optimization. However, the research used only the former approach to calculate the weight of the criteria.

In [3], the weighting method generally used for ANP will be a pairwise comparison like AHP. It is a technique in which the elements are compared against each other to determine which is more relatively more important. The steps followed in the method start with defining the problem domain followed by identifying the main factors along with its subsequent criteria. Then a pairwise comparison matrix is calculated using the values that are given according to experts' judgment by following Saaty's Scale. The comparison will be carried out between the criteria falling under each category and finally between the main factors as well. This process will give out two matrices one for the criteria and the other for the factors. These two matrices are then multiplied to give a weighted matrix.

In [7, 25], the calculation of weights is done using pairwise comparison as in AHP according to the expert's judgment by following Saaty's scale. [8] uses the AHP comparison matrix and eigenvector to

rank the factors based on user preferences. This is done for each level in the factor hierarchy and the products and also to rank the products. This gives a shortlist of factors that will be used to evaluate the products. Again AHP comparison matrix and eigenvector for ranking the products based on quantitative metric values(computed for each attribute) for each attribute. [15] uses a fuzzy pairwise comparison of the fuzzy extension of AHP(FAHP) for weight derivation.

[11], the weighting of criteria is done using pairwise comparisons(ANP). Priorities are given to the clusters and elements of each subnet(B, O, C, R). After independently synthesizing the subnets, the first level of team members rate the weights of B, O, C, and R and synthesize the final results. By making pairwise comparisons, the relative value of different criteria is assessed. These assessments are transformed into numerical weights or priority by the AHP, and these values are then utilized to determine a score for each attribute[14]. In [21], the decision-makers set preference thresholds that allow for minimum levels/values for the criteria. Then pairwise comparison is conducted to calculate the weights.

2.4.2.2 Other Approaches

[12] introduced a data mining fuzzy clustering algorithm to evaluate SaaS. The motive is to identify clusters among the alternatives. To collect data from the internet web scrapping and manual entries were done to collect factors and the values for it. Then data preparation and cleaning like removing rows with missing data and standardization of the values are performed. The number of clusters is identified using the elbow method. Using the Fanny Function available in R studio, fuzzy clustering is performed. This means will enable a customer to choose a vendor easily from a cluster.

[19] proposes a heterogenous similarity metrics(HSM) ideology for QoS-based ranking SaaS alternatives. There are 5 HSMs introduced namely the Heterogenous Euclidian-Overlap Metric, Heterogenous Value Difference Metric, Heterogenous Euclidian-Eskin Metric, Heterogenous Euclidian-Lin Metric, and Heterogenous Euclidian-Goodall Metric. The paper evaluates the ranking accuracy of these 5 metrics. The ranking performances of these 5 metrics were performed using the Kendal tau coefficient and precision as accuracy. The results show that the Heterogenous Euclidian-Eskin Metric turned out to be a promising metric for ranking heterogeneous datasets.

[5] introduces the ASMAN(Appropriate selection of SaaS model necessary) framework which uses SCA(SaaS Comparison Algorithm). This study focuses on implementing the SaaS selection framework to offer a pool of SaaS services to guide decision-makers to find their choice. The purpose of this framework is to find and compare the best SAAS services. This framework tags speed, ease of use, reliability, and availability as the mandatory parameters for the computing performance of the services. The admins can add extra features to the services to let users know more about the options. The framework will compare the user requirements and that of the data stored In the database and provide a list and charts to view the data and let the user make comparisons. [6] proposed a Balanced Scorecard approach to software selection. It is mainly used to analyze how a business is doing and gives a picture of where the business can improve. The model wants to test if a business has improved overall after acquiring a product. The approach has four perspectives – financial, customer, internal business process, and organizational capacity. The paper showed the correlation between the perspectives by using hypothesis testing and proved that organizational capacity improved the internal business process as well as the customer experience, whereas internal business process has positively improved the customer experience. This overall improved the financial capability of the organization after buying a product.

2.4.3 Factors Selection

To select a software service from a list of choices the end user must convert their preference into attributes that need to be quantified or qualified to compare the results between the different choices. There are certain principles that one must consider to determine these attributes[25].

- The set of attributes selection must be comprehensive meaning no important attribute should be left out that might affect the selection process.
- If there are attributes that are high priority much attention needs to be given in analyzing those attributes.
- The levels of attributes should be correctly mapped in the hierarchical order
- The most important point to consider is the definition of the attributes. The meaning of the attribute should be accurate
- The attributes need to be independent.

[2] considered 16 criteria from past literature that it considered were important for choosing an ERP system. The criteria included cost, ease of customization, cross-module integration, domain knowledge of the supplier, implementation time, maintenance, service and support, system reliability, the market position of the supplier, compatibility, functionality, methodology of software, user-friendliness, information security, employee's comfort, fit with parent organization. [3] used the "quality model of cloud service" proposed in 2015 to finalize the quality attributes which included usability, security, reliability, tangibility(aesthetics, user interface, visibility), responsiveness, and empathy. [4] uniquely factorized the criteria by using AHP(Analytical Hierarchy Process). It considered functionality and user preferences as the first level criteria in the hierarchy and further broke down functionality into several in-depth criteria depending on the type of software under consideration(CRM, ERP, BI, Office, SCM), and user preference into reputation, cost, usability, architecture, configuration, and personalization. [5] used cost, reliability, speed, ease of use, and availability taking into account the previous literature recommendation. [6] used a balanced scorecard (BSC) approach to evaluate software after it is offered to the customer. It used the four perspectives of BSC – Learning and growth, Internal business process, customer performance, and financial performance to evaluate how the acquirement of software has improved the overall business. [7] used the knowledge of the past researcher's work and used a BCR(Benefits Cost Risk) hierarchy to evaluate the. The next level attributes included functionality, vendor reputation, QoS factors like reliability, security, cost of business, and support. [8] used 23 factors to evaluate a SaaS product. Apart from the frequently used factors some other included were remote access, service audit logs and change notifications, updation frequency, sustainability, backup frequency, data storage location, and self-service. The factor weightings are calculated using AHP. [9] interviewed stakeholders(service researcher, independent service developer, service client, service developer, and SaaS provider) and came up with 17 criteria for evaluation. These are split the factors into product-related(9), process-related(7), and organization-related(7) quality factors.

[10] used success factor analysis to identify the factors that contribute to the company's success. The researchers mapped the factors in a performance-priority matrix. Security and service, facilitating conditions, costs, perceived usefulness, availability, compatibility, performance, functionality, trust, and ease of use are the ones that influenced high performance and were given top priorities from a survey conducted. [11] did research with four virtual teams dispersed geographically. Each team worked to analyze the different clusters – Benefits, opportunities, costs, and risks. [12] used reviews and ratings of the software to analyze the cluster through a data mining approach. [13] used [29] as a reference to cite out the dimensions covering flexibility, costs, scope and performance, security and compliance, reliability and trustworthiness, service and cloud management. [14]considered criteria that the researchers believed could improve the business strategically. These include functionality, total cost of ownership(TCO), technology vendor reputation, and software quality. Under these main dimensions, several criteria are discussed in detail. [15] considered only four factors availability, response time, reliability, and cost to evaluate its proposed model. [16] followed the AHP methodology to rank the

factors in terms of importance. The top 10 factors that made it to the list include relative advantage, compatibility, complexity, security, privacy, technology readiness, support, organization readiness, and regulations. [17] considered cost, performance, SLA(Service Level Agreement), and environmental impact to guide cluster comparison. [18] after discussion with experts and a literature review concluded that support, vendor reputation, training, security, recoverability, interoperability, usability, and integration as the main attributes.

[19] lists have 6 attributes namely response time, availability, cost, usability, security, and flexibility from the 6 categories in the SMI(Service Measurement Index) which is a standardized service measurement framework proposed by CSMIC(Cloud Service Measurement Index Consortium). The reason for this choice is to consider three quantitative and three qualitative factors for evaluating their proposed model.[26] considered functionality, usability, integration, security, efficiency, and price but no detail is provided as to why these factors were chosen.[28] denote the vendor selection from two different perspectives, the Customer's and Vendor's. Factors like functionality, usability, brand name, start-up time, pricing, and legal compliance fit both parties' perspectives. [20] introduces and proposes security(customer, application, network, data and management), QoS(QoP, QoA, QoE) to cluster different SaaS service levels. [21] conducted in-depth interviews with ERP vendors and experts from universities and finalized on reputation, market share, technical and management expertise, support, ease of use, integrability, collectivity, turnover, net profit, and growth rate of main business revenue. [22] used fuzzy LinPreRa, an MCDM technique to rank the factors in terms of importance. The factors topped the list are cost, technology readiness, organizational size, support, trust, relative advantage, security risks, complexity, and trialability. [23] used AHP to rank the factors by interviewing experts with 4 to 18 years of experience. The resultant gave 32 factors, 15 for product-related, 10 for process-related, and 7 for organization-related factors. The top 5 in each category would be performance, security, scalability, interoperability, configurability, availability, cost, governance, reliability, and customizability. [24] research considers only quantitative parameters. Among these are response time, availability, throughput, and cost. [25] provides no clear information on the finalization of the criteria but gives out a list of criteria considered for the vendor selection process. The main list includes cost, functionality, service, and vendor reputation.

2.5 Research Gap

A systematic literature review was conducted to analyze the selection of cloud computing services concentrating on SaaS selection. Many observations were made related to the types of methodologies used, how the factors are selected, considerations of perspectives from different stakeholders on technique/attribute selection, data collection techniques for weighing factors, and finding alternatives. From the findings and taking into consideration the contribution that needs to be given to SISAR, further research is to produce an effective way of selecting a payroll software by considering the prospective perspectives of the end user and SISAR. The research will further consider a systematic quantitative data-driven approach to select a vendor that provides payroll solutions.

The existing body of literature overlooks the possibility of integrating business strategies into the proposed selection frameworks. This research will incorporate the business expansion goals of SISAR along with software selection decision-making. While there are studies that explore concepts of integration and customization there is a gap regarding SaaS selection tailored to the possibilities of the customer's business strategic objectives. Therefore the goal of this research is to introduce a software selection framework with an understanding of business expansion goals. By doing so, the organization can make informed decision-making regarding business expansion initiatives to mark its presence in competitive markets.

2.6 Chapter Summary

In this chapter a literature review was conducted to have background knowledge on how Software-as-a-service Selection has been demonstrated in the past. The literature review will guide through the design and development of a software selection framework which will be the artifact to drive software selection process. The next chapter will discuss the design of Software Selection Framework.

Chapter III

3 Software Selection Framework Design

This Chapter presents the design of the conceptualized selection framework addressing the research question, SRQ3. This framework will guide a decision-maker through a software selection process to choose a software. The step-by-step process is detailed in the following subsections.

3.1 Problem Analysis

The problem analysis includes examining the problem statement, briefing the relevant stakeholders participating in the treatment of the problem, and identifying and understanding the goals and reasons why the problem needs a solution.

Goals

As mentioned earlier in Section 1.2.1, SISAR is building an HRM tool, which is a SaaS product. The key feature of this product is that it facilitates numerous integrations with other tools to manage the workforce of a client organization. An integrated platform enables automated data exchanges and synchronization across the system, data accuracy, reduces the amount of manual time, improves efficiency, and saves cost. In this context, a selection framework is going to be designed for the selection of payroll software that could be integrated with the HRM tool. In addition to selecting the product, the company is also looking to use the B2B consumerism platform to expand its business through the vendor. The company is looking to collaborate with potential payroll vendors to form strategic partnerships that could enable the company to expand its business and mark a place in new unknown markets. So choosing a software vendor that can compensate the company both with technical capability and strategic business alignment is essential for achieving long-term success and sustaining competitiveness in the market.

Stakeholders

The next step is to identify the stakeholders whose participation is essential in producing the selection methodology/framework. According to Wieringa [33], a stakeholder is a person, group of people, or an institution affected by the treatment of a problem. In this research a stakeholder could be the employee internal to the organization, the software vendors that will be participating in the selection process, or the decision-maker of the final selection of the vendor. Mapping the stakeholders according to the checklist of Alexander[35] for the research project gives the following set of stakeholders participating actively and indirectly in the research. Table 2 gives the list of stakeholders participating in the design and development of the selection framework. The key stakeholders include the Normal Operators who are the Product development team and are responsible for analyzing and evaluating the software using the selection model. The director of the company will make the final decision after discussions with the vendors about potential integration. Additionally, the director who is the beneficiary and consultant offers guidance in the form of functional/non-functional requirements that will help in designing the selection methodology/framework. The vendors are the suppliers/ providers of payroll solutions who share valuable information that will be used as attributes to evaluate certain criteria that will be discussed in the following sections. The author of this report is the developer who is responsible for the design and development of a theoretical selection model and the University of Twente guides the researcher by providing scientific/academic guidance for carrying out the research.

Stakeholder	Stakeholder classification	Goal
Product Development Team/ HR /Sales Executives	Normal Operator	Who makes use of the selection framework to analyze software and the vendors
Director of SISAR	Functional Beneficiaries	Who benefits from the end output of the framework to make informed decisions on selections?
Director of SISAR	Consultant	Who gives expert guidance on the choice of functional and non-functional parameters to be considered for selection?
Payroll Vendors	Supplier(product/company information)	Who shares information about their product to be used in the evaluation of the software and vendor?
Researcher	Developer	Who develops the selection framework for the benefit of the organization
University of Twente	Supplier(knowledge)	Who provides expert guidance on the research from a scientific perspective?

Table 2 List of Key Stakeholders

3.1.1 Requirement Analysis

The requirements of the company include both functional and non-functional requirements. This is because though collaboration is between SISAR and the vendor, the end users are going to be potential customers of SISAR. The requirements gathered will be elaborated in detail in the remaining sections of Chapter 3 through each step of the design phase.

An interview was conducted with the Director of the company, to get to know about the HR tool the development team is working on and the expectations out of a third-party payroll software.

S No	Requirement Specification	Functional/ Non-functional	Interview Duration
1	Cloud-based software	Functional	25:14 minutes
2	Provision of open-access API	Functional	
3	A standalone payroll solution with no provision of an HR solution	Functional	

Table 3. Constraints for Filtering Vendors

A set of constraints is discussed and finalized to be applied to each software before evaluating them. The first checkpoint is that the payroll software should be cloud-based because it has SaaS architecture. The second constraint is that the software should facilitate API integrations such that it could be integrated with other SaaS systems. The third constraint and the most important filtering constraint is

that the payroll should be a standalone software that is the vendor should not provide additional HR solutions. This is because SISAR is selling HR solutions and it is important to identify vendors that target similar audiences but do not sell competitive products. Also, companies that sell HR solutions do not want to partner with us because they already provide HR. The available software in the market is filtered based on these constraints. In other words, the payroll vendors that provide payroll services are screened and shortlisted by analyzing and collecting data from their websites based on the points given in Table 3. Figure 6 shows the prerequisite steps involved in the Screening of payroll vendors.

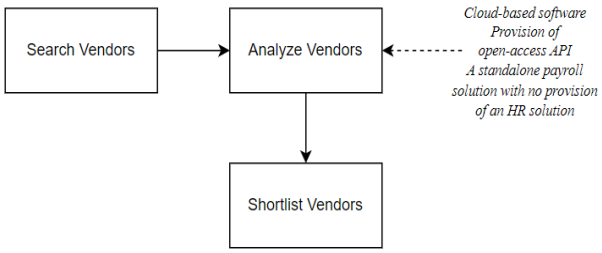


Figure 6. Filtering Payroll Vendors by Applying Constraints

The set of requirements to check the quality of service and the possibilities of collaboration offered by the vendors is shown in Table 4. The vendors will be evaluated based on these requirements. The following sub-sections will detail on evaluation of the software and its vendors.

S No	Requirement Specification	Functional/ Non-functional	Interview Duration
1	Check Quality of Service	Functional/ Non-Functional	57:39 minutes
2	Check for Business Expansion possibilities	Non-Functional	

Table 4. Requirements of the Organization

3.2 Evaluation and Ranking

Post the problem analysis stage which winds up with collecting requirements and analyzing the suitability of vendors to filter them out to consider for evaluation, we focus on finding the selection technique that will evaluate and rank the software. Here, we discuss the evaluation of the software based on a set of criteria. As discussed in Section 1.2.5 a systematic literature study was conducted to have an understanding of the selection processes done by researchers in the past. In the following subsections, we will discuss the step-by-step procedure to determine the selection process.

3.2.1 Selection of the Technique for Evaluation

Several techniques were discussed in the literature for the selection process, and it is crucial to select one that applies to the current research. In the literature techniques like MCDM, Linear Utility Model, Data Mining approach, BSC approach, and Heterogenous Similarity Metrics were discussed as detailed in Section 2.4.2. In this research, an MCDM approach will be used as a methodology to guide through the process of evaluating and selecting payroll software because it is one of the most precise techniques for decision-making [36]. The advantage of this technique is that it can accommodate both quantitative and qualitative criteria that need to be evaluated and its applications are manifold. Figure 7 shows the

applications of MCDM methodologies in various sectors and applications. It has been highlighted that it is used in Organizations and corporations for System Selection Processes in Enterprises and Corporate Sustainability.

Application Fields	Examples of the Application Focus
Healthcare	The assessment of COVID-19 regional safety, occupational health, and safety risk assessment
Energy sector	Ranking renewable energy sources, techniques for energy policy
Engineering and Production	Engineering, material selection for optimal design, Optimum Process Parameters
Career and Job	Occupational stressors among firefighters, personnel selection problems, Job Choice
Supply chain management	Supporting sustainable supplier selection, green supplier evaluation, and selection
Organizations and corporates	System Selection Process in Enterprises, corporate sustainability
Education	Contextual Learner Modelling in Personalized and Ubiquitous Learning, E-learning
Transportation	Urban passenger transport systems, integrated transportation systems
Civil Engineering	Flood disaster risk analysis
Finance/economics	Project portfolio management

Figure 7. Use of MCDM Technique in Different Sectors and its Applications[36]

MCDM technique

If multiple criteria have to be used to evaluate software, then MCDM techniques are used. In MCDM techniques, solving an MCDM problem means that it could be choosing the best alternative or choosing a small group of desired alternatives. Some of the concepts/ terminologies that one should know before solving an MCDM problem, and apply to this research are as follows:

a) Alternatives – Different possibilities of software products/services
b) Criteria – are the different factors that are considered important for the evaluation of software
c) Aggregation – consideration of the performance of an alternative based on the criteria.

There are many ways to interpret an MCDM problem. It depends on the application context in which the decision maker chooses to apply the technique. It could be selecting an optimal solution or grouping/ranking of the alternatives. But the general mathematical formula is given below.

$$A = \{A_k \mid k = 1, 2, \ldots.m\}$$

Where A is a set of alternatives and m denotes a finite positive integer.

$$C = \{C_l \mid l = 1, 2, \ldots..n\}$$

Where C is a set of criteria that are used to evaluate an alternative, A and n are the number of criteria.

$$W = \{W_t \mid t = 1, 2, \ldots..n\}$$

Where W is the set of normalized weights assigned to the criteria based on the weighting method that is used. The information gathered from the above formulae is organized into an MCDM matrix as shown in Figure 8.

MCDM Matrix	C_1	C_2	...	C_n
A_1	x_{11}	x_{12}	...	x_{1n}
A_2	x_{21}	x_{22}	...	x_{2n}
...	...	...	x_{ij}	...
A_m	x_{m1}	x_{m2}	...	x_{mn}

Here x is the attribute value of Alternative A, concerning the criteria C.

Figure 8. MCDM Matrix [36]

The general steps of the MCDM problems is shown in Figure 9. The multi criteria decision making process brings in three activities together – the selection of list of criteria, the selection of weighting method to assign weights for the criteria based on their importance to influence the evaluation of alternatives and the selection of the ranking MCDM method to rank the alternatives.

Figure 9. Steps Involved in the MCDM Process [36]

Significance of MCDM

Figure 10 shows the popularity of MCDM techniques. The use of MCDM increased even more with the covid pandemic where it was used for the simulation of concerns. There are over 60 MCDM techniques each having its set of application fields and categorized into different types proposed by different researchers.

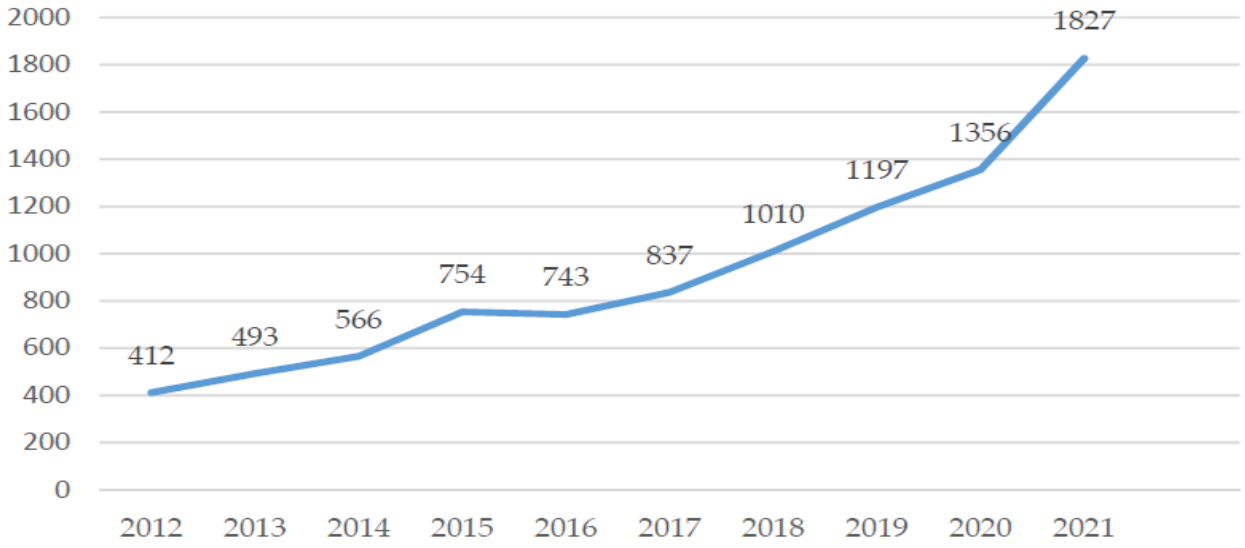


Figure 10. The trend in the Popularity of MCDM[36]

Choice of MCDM technique

[36] ranked the most cited MCDM techniques that have been used between 2012 and 2022. From the list of 60 techniques considered it gave the top 5 most cited ones. They are shown in the Figure 11.

Method	Description	Original Reference or Underlying Source
AHP	Pairwise comparison of hierarchical criteria considering difference information.	Saaty [16]
DEA	Performance assessment of a set of homogeneous DM units with multiple inputs and outputs.	Charnes and Cooper [17]
FST	Quantifying the linguistic facet of accessible data and preferences to address subjective and ambiguous problems.	Zadeh [18]
TOPSIS	Evaluating based on the distance of alternative to the ideal solution.	Hwang and Yoon [12]
GP	Minimizing the derivation of each objective from the desired target together with optimizing manifold goals.	Charnes and Cooper [19]

Figure 11. Top Most Cited MCDM Techniques between 2012 and 2022[36]

Research is carried out to choose a methodology out of the five that fits the selection problem in this research. For this purpose, the 5 methodologies will be analyzed based on different aspects and a final choice will be made.

AHP(Analytical Hierarchy Process)
This theory was proposed by Saaty[39]. The concept of AHP revolves around pairwise comparison that depends on the judgment of experts[39]. It has been applied in the fields of industrial and manufacturing, business and management, healthcare, and urban planning predominantly[40]. It is the most frequently used technique around the world due to its simplicity ease of learnability and ease of understandability[40].

DEA(Data Envelopment Analysis)
This theory was proposed by Charnes and Cooper[41]. It is a linear programming technique that evaluates the efficiency of decision-making units(DMUs). An alternate along with its criteria is considered a DMU. This technique will consider multiple inputs and outputs to calculate the performance or efficiency of the DMUs where the inputs are the non-beneficial criteria and the outputs are the beneficial criteria. The ideology behind DEA is to select a unit that maximizes the output with minimum input. The application areas include international banking, economic sustainability, police department operations, logistical applications, and assessment of the performance of natural language processing models.

FST(Fuzzy Set Theory)
This theory was proposed by Zadeh[42]. In literature, this technique is often called fuzzy Logic as it is used to capture vagueness in information in a systematic manner. This approach helps decision makers to give their opinions using linguistic terms. This method like AHP uses subjective input of the expert's judgment. The linguistic terms have some ratings that are assigned to the alternatives and these ratings are aggregated to rank the alternatives. The technique is used in fields such as pattern recognition, environmental management, medical diagnosis, and traffic control.

TOPSIS(Technique for Order of Preference by Similarity to Ideal Solution)
This model was proposed by Hwang and Yoon[44]. It is quite a simple straightforward method[46] and the fundamental notion behind this approach is that the best option is the one that is closest to the positive ideal solution and farthest from the negative ideal solution. Nowadays this technique is used in different fields of life such as energy, medicine, engineering and manufacturing systems, safety and environmental fields, chemical engineering, and water resources studies[47]. It is mainly used for ranking selection problems in any industry[24,15].

GP(Goal Programming)

This model was proposed by Charnes and Cooper[43]. This model is an extension of a linear programming model like DEA and is used in scenarios where there is a need to handle multiple conflicting objective measures. The applications of GP include Supply Chain and logistics, manufacturing and production, maintenance engineering, portfolio selection, marketing, strategic management, and social sciences.

From an overview of the above techniques AHP and FST are not considered as they both use subjective input for assigning values for the alternatives based on an expert's judgement. The opinions of experts can conflict, leading to contradictory results. The assessment procedure is carried out once more until consistency is reached and it is a time-consuming process[48]. Also, there is no rational explanation for why a certain weight is employed suggested by the experts. DEA and GP use linear programming models. The complexity of these models increases with an increase in the number of criteria. TOPSIS on the other hand is simple to use, and less complex irrespective of the number of criteria and alternatives considered but it is not a standalone technique and is often used alongside other weighting methods to provide a comprehensive analysis of the alternatives. The choice of weighting method is discussed in Section 3.2.2.

3.2.2 Selection of Weighting Method

In MCDM techniques assigning weighting to the criteria is one of the important steps. There are two approaches to weighting methods – Subjective and Objective. Subjective is based on experts' opinions and objective is based on information derived from real data for the criteria under consideration. Some of the methods used in the literature are shown in Figure 12.

Weighting methods	
Subjective weighting methods	**Objective weighting methods**
Point allocation	Entropy method
Direct rating	Criteria Importance Through Inter-criteria Correlation (CRITIC)
Ranking method	Mean weight
Pairwise comparison (AHP)	Standard deviation
Ratio method	Statistical variance procedure
Swing method	Ideal point method
Delphi method	
Nominal group technique	
Simple Multi-attribute Ranking Technique (SMART)	

Figure 12. Subjective and Objective Weighting Methods[56]

In this research, an objective approach is encouraged to avoid the influence of subjectivity. An objective approach will use real data to give weightage to the criteria. The entropy method is used in this research as it has been used in the literature along with TOPSIS for the weighting of criteria in past research [48, 52, 53] for System Selection problems.

Thus a hybrid Entropy TOPSIS approach will be used for the software evaluation and ranking outlined in Figure 13. The working of the Entropy TOPSIS will be discussed in detail in Chapter 4.

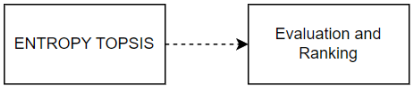


Figure 13. Technique for Evaluation and Ranking

3.3 Criteria Selection

In this section, the requirements mentioned in Table 4 are interpreted as criteria. Several criteria could be used as factors to analyze software and service quality. Data is collected for these criteria from the vendors through surveys and interviews as shown in Figure 14.

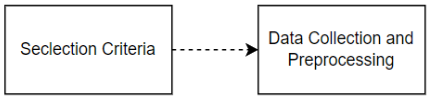


Figure 14. Role of Selection Criteria

3.3.1 Criteria Selection(Quality of Service)

For evaluating the SaaS alternatives, the service quality and technicality of the software need to be analyzed. A set of top-level criteria was selected from the literature that dominated their influence in evaluating the alternatives and their relevance in applicability to this research. The consolidated criteria for this research are Functionality, Security, Scalability, Reliability, Availability, Response Time, Integration, Support, Compliance, Usability, Vendor Reputation, and Cost. These criteria are relevant to the choice of software as Functionality and Integration determine whether the software meets the specific needs and operations intended to, Security, Availability, Scalability, Reliability, Response Time, and Usability to ensure the performance of the software. Compliance, Support, and Reputation establish the image of the software vendor and Cost determines the perceived value of the software. The list of Criteria also aligns with the quality model of ISO 25010 to evaluate the properties of a software product.

Criteria	Literature studies
Functionality/Technicality	[2,7,10,11,14,16,21,22,23,25,26,28]
Security	[2,3,4,7,8,9,10,13,16,18,19,22,23,25,26]
Scalability	[4,8,9,11,14,23]
Reliability	[2,3,4,5,9,11,13,14,15,23,24,25,28]
Availability	[5,8,9,10,15,19,23,24,28]
Response Time	[3,5,15,19]
Integration	[2,4,13,14,18,21,25,26]
Support	[2,7,9,13,14,16,18,21,22,25]
Compliance	[8,16,23,28]
Usability	[2,3,4,5,8,10,11,18,19,21,23,26,28]
Reputation	[2,4,7,9,10,12,14,18,21,23,24,25,28]
Cost	[2,4,5,7,8,10,11,13,14,15,19,22,23,24,25,26,28]

Table 5. Criteria Used for Alternatives Evaluation

The 12 criteria listed in Table 5 will be used to evaluate the quality of service(QoS) offered by each alternative. The description of the terminologies for each criterion is given below along with the possible metrics to quantify them supported by the literature.

Functionality - The product's functionality is important to check if all the essential elements and functions of the product are promised. Functional fit essentially ensures that a software package's functional competency satisfies the present and future requirements of the organization[2]. The value for functionality can be derived from[8].

$$Functionality = \frac{Number\ of\ features\ matched\ by\ the\ product}{Number\ of\ features\ required}$$

Security - It is an inevitable criterion in a cloud-based application as data is stored in the cloud. Many vendors address data security and control over who can access customers' data which enhances customers' trust in the product[8].

$$Security = \frac{Number\ of\ built-in\ security\ features\ guaranteed}{Number\ of\ features\ required}$$

Scalability - It refers to the capability of processing more requisitions in a time interval without compromising the service[9]. The formula for calculating scalability is given below.

$$Scalability = \frac{Response\ Time}{load}$$

Reliability – It refers to services that are free from hardware disasters, software errors, and other faults and weaknesses that could make them collapse[48]. It can be calculated as

$$Reliability = \frac{Number\ of\ failures}{month}$$

Availability - Availability shows the actual functional time of a software i.e. how much time it is running without interruption over the network. For SaaS, it defines how much time software resources are running. It is calculated in percentage (%). Availability is calculated by dividing the number of successful invocations of cloud service by the total number of cloud service invocations. Also, it could be calculated by deploying a monitoring tool on the application server[48].

$$Availability = \frac{Number\ of\ successful\ invocations}{Total\ number\ of\ invocations}$$

Response Time – The actual performance of a software represented by Response time. This criterion shows how much faster service is available to the user for using the software. Response time is defined by the total amount of time taken to respond to a request for cloud service. It is measured in milliseconds (ms)[48]. Also, it could be calculated by deploying a monitoring tool on the application server.

$$Response\ Time = \ Total\ time\ taken\ to\ respond\ for\ a\ request\ of\ a\ process\ that\ the\ software\ is\ intended\ to\ do.$$

Integration – It is the ability to interoperate with other systems[28]. In this case, it will be how well the SaaS product is going to be integrated with the customer's product.

$$Integration = \frac{Number\ of\ API\ integrations\ possible}{Total\ number\ API\ integrations\ required}$$

Support – The post-purchase support services provided by the vendor. The vendor must offer to assist when required[23].

$$Support = \frac{Number\ of\ support\ services\ guaranteed}{Total\ number\ of\ support\ services\ required\ by\ customer}$$

Compliance – Having a current compliance certificate guarantees that the data is safeguarded legally. Depending on the type of business, different compliance certificates may be needed; therefore, the user is required to provide the necessary certificate data[8].

$$Compliance = \frac{Number\ of\ possession\ of\ required\ compliance\ certificates}{Total\ number\ of\ required\ compliance\ certificates}$$

Usability – This attribute relates to the user's point of view of using a SaaS product. It is analyzed to determine how easy to use, easy to learn, and efficient it is[8].

$$Usability = \frac{Number\ of\ usability\ features\ present\ in\ the\ product}{Total\ number\ of\ usability\ features\ required}$$

Reputation – It refers to the vendor's perceived credibility, dependability, and trustworthiness that have been cultivated over time by its actions, offerings, and interactions with stakeholders and consumers.

$$Reputation = Total\ number\ of\ clients.$$

Cost – It is the cost of billing the subscription per month/year.

3.3.2 Criteria Selection(Business Strategy)

SISAR through its HRMS tool and its ability to provide possible integrations with other cloud-based software wants to leverage third-party software solutions like Salesforce's CRM, Slack, Jira, Google, and Outlook calendar to provide workforce management solutions to a client organization to streamline data flow and automate workflows within its organization. Likewise, the tool provides integration possibilities with payroll solutions. Since HR and payroll are complementary solutions, in addition to integrating payroll software with the HRMS tool SISAR wants to collaborate with the payroll providers, access their solution, and leverage the partnership to expand their business. This strategy for business expansion can help the organization stay ahead of its competitors and through strategic expansion efforts, the organization can establish itself as a key player and strengthen its market position, ultimately achieving organizational goals and profitability.

One of the goals of this research is to translate the business expansion goals into criteria such that these goals could be used along with the QoS criteria to evaluate the software providers. These strategies were chosen after careful consideration during the requirements-gathering phase.

White-labeling – The term "white label" describes items, products, or services that are manufactured by one business (producer), distributed, transported, and sold by another a different business using their name or label[49]. [50] defines the phrase "white label" as the process of creating manufactured goods without a set brand so that they can be quickly rebranded and offered for sale to other clients under the guise of having been made themselves. [51] describes white labeling as a scenario where one company, the producer, creates a white-label good or service, which is then utilized or marketed by other

businesses, the marketers, under the marketers' trademark. The primary idea of this concept is that the end users who use a product or a combination of products don't have any idea that the product's provider is not the vendor they buy it from. The vendor asks permission for rebranding from the product's provider and takes care of the marketing activities. Figure 15 illustrates the white-labeling activity between the provider, vendor, and customer.

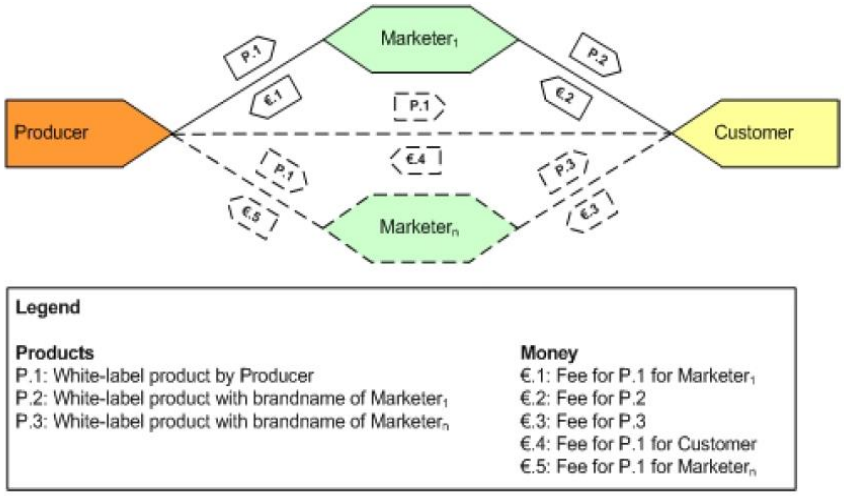


Figure 15. White-labeling activity example [51]

Some of the reasons for white labeling include the possibilities of achieving growth and with this the opportunity to increase revenues, shorter time-to-market, and high-quality products/services[51]. Another advantage is the possibility of faster integration with other frameworks or systems.

There are three types of White-labeling methods

Co-branded product, where SISAR's brand will be defined along with the vendor's brand.

Loosely branded, where SISAR's brand will be defined along with the vendor's brand. In addition to that, the product is customized to the needs of SISAR.

Deep branding, where the SISAR's brand is defined and the end user of the solution will have no idea of the involvement of the vendor company.

As mentioned above, the customization of the product is done by incorporating a UX strategy. This might include overall product redesign, color/brand theme, tone/style change of content, typography, page layout, button styling, top header, messaging strategy, menu theme, iconography, and so on.

Co-selling - Co-selling is a sales approach in which a third-party business cooperates with another business to market goods or services to clients they share. This approach combines the advantages, the products/services, and the clients of each business to provide a more complete solution for the client. Co-selling partnerships involve the cooperation of two or more companies, usually a vendor and a partner or reseller, to sell products or services to shared clients. The motive of this partnership is to reach a new market for either of the participating parties. When the partnerships cooperate to sell complementary products, then it can also be called cross-selling partnerships.

Impact on the Company

Software startups/scaleups are innovative businesses that impact the competitiveness and growth of the world economy. The main motive of startups/scaleups is to accommodate new customers and prepare for growth, so they plan for scalable processes that benefit them[50]. White-labeling benefits the company in fast entry into unknown markets[51]. In this context, SISAR is developing an in-house HR tool which is a platform that could be integrated with third-party cloud-based payroll software. SISAR's business strategy is to penetrate the market through the potential partnership of the vendor. Thus, it wants to white-label the payroll software rebrand the product, and sell a packaged HR payroll solution as its own. Co-selling benefits SISAR to tap into the payroll vendor's marketplace, increase possibilities to acquire new customers, improve its brand value, and accelerate sales of its product. Payroll vendors in the respective country can make partnerships with SISAR so that SISAR can sell its HR tool to the vendor's clients as well.

Since in this research, an objective approach is followed for software selection, in addition to the criteria determining technicality and QoS that have been quantified as discussed in Section 3.3.1 these two concepts of business expansion strategies are translated into criteria and are used to compare the payroll vendors. Quantifying metrics for White-labeling and Co-selling will depend on the following parameters.

$$White\text{-}labeling = Number\ of\ \ white\text{-}labeling\ projects\ involved$$

$$Co\text{-}selling = Number\ of\ \ co\text{-}selling\ projects\ involved$$

3.4 Software Search and Filtering

This section consolidates the software selection process by applying the constraints, the requirements interpreted into criteria, and the selection technique that will bring the criteria together to evaluate the alternatives. During the selection process, a country is chosen where payroll software is to be selected. The country has hundreds of vendors that provide payroll solutions. Not all the vendors will be evaluated. The vendors will be filtered based on the constraints put forward(Table 3, Figure 6) and selected based on the evaluation carried out by the selection techniques(Section 3.2, Figure 13) against the criteria(Section 3.3, Figure 14). Figure 16 shows the flow of searching, screening, and selecting activities. This is the proposed framework for Software Selection in this research.

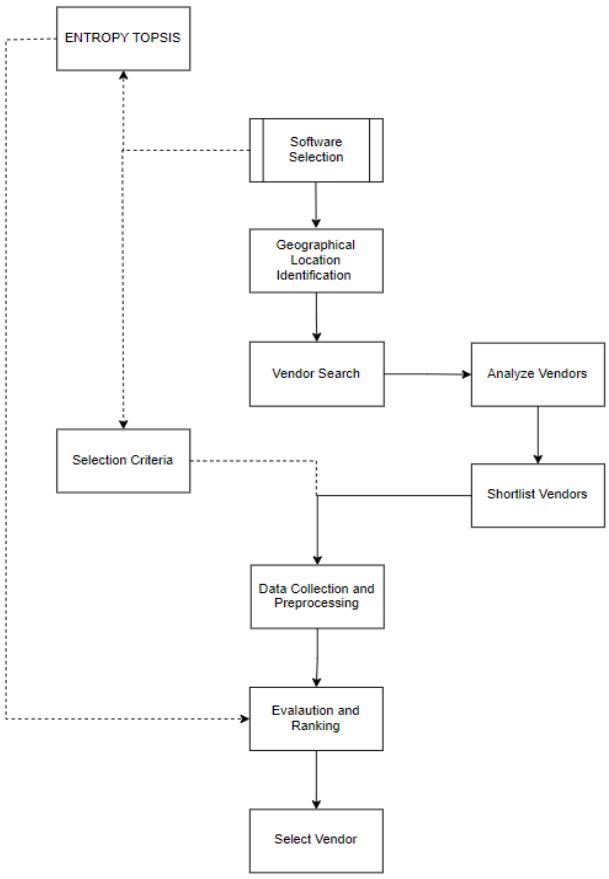


Figure 16. Proposed Framework for Software Selection

3.5 Chapter Summary

This chapter presents the treatment design, a framework for software selection. The step-by-step procedure - the requirements analysis, selection of a technique evaluation technique, selection of weighting method, and choices of criteria are discussed. A framework is developed taking into account all the steps needed for the selection process. Compared to the existing works in the literature that concentrate on sustainable software selection this research also includes Business Expansion Strategies to evaluate the software provider. The next chapter will discuss validation of the framework.

Chapter IV

4 Treatment Validation

This chapter is dedicated to justifying that the software selection framework contributes to the goals of the organization when applied to a problem context[33]. The steps in the proposed framework were discussed and analyzed with the internal stakeholders and any refinements needed in the proposed selection process were incorporated. Chapter 2 discusses the existing work on software selection and Chapter 3 introduces the proposed software selection framework. Though these provide the knowledge and input to solve the selection problem, it is important to get suggestions from the organization's point of view on how certain activities could be carried out in a real-world scenario. This first stage of validation incorporates interviews with internal stakeholders. The process entailed in Treatment Validation is shown in Figure 17.

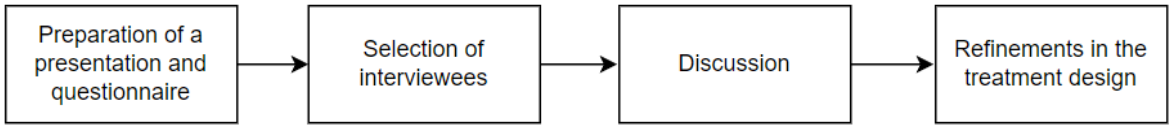


Figure 17. Validation Approach

4.1 Preparation of a Presentation and Questionnaire

For the validation of the proposed framework, a semi-structured interview was conducted. As a preliminary step, a presentation with an overview of the proposed framework was prepared along with a set of questions given in Table 6. The presentation slides have been presented in Appendix Chapter A.

S No	Questionnaire
1	1.1) How is Software selection done? in the past? 1.2) What are the problems/dilemmas faced during the selection process? If yes, elaborate 1.3) Which kind of judgment led to the choice of software selection in the past? 1.4)How payroll software was selected for SISAR?
2	Do you think the set of criteria proposed in the research is suitable to evaluate the software? If yes/no elaborate
3	Do you think the proposed framework could prove useful for the company?
4	What do you think about the quantification metrics for each criterion?
5	Do you find any areas of improvement In the software selection approach? (Could be the criteria, quantification method, or the framework)
6	Do you have any other feedback?

Table 6. Validation Questions

4.2 Selection of Interviewees and Discussion

The selection of interviewees was based on their job profiles. Expert opinions were collected whose profile is relevant to HR/Payroll or participation in the development of the HR system. They were interviewed after giving an overview of the treatment design. A short description of the interviewees is given in Table 7. Post the preparation step and selection of the interviewees, prior permission was asked to record the conversation and the interview summary is shown in Table 8.

Participants	Role	External/Internal	Duration
S1	Director of SISAR	Internal Stakeholder	20:56 minutes
S2	HR Business Partner	Internal Stakeholder	38:49 minutes
S3	HR Talent Manager	Internal Stakeholder	30:14 minutes

Table 7. Interviewee Details

Questions (From Table 6)	Discussion
1	Understanding of gaps in the existing system and realizing if there is a need for software, Then comes an analysis of the gaps, and requirements gathering which point out to the question of whether a software could bridge the gaps and clearly define the need for a software. In the past lots of software were not able to integrate. The prices and licensing of software have gone up such that instead of buying software as such, based on the analysis of the gaps there is a lookout for software solutions that could integrate well with the system/organization. Decisions will be taken based on the demo, a trial period, and see how the software interacts with IT systems. If testing is successful then it is implemented across the organization. Problems faced - Too simple to use and did not allow for customization, more complex software that led to mistakes. Factors that were considered are size of the organization, requirements of the team, which region requires the software, how many people need it, usability, and free training programs. The organization bought a top player and popular HR payroll provider.
2	The list is good and thorough. Any other requirement or functionality could fit into one of the listed criteria. Scalability, Integration, and Cost were excluded from the list of criteria considered. Scalability – As response time and availability, reliability are calculated which are enough Integrations – The number of Integrations doesn't matter. Cost – Cost couldn't be compared because each software offers a different set of features and also the pricing package depends on the number of employees in the client's organization.
3	Yes. This approach/framework fits the company.
4	White-labeling and Co-selling - It is suffice to enquire if they are prepared for the above forms of collaboration
5	The list of criteria could be shorter.

6	Since the framework looks fit for other software selections as well, there might be some tweaking of the criteria to accommodate some quick decisions. But for payroll selection, this is viable.

Table 8. Interview Summary

4.3 Refinements in the Treatment Design

After discussion with the internal stakeholders, changes were made to the respective aspects of the treatment design. The updated list of criteria is shown in Table 9.

S No	Criteria
1	Functionality
2	Security and Compliance
3	Availability
4	Response Time
5	Reliability
6	Support Service
7	White-labeling
8	Co-selling
9	Usability

Table 9. Revised List of Criteria

The quantifying formula for White-labeling and Co-selling is changed to the following.

White-labeling = Would the company be open to white-labeling initiatives?

Co-selling = Would the company be open to co-selling partnerships?

Customization of the product is added as one more functionality feature that needs to be checked with the Vendor. Security and Compliance are merged as one criterion.

4.4 Chapter Summary

In this chapter, the first step to validation was conducted. During this phase, the proposed artifact was discussed with the internal stakeholders of the company. Interviews were conducted with the stakeholders of the company. The suggestions and input were included as refinement into the framework. The next chapter will discuss a case study as Treatment Implementation.

Chapter V

5 Case Study

This chapter discusses the case study conducted to evaluate the selection framework to address research questions SRQ4 and SRQ5. During this case study real-world examples of payroll solution providers were considered and evaluated using the framework proposed in Chapter 3.

5.1 Filtering of Vendors

SISAR exclusively works and has customers in the Netherlands, the UK, and India. For this case study, the country chosen is the Netherlands. The initial focus is to find a government website that could provide data on payroll services. But the search was not successful. Instead, software reviewing websites like Capterra, G2, Software Advice, and LinkedIn were used to do an extensive search and collect information on payroll services in the Netherlands because [24] used Capterra to collect their data. The result showed 124 results. Setting the constraints that the software should be cloud-based and should allow integrations with other systems through API, the results went down to 25. To check whether the payroll providers offer only standalone payroll solutions and not HR the brand name and the website of the vendors were analyzed and the result went down to only 1. So, in this case study, payroll vendors from the UK were also considered. Gov.UK website allows to find the government services and information. The results gave 161 results. Again applying the same constraints the result gave 5 vendors. To maintain confidentiality, the 6 vendors are identified as A, B, C, D, E, and F.

Payroll solutions that offer EOR(Employee of Record), PEO(Professional Employer Organization), and software vendors that provide solutions for umbrella companies and temporary recruitment were excluded. An organization that lawfully hires employees on behalf of another company is known as an employer of record (EOR). Every facet of employment, such as payroll, taxes, benefits, and compliance, is fully the responsibility of an EOR. Professional employer organizations, or PEOs, are a subset of co-employment that is full-service HRM outsourcing. Under this arrangement, a business hires the PEO to handle a variety of employee administration functions, including payroll and benefits management.

5.2 Data Collection and Preprocessing

Each website had a chatbot through which a vendor representative was contacted to collect data about the software and the company. Meetings were scheduled with the respective stakeholders. The overall process of data collection took three weeks. Only 4 out of 6 vendors responded to the request for a meeting. Therefore this case study is performed for 4 vendors. The interview details are given in Table 10.

Vendor	Representative
A	Sales Personnel
B	Sales Personnel
C	Sales Personnel
D	Sales Personnel

Table 10. Number of Vendors

A semi-structured interview was conducted with each of the sales representatives to collect data. Pre-determined questions for the survey were prepared using Google Forms and were shared during the interview. The questions for collecting data for the criteria are given in Table 11. A different set of questions were asked for some required input as the vendors were reluctant to share a demo of the software. The initial plan to get values for Availability, Reliability, and Response Time was through the demo, either using the approach given the quantification problem or by using the site24*7 monitoring tool[24], however, a different approach was used and is given in Table 11.

Criteria	Method of Collecting Data - Question	Input for the question
Functionality	What are the functionalities/features provided by the software?	1.Payroll Processing 2. Payroll Reporting 3. Employee Management 4. Compensation Management 5. Data Import/Export 6. Automated payroll calculation 7. Tax-filing services 8. Customization
Criteria	Method of Collecting Data - Question	Input for the questions
Security Compliance	1) What are the built-in security features offered in the product? 2) What are the minimum requirements for Compliance with the country's standards?	United Kingdom 1. a) Single-Sign-On 1. b) Multifactor Authentication 2. a) GDPR 2. b) ISO 27001 2. c) H1C 2. d) HMRC Netherlands 1. a) Single-Sign-On 1. b) Multifactor Authentication 2) No compulsory requirement to have compliance certificates are need. Need to be compliant with GDPR.
Criteria	Method of collecting data - Question	Input for the question
Support	1) What are the support services offered by the company?	1. 24/5 assistance after the product is bought 2. Multiple support channels like email, phone, and helpdesk ticketing system 3. Onboarding assistance such as user manuals, videos and trainings 4. Updates on product improvements, development and bug fixes
Criteria	Method of collecting data – Analysis of Demo	Input for evaluation(ISO 25010 software quality standard)
Usability	Personal Experience while using the software	1. Ability to recognize that the product is appropriate for payroll activities 2. Ability to easily understand, learn to operate, and interact with the system 3. Ability of the system to protect the users against making mistakes 4. Ability of the system to provide a pleasing UI experience 5. Ability of the system to be accessible by a wide range of people to achieve a specific task

Criteria	Method of collecting data – Question	Input for the question
Reputation	How many clients does the company have?	None
Criteria	Method of collecting data – Questions	Input for the questions
White-labeling Co-selling	Would the company be open to white-labeling initiatives? Would the company be open to co-selling partnerships?	If yes – value 2 is assigned If No – value 1 is assigned

Criteria	Method of collecting data – Question	Input for the question
Availability	What is the downtime per day?	<1 minute 26 seconds, 99.9% >1 minute 26 seconds and <7 minutes 12 seconds, 99.5% >7 minute 12 seconds and <14 minutes 24 seconds, 99%
Criteria	Method of collecting data – Question	Input for the question
Response Time	What is the response time?	If Response Time < 1 second, value assigned is 2 If Response Time > 1 second, value assigned is 1
Criteria	Method of collecting data – Question	Input for the question
Reliability	What is the number of failures per month?	None

Table 11. Questions for Interviews with Vendors

The data collected from the 4 vendors based on the questions are listed in Table 12. Since there was no accessibility to the demo of the software, Usability criterion has not been used for this case study.

Company	Functionality	Security and Compliance	Support	Availability	Response Time	Reliability	Reputation	White-labeling	Co-selling
A	All except Customization	All	All	Downtime less than 1 minute per day	0 – 1 seconds	Less than 2 failures per month	500	Yes	Yes
B	All	All	All	Downtime less than 1 minute per day	0 – 1 seconds	Less than 2 failures per month	100	No	No
C	All	All	All	Downtime less than 1 minute per day	0 – 1 seconds	Less than 2 failures per month	100	No	Yes
D	All	All	All	Downtime less than 1 minute per day	0 – 1 seconds	Less than 2 failures per month	100	Yes	Yes

Table 12. Data Collected from Vendors

The preprocessed data applying the quantification methods proposed in Section 3.3 is shown in Table 13 and separate visualizations of criteria with the alternatives are shown in Appendix Chapter B.

Company	Functionality	Security and Compliance	Support	Availability	Response Time	Reliability	Reputation	White-labeling	Co-selling
A	7/8	3/3	4/4	99.9%	2	1	500	2	2
B	8/8	6/6	4/4	99.9%	2	1	100	1	1
C	8/8	6/6	4/4	99.9%	2	1	100	1	2
D	8/8	6/6	4/4	99.9%	2	1	100	2	2

Table 13. Preprocessed Data for the Criteria

5.3 Software Evaluation and Ranking

Using the hybrid Entropy TOPSIS technique, the payroll software selection process will be carried out step by step in detail in the following sub-sections. The selection evaluation and Ranking are shown in Figure 18.

5.3.1 Calculation of Criteria /weight using the Entropy Method

As discussed in Chapter 3 and Section 3.1.1, several subjective weighting techniques like AHP and Fuzzy involve the participation of experts and consideration of their judgment to weigh the criteria in terms of importance and on the other hand objective weighting methods Entropy, Mean weight, and standard deviation that could be used to find out the weight of the criteria with less human intervention. In this research, the Entropy Weight Method has been used for several reasons. This method introduced by Shannon[55] is a very simple and easy-to-use method and has the potential to give more accurate results[54]. It avoids human interference in determining weights and thus reduces bias[48, 54]. The algorithm goes as follows:

Step 1: Construct a decision matrix. If there are m alternatives and n criteria, then the matrix would be

$$D = (x_{kl})_{m \times n}$$

Step 2: Calculate of normalized matrix using the formula below.

$$p_{kl} = \frac{x_{kl}}{\sum_{k=1}^{m} x_{kl}}, \text{ Where k = 1,2,…m and l = 1,2….n}$$

Step 3: The entropy of a criterion is calculated using,

$$E_l = -h \sum_{k=1}^{m} p_{kl} \mathrm{Ln}(p_{kl}), \text{ Where } h = \frac{1}{ln(m)} \text{ and k= 1,2,…m}$$

Step 4: the final step is to calculate entropy weight using

$$W_l = \frac{1-E_l}{\sum_{l=1}^{n}(1-E_l)}$$

5.3.2 Calculation of ranks of the alternatives using TOPSIS

TOPSIS is one of the most attractive, simple methods to deal with an MCDM problem. The main ideology is that the best alternative would be at the closest distance to the ideal solution and farthest from the worst ideal solution[48]. The steps in the algorithm are given below.

Step 5: Use the decision matrix generated in step 1 and calculate the normalized matrix using

$$p_{kl} = \frac{x_{kl}}{\sqrt{\sum_{k=1}^{m} {x_{kl}}^2}}, \text{ Where k = 1,2,…m and l = 1,2….n}$$

Step 6: Create a Weighted normalized matrix

$t_{kl} = w_l . p_{kl}$, where w_l is the weight of lth criteria obtained from step 4

Step 7: Determine the positive ideal solution(t^+) and negative ideal solution(t^-) for each criterion.

$t_l^+ = \max\{t_{1l},\ldots.t_{ml}\}$ and $t_l^- = \min\{t_{1l},\ldots.t_{ml}\}$ for beneficial criteria

$t_l^- = \min\{t_{1l},\ldots.t_{ml}\}$ and $t_l^+ = \max\{t_{1l},\ldots.t_{ml}\}$ for non-beneficial criteria

Step 8: Calculate Euclidean distance for the alternatives

$$S_k^+ = \sqrt{\sum_{l=1}^{n}(t_{lk} - t_l^+)^2}$$

$$S_k^- = \sqrt{\sum_{l=1}^{n}(t_{lk} - t_l^-)^2}$$

Step 9: Calculation of Closeness co-efficient P_k,

$$P_k = \frac{S_k^-}{S_k^- + S_k^+}$$

Step 10: Rank the P_k values in descending order from 1 to m.

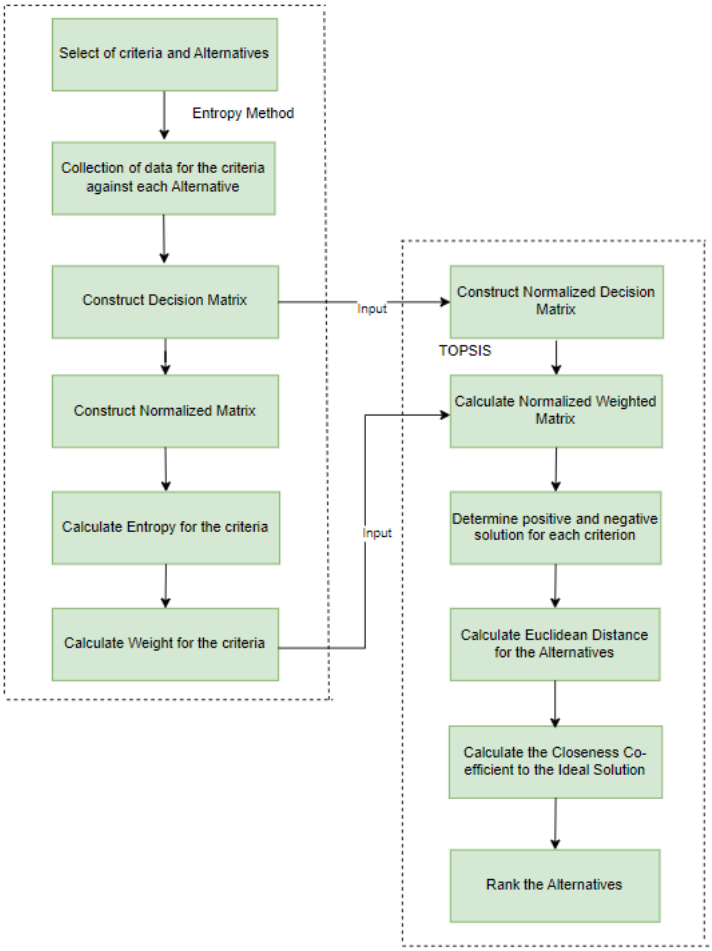


Figure 18. Software Evaluation and Ranking

5.4 Case Study Results

The 4 x 9 decision/MCDM matrix is constructed by taking the alternatives along the rows and the criteria along the columns. The data collected from the vendors for the criteria are processed using the quantifying formula discussed in Section 3.3. and are input to the matrix as shown in Figure 19.

Vendor	Functionality	Security/Compliance	Availability	Response Time	Reliability	Support	Whitelabelling	Co-selling	Reputation
A	0,875	1,00	99,9	1	1	1,00	2	2	500
B	1,000	1,00	99,9	1	1	1,00	1	1	100
C	1,000	1,00	99,9	1	1	1,00	1	2	100
D	1,000	1,00	99,9	1	1	1,00	2	2	100

Figure 19. Construction of Decision Matrix

a) Calculation of Weight of criteria using Entropy Weight Method

Since each criterion has different units/measurement scales, the decision matrix is normalized to make sure that all the values of criteria are between the scale of [0, 1] shown in Figure 20.

Vendor	Functionality	Security/Compliance	Availability	Response Time	Reliability	Support	Whitelabelling	Co-selling	Reputation
A	0,23	0,25	0,250	0,25	0,25	0,25	0,33	0,29	0,63
B	0,26	0,25	0,250	0,25	0,25	0,25	0,17	0,14	0,13
C	0,26	0,25	0,250	0,25	0,25	0,25	0,17	0,29	0,13
D	0,26	0,25	0,250	0,25	0,25	0,25	0,33	0,29	0,13

Figure 20. Calculation of Normalized Matrix - Entropy

The next step involves the calculation of Entropy to measure the randomness of the values of criteria across the alternatives. Entropy identifies criteria with more variability and the higher the entropy value more influential are the criteria in the decision-making process. Following this, the weight of each criterion is calculated as shown in Figure 21.

Vendor	Functionality	Security/Compliance	Availability	Response Time	Reliability	Support	Whitelabelling	Co-selling	Reputation
A	-0,3360174	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,366204096	-0,357932277	-0,2937523
B	-0,34956017	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,298626578	-0,277987164	-0,2599302
C	-0,34956017	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,298626578	-0,357932277	-0,2599302
D	-0,34956017	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,366204096	-0,357932277	-0,2599302
	-1,38469791	-1,386294361	-1,38629436	-1,386294361	-1,3862944	-1,386294	-1,329661349	-1,351783994	-1,0735428
Entropy value	0,99885	1	1	1	1	1	0,95915	0,97511	0,77440
Divergence	0,00115	0	0	0	0	0	0,04085	0,02489	0,22560
Weight	0,003937071	0	0	0	0	0	0,139665158	0,085107531	0,77129024

Sum
0,29250

Figure 21. Entropy and Weight Calculation

The weightage concentration is visualized in a pie chart given in Figure 22. It can be seen that reputation, functionality, white-labeling, and co-selling have more weightage compared to the other criteria and hence have more influence in the decision-making process. This is because the other criteria have similar values across the alternatives largely determined by the method of data collection from the vendors as elaborated in Section 5.2.

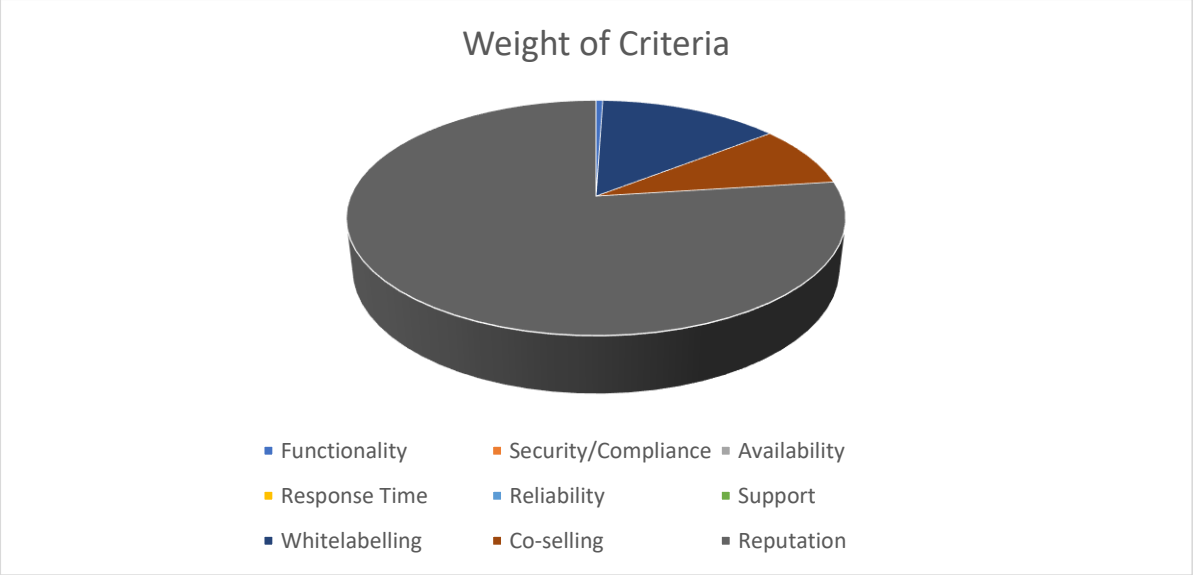


Figure 22. Weightage of Criteria in Case-Study

b)Evaluation and Ranking of Alternatives using TOPSIS

After determining the weights of the criteria, TOPSIS is used to evaluate and rank the alternatives. The first step in this technique is to normalize the decision matrix constructed as shown in Figure 19. This normalization is performed to serve the purpose of consistent calculation of the Euclidean Distance to give meaningful values. The normalized matrix is shown in Figure 23.

Vendor	Functionality	Security/Compliance	Availability	Response Time	Reliability	Support	Whitelabelling	Co-selling	Reputation
A	0,45	0,50	0,500	0,50	0,50	0,50	0,63	0,55	0,94
B	0,515325301	0,50	0,500	0,5	0,5	0,5	0,316227766	0,277350098	0,18898224
C	0,515325301	0,50	0,500	0,5	0,5	0,5	0,316227766	0,554700196	0,18898224
D	0,515325301	0,50	0,500	0,5	0,5	0,5	0,632455532	0,554700196	0,18898224

Figure 23. Calculation of Normalized matrix - TOPSIS

The normalized weighted matrix is calculated followed by the calculation of positive ideal and negative ideal solutions on the left matrix of Figure 24. The Euclidean distance and the Closeness co-efficient are calculated for the alternatives and are shown on the right matrix in Figure 24. Finally, the rank is allocated as per the decreasing order of the Closeness co-efficient value. Vendor A is ranked 1 and is the choice of the software provider. The ranked alternatives are visualized in Figure 25. It can be seen that A > D > C > B.

Vendor	Functionality	Security/Compliance	Availability	Response Time	Reliability	Support	Whitelabelling	Co-selling	Reputation
A	0,001775263	0	0	0	0	0	0,088332002	0,047209164	0,72880077
B	0,002028873	0	0	0	0	0	0,044166001	0,023604582	0,14576015
C	0,002028873	0	0	0	0	0	0,044166001	0,047209164	0,14576015
D	0,002028873	0	0	0	0	0	0,088332002	0,047209164	0,14576015
t_i+	0,002028873	0	0	0	0	0	0,088332002	0,047209164	0,72880077
t_i-	0,001775263	0	0	0	0	0	0,044166001	0,023604582	0,14576015

Sk+	Sk-	Pk	Rank
0,000	0,585187299	0,999566807	1
0,585	0,000253609	0,000433193	4
0,585	0,023605944	0,038805335	3
0,583	0,0500787	0,079098361	2

Figure 24. Ranking of Alternatives using TOPSIS

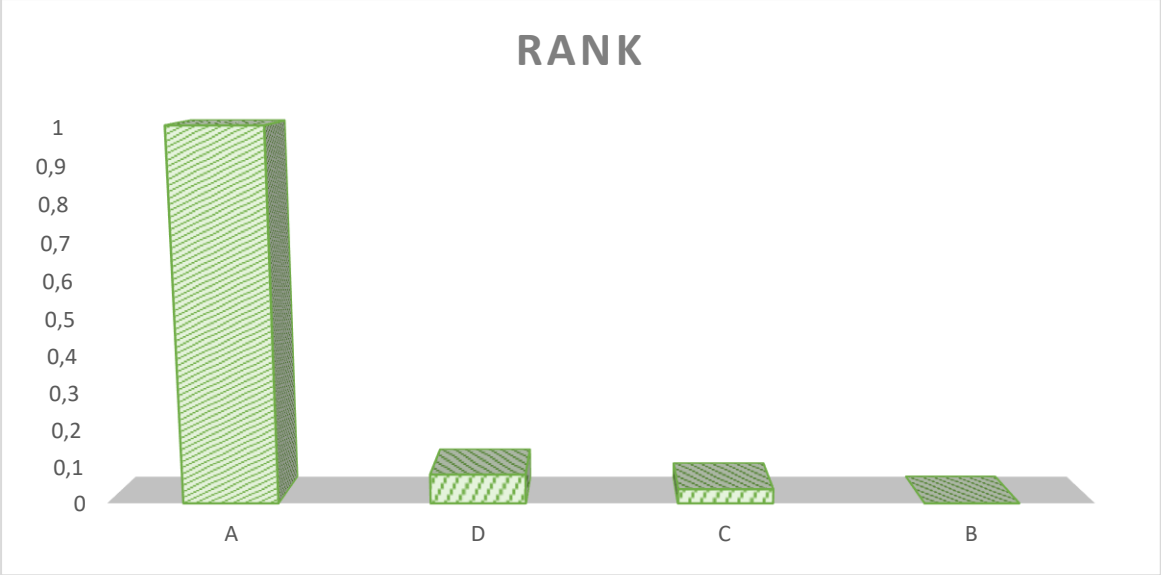


Figure 25. Ranked Alternatives in Case-Study

5.5 Critical Discussion with Experts

This Section concludes by evaluating the selection framework with the help of the case study conducted. The discussion was carried out with the internal stakeholders(HR/Sales Executives) of the company. The concluding remarks of the stakeholders are given in Table 14.

Stakeholders	Remarks
SK1	The implementation of the framework is well managed – the requirements are quantifiable and in a way that it is detailed. The deliverable in the Excel sheet is usable. The framework could prove useful to the company provided there is a manual attached to the deliverable. Since the decision maker's emotion has been taken away from the equation, it can be used by a single person and doesn't require a bigger team to make the final decision. The framework has the potential to make payroll selection decisions. If there is a requirement to select any other software other than payroll and if the criteria match then the framework can be used.
SK2	If a similar kind of input is generated as done in the case study then the framework can be implemented in real time. The implementable framework developed in the case study is to be reusable for four vendors. And since the number of decision-makers in the company is less, this framework would be helpful. But if the company grows then more qualitative input would be considered. This framework is definitely usable for finding payroll solutions in other countries.

Table 14. Final Remarks

5.6 Chapter Summary

This chapter demonstrated the case study to evaluate the proposed framework. This case study provides insights to translating the theoretical framework into practical use case. The Evaluation and Ranking of the software have been automated and will be produced as a deliverable for future use.

Chapter VI

6 Discussion

This chapter summarizes the steps taken to achieve the research's goals and gathers the results obtained for each of the research questions outlined in Section 1.2.4. It also explains the findings and analyses their importance. Lastly, it looks at the limitations of this study and suggests possible directions for further research.

6.1 Procedural Summary

The research began with a systematic literature review using the acclaimed database Scopus and following the procedures proposed by Kitchenham[1]. This process resulted in a collection of studies that targeted software selection, the methodologies used to carry out a software selection process, the type of methodologies, the factors that help to evaluate and analyze software, and the type of SaaS solutions that were targeted. Following the SLR, gaps in the research were identified, and possibilities to explore new areas of suggestions. This led to analyzing and designing a software selection process for the selection of payroll solutions which started with the analysis of developments in the company, gathering requirements, analysis of the software selection methodologies that would suit the problem at hand, and finalizing the factors that would be used for evaluating payroll software and ways of quantifying the factors to be able to compare the software. After the proposal of a framework for the software selection process, the work done was validated by the stakeholders of the company. The feedback obtained was used to refine certain parts of the selection framework post which a case study was conducted that demonstrated the framework. The case study considered an example of a real-world scenario. Figure 26 outlines the research process.

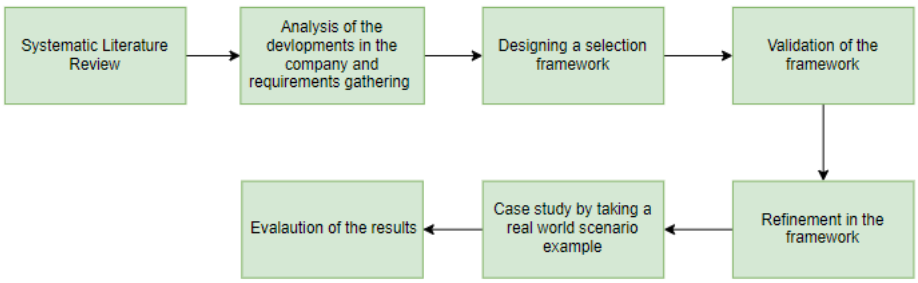


Figure 26. Approach to Design of Software Selection Framework

6.2 Answers to Research Questions

This section answers the research questions of Section 1.2.4. The main question is

How to approach a software selection process that would meet the organization's strategic requirements?

The choice to incorporate a new IT system into an organization has never been easier. Solid reasons are needed for why an IT system is needed, what kind of problems the existing architecture is facing, how software going to solve the problem, and analysis is performed to how it could be integrated into the organization. Research is done to which branch of the organization is going to use it, which team is going to serve, or how many people are going to use it. Post this analysis after deciding to buy software, again study is done to choose an IT system. The software market a hundreds and thousands of solutions for a single type of service. So following a software selection framework will help reduce cognitive overload, and allow the organization to follow a structured procedure to make final decisions. A selection framework will incorporate the technical requirements, service quality, and business strategies leaving no stone unturned and making the selection process thorough.

SRQ1: What methodologies and approaches have been employed to conduct software selection in a business context?

This question has been answered by a systematic literature review in Chapter 2. The literature gave a vast idea of how selection has been done in the past. Several methodologies/frameworks were discussed. Each study reviews why the chosen methodology is better than the previous ones considered. The final decision on a methodology depends on the application context in hand, the complexity and practicality of the methodology, and the type of input(subjective or objective) that is suitable for comparison purposes. The selection technique in this research has been inspired by the literature study and is explained in Section 3.2.

SRQ2: What are the principal criteria that influence the choices of stakeholders of an organization when selecting software?

This question has been answered by the literature review in Chapter 2. Each study discusses a set of factors that the paper proposes would help evaluate the SaaS products. Some papers propose factors that could be applicable for selecting any software and some have put forward criteria that apply to certain types of software. However, most of the criteria were related to technical and service quality. The choice of the factors depended on the stakeholder's needs for the software. The final choice of criteria for this research has been outlined in Chapter 4. The criteria have been chosen from various perspectives including SISAR's and SISAR's clients, who utilize SISAR's HRMS and the vendor's payroll for their workforce management. The quantification formula for the criteria has been mentioned in Chapter 3 and Chapter 4.

SRQ3: What are the prerequisites an organization needs to consider in choosing software and how to align its business' strategic goals with the technical requirements to develop a framework for the selection process?

The requirements of what is needed out of the software are collected from the experts in the company and are outlined in Section 3.1. Then the constraints obtained from requirements are used to filter the applicable software in the market. In addition to that the mission of the organization to expand its business to reach out to unknown markets and increase its customer base are also translated into criteria and has been aligned with the technical and QoS criteria and the final list of criteria is quantified with the support of literature. These are then incorporated into Entropy TOPSIS methodology to evaluate

and rank the filtered software. The selection process treatment has been extensively discussed in Chapter 3.

SRQ4: How to put into practice the framework for the software selection practices for the organization?

The proposed selection framework was validated by the experts in the company as discussed in Chapter 4. The changes suggested were incorporated and a case study was conducted. A country was chosen and payroll vendors that matched the requirements were collected. A set of questions for the survey purpose was prepared beforehand that were related to the quantification of the criteria. The questions are given in Chapter 5. Meetings were scheduled with the sales representative of each vendor to collect data. Using the Entropy TOPSIS MCDM technique the vendors were evaluated and ranked using the data collected from the vendors. A working template for the MCDM technique has been developed in a Microsoft Excel sheet as a deliverable to the company to be used for future purposes.

SRQ5: How effective is the proposed framework after its application is put into practice?

The proposed framework was evaluated through conducting a case study and discussions with the employees in the company. It was mentioned that the framework is implementable for future payroll software selection. If it has to be implemented for other software selection, and if the list of criteria matches with requirements then it can be used. On the other hand, if the list of criteria doesn't match, then little work needs to be done. It was added that since the number of decision-makers is less in the company, this data-driven quantifiable framework is useful in the decision-making process. Thus the proposed framework was agreed to be effective for future software selection processes. The objectives from Table 2 are mapped to the results of the evaluation and listed in Table 15.

Stakeholder	Stakeholder classification	Goal
Product Development Team/ HR /Sales Executives	Normal Operator	Can utilize the framework for software selection in the future.
Director of SISAR	Functional Beneficiaries	Can make informed decisions from the framework's output.
Director of SISAR	Consultant	Expert guidance on the choice of functional and non-functional parameters have been translated into selection criteria.
Payroll Vendors	Supplier(product/company information)	Data driven selection has been facilitated using the shared information about their product was used in the evaluation of the software and vendor.
Researcher	Developer	A solid framework has been developed for software selection from the requirements of the company.
University of Twente	Supplier(knowledge)	A scientific approach has been employed to arrive at the design of the selection framework.

Table 15. Results of Research Mapped to Stakeholder's Goals

6.3 Key Findings

The list of general findings has been outlined in Table 16. This list has been summarized from the overall research interpretation.

S No.	Findings from Research
1	When multiple criteria needs to be considered for evaluation of software, MCDM techniques are used. MCDM brings criteria with different units of measurement together.
2	Quality of Service criteria are predominantly used for software evaluation from literature point of view.
3	Qualitative QoS criteria like usability, support, compliance, reputation can also be quantified using a few mathematical formula
4	Strategic goals within business context can be translated into criteria and quantified
5	When choosing a software, more importance is given to factors such as usability of the software, reputation of the vendor, support/training offered and customizability of the product from internal stakeholder's perspective.

Table 16. General Findings from Research

6.3.1 Analysis on the Case Study

This section summarizes findings from the case study conducted to validate the software selection framework. These findings are the analysis of the results obtained from the implementation of the selection framework proposed shown in Figure 16.

a) Not all data is shared by the vendor. In this case study estimated values have been provided in place of actual values for availability, reliability, and response time. This can be seen in Table 11.

b) From Figure 21 and Figure 22 it is evident that Reputation, White-labelling, Co-selling, and Functionality criteria share the most weightage. This is because there is no variability in the values of other criteria across the alternatives. Thus in the case study Availability, Response Time, Reliability, Support, and Compliance do not influence decision-making, whereas Reputation, White-labeling, Co-selling, and Functionality are the list of criteria that contribute to the evaluation of the alternatives. Amongst these four criteria, Reputation has the most and Functionality has the least weightage.

c) According to the research the criteria "support" services offered by the Vendor and "Security/Compliance" are very important to be considered but in the case study even when the vendors offer the required support, have all the required in-built security features, and possess the needed compliance certificates, they have zero impact in decision making.

d) Results of Sensitivity Analysis

Sensitivity analysis is used to assess the robustness and stability of the outcomes in an MCDM problem concerning changes in the weights of the criteria, the value of criteria, or the assumptions and estimates made during the evaluation of the alternatives. It helps the decision maker to comprehend the impact of changes in ranking the alternatives and to observe how sensitive the results are based on these changes. A few sensitivity aspects are worth noticing as discussed below.

The weightage of criteria remains unchanged if it comprises a positive integer or if the value falls between 0 and 1 determined by the formula of division. For example, if Reputation values are taken in ranges as follows

If number of clients >0 and <=100, value is 1

If number of clients >100 and <=200, value is 2

If number of clients >200 and <=300, value is 3

If number of clients >300 and <=400, value is 4

If number of clients >400 and <=500, value is 5

The weightage of the Reputation is not going to change. So it is not how big a criteria's value is compared to other criteria, the weight is based on the normalization and spread of values within the criteria values across the alternatives. This is shown in Appendix Chapter C(Figure C1 and Figure C2).

In this study, the Entropy Weight algorithm is allowed to decide on the weightage of the criteria but to check the stability of the rankings, the following case studies are conducted.

Case I: Assigning equal weights to the criteria.

There are in total 9 criteria. The sum of the weights of all criteria is always 1. Here, the weights are split equally giving equal importance to all criteria in the decision-making process. The normalized weighted matrix(TOPSIS) uses these weights to assign rankings to the alternatives. The results are shown in Appendix Chapter C (Figure C5 and Figure C6). From the results, it can be seen that the ranking of the ranking of alternatives are

$$A > D > C > B$$

Case II(a): Assigning 60-40 weights.

If the Expansion Goal criteria need to have more impact on the final decision, then 60 percent weightage is split between the two criteria(White-labeling and Co-selling), and 40 percent is split among the remaining criteria. The results are shown in Appendix Chapter C (Figure C7 and Figure C8). From the results, it can be seen that the ranking of the ranking of alternatives are

$$A > D > C > B$$

Case II(b): Change in the variability of the data.

If White labeling and Co-selling criteria need to have more impact on the final decision, then the criteria data could be processed in a way that there is more variability within the values. Table 11 discussed that if the vendor is open to White-labeling initiatives, the value assigned is 2, else the value assigned is1. This can adjusted to "yes" taking the value of 10 and "no" taking the value of 1. This will increase the weightage of the criteria and eventually will have more impact on the selection. This is shown in Appendix Chapter C(Figure C3 and Figure C4). Note that the original data shouldn't be altered but could be manipulated during the preprocessing stage. From the results, it can be seen that the ranking of the ranking of alternatives are

$$A > D > C > B$$

By comparing the results of the sensitivity Analysis with Figure 25, It can be seen that the rankings of the alternatives remain the same. The next chapter will provide concluding remarks on the analysis of the case study.

6.4 Limitations

First, although the selection framework, the MCDM technique used in this project can be used in the future for other software selection, this research limits selecting payroll software from any country that meets the organization's technical requirements and business needs. For any other software selection, there might be some changes in the choice of criteria and the type of data collected for those.

Second, due to the inaccessibility of the demo from the vendors for the case study, certain data for criteria were given as an estimate or as a range by the vendors(Availability, Reliability, and Response

Time) and not exact values as expected through the quantification methods proposed. But actual values of those could be obtained through a demo or trial version when the company approaches the vendors officially.

Third the value for the criteria against the alternatives in the decision matrix cannot take the value of 0. This is because the calculation of Entropy value includes a natural logarithmic function that cannot take the value of zero. Ln(0) is not defined and does not exist.

6.5 Future Scope

The selection framework could be automated and developed into an application. A user can input the number of alternatives, and details of the alternatives, automate the quantification of the criteria for which the user can choose, or input values corresponding to each criterion through an interactive Graphical User Interface. The framework could be developed using a programming language that could use the requirements and user input to filter candidates and evaluate them using the selection technique to give out ranks for the alternatives.

6.6 Chapter Summary

This chapter outlines the research conducted to achieve the results. It examines the results of the main and sub-research questions. Following this, the limitations and future scope are discussed. The next chapter will conclude the research project and its contribution to science.

Chapter VII

7 Conclusion

The decision to integrate an Information System into an organization requires a thorough analysis of the system's need, existing architecture issues, and its integration into the organization. Once the decision is made to bring in a system to bridge the gaps in the organization, the next step would be to choose one. A software selection framework helps deal with information overload and ensures a structured process for final decisions, considering technical requirements, service quality, and business strategies.

7.1 Academic Contribution

This research is guided by the scientific literature perspective. The techniques proposed in the literature have been analyzed and a hybrid technique of Entropy TOPSIS has been used in this research for software selection as this technique uses an objective method that relies more on a data-driven approach and less on people's opinions.

Generally, a software selection is determined for use by the organization. In this research, software selection is carried out for an end user who is a potential client of SISAR's HR tool. The criteria have been chosen from various perspectives including SISAR's and SISAR's clients, who utilize SISAR's HRMS and the vendor's payroll for their workforce management. The software is chosen that benefits the company's mission as well as the end users of the software.

The software selection framework has been employed to meet the company's objective to expand its business internationally and diversify its presence in new markets. Through the selection, the company looks for possible collaborations with the software vendors through strategic partnerships to leverage complementary strengths. These goals were translated into criteria and are used for the evaluation of vendors in addition to the technical and Quality of Service criteria.

7.2 Practical Contribution and Recommendation to the Company

This research conducted a case study and the technique proposed in the literature could be put to use for practical purposes so that software evaluation and ranking could be automated. This research aims to provide a platform for software selection accompanied by visualizations for decision-making. The data collected from vendors' project insights into the requirements. It is up to the company to make a final decision call.

Analysis of the case study puts forward the following conclusions

One of the major goals of the thesis is to show that the business strategic goals could be interpreted as criteria and can be used along with QoS criteria to evaluate the software. This has been achieved through the case study. From the results, it is positive that the expansion goals interpreted criteria influence the decision-making process(Figure 21 and Figure 22). It is evident that Reputation, White-labelling, Co-selling, and Functionality criteria dominate the ranking of the software(Figure 22). As a suggestion during the phase of preprocessing the data, the values can be manipulated in a way that there is more diversity between the values of the criteria. This can be done when the decision maker wants a particular criteria to have more impact on the final selection. From the results of the sensitivity analysis, it can be concluded that the outcomes point out that the decision outcomes are robust. In addition, it cannot be concluded that Reputation has more influence on decision-making because its values are bigger

compared to the rest. The reason behind its influence is that there is more variability within the values of Reputation that resulted in its dominance.

The criteria Availability, Response Time, and Reliability in real time do not have similar values. The case study relied on estimated value because of the unavailability of data. Real-time data will have diverse values for these criteria. Support and Security/Compliance also did not influence the decision-making process because there is no variability in the values of the data though proper data has been collected. Even though the above-mentioned criteria have zero impact on the case study, it doesn't mean these should be eliminated as these criteria have a much bigger effect on software selection in real-time. The data collected by the decision maker for these criteria will give an overall understanding of the image of the vendor and the performance of their product. Therefore, the evaluation of the alternatives using all 9 criteria has given good results in the case study and is also recommended for future purposes.

Overall, the proposed framework can be used to select payroll software from other countries. It can be used for software selection other than payroll provided that the same set of criteria is used for analyzing the software. An implicit conclusion from the above statement is that the selection technique could be used for evaluating and ranking any other software provided that a data-driven approach is employed.

Abbreviations

SaaS – Software-as-a-service

MCDM – Multi-criteria decision making

AHP – Analytical Hierarchy Process

ANP – Analytical Network Process

BSC – Business Scorecard

HRMS – Human Resource Management System

BCR – Benefit Cost Risk

QoS – Quality of Service

CRM – Customer Relationship Management

ERP – Enterprise Resource Planning

BI – Business Intelligence

SCM – Supply Chain Management

TCO – Total Cost of Ownership

SLA – Service Level Agreement

QoP – Quality of platform

QoA – Quality of Application

QoE - Quality of Experience

TOPSIS – Technique for Order of Preference by Similarity to Ideal Solution

API – Application Programming Interface

IT – Information Technology

SLR – Systematic Literature Review

References

[1] Barbara Kitchenham, O.P.B., *Systematic literature reviews in software engineering – A systematic literature review.* Information and Software Technology, 2008. 51: p. 7-15.

[2] Deb, P.B., Diptendu & Chatterjee, Indranath & Saha, Abhijit & Mishra, Arunodaya & Shaik, Hasane. *A Decision-Making Model With Intuitionistic Fuzzy Information for Selection of Enterprise Resource Planning Systems.* IEEE Transactions on Engineering Management. 2022: p. 1-15.

[3] Naseer, Mehwish and Maryam Nazar. "A framework for selection of SAAS by evaluating the quality of Freemium model." *2016 Sixth International Conference on Innovative Computing Technology (INTECH)*. 2016. 78-82.

[4] N. Boussoualim and Y. Aklouf. "An Approach based on user preferences for selecting SaaS product," *2014 International Conference on Multimedia Computing and Systems (ICMCS)*, Marrakech, Morocco. 2014. pp. 1182-1188.

[5] Rathore, M.D.a.V.S., *ASMAN Framework: A Framework for Comparison and Selection of SaaS Services*, in *Smart Trends in Systems, Security and Sustainability*, P.A.o.S. Janusz Kacprzyk, Warsaw, Poland, Editor. 2018. p. 287 - 295.

[6] Sangjae Lee, S.B.P., Gyoo Gun Lim *Using balanced scorecards for the evaluation of "Software-as-a-service".* Information & Management,Volume 50, Issue 7, 2013. pp. 553-561.

[7] Nguyen-Hanh Tang, Y.-C.L., *BCR model for cloud-based social CRM service selection using the AHP.* 2015. 18: p. 4917-4922.

[8] R. Vidhyalakshmi, V.K., *CORE framework for evaluating the reliability of SaaS products, Future Generation Computer Systems*, 2017. **72**: p. 23-36.

[9] Maiara Heil Cancian, J.C.R.H., Christiane Gresse von Wangenheim, Ricardo José Rabelo. *Discovering Software Process and Product Quality Criteria in Software as a Service*. in *PROFES*. 2010. 234-247.

[10] Dietmar Nedbal, M.S., *Findings from a Success Factor Analysis for SaaS Usage*, in *The 10th International Conference on Intelligent Networking and Collaborative Systems*, L.B. Fatos Xhafa, Michal Greguš, Editor, 2019. p. 3-15.

[11] Daji Ergu, Y.P., *A framework for SaaS software packages evaluation and selection with virtual team and BOCR of analytic network process, The Journal of Supercomputing* 2013. 67. 219-238.

[12] Dhanamma Jagli, D.M.S.P., Dr N. Subash Chandra, *Fuzzy Clustering Algorithm Intended for Mining Software Services on the Cloud.* 2017. 1-4.

[13] Repschlaeger, J. *Transparency in Cloud Business: Cluster Analysis of Software as a Service Characteristics*. in *8th International Conference, GPC 2013 and Colocated Workshops*. 2013. 1-10.

[14] Shree Ranjan, V.K.J., Pralay Pal, *A strategic and sustainable multi-criteria decision making framework for ERP selection in OEM.* International Journal of Applied Engineering Research. 2016. **11**: p. 1916-1926.

[15] Adigun, A.E.M., *Integrating fuzzy theory and visualization for QoSaware selection of SaaS in cloud e-Marketplaces.* Cogent Engineering. 2021. 8. 1911592.

[16] HIBA JASIM HADI , M.A.O., WAN ROZAINI SHEIK OSMAN, MUKTAR HUSSAINI, *FACTORS AFFECTING THE INTENTION TO ADOPT SOFTWARE-AS-A-SERVICE IN PUBLIC ORGANIZATION FROM EXPERT'S PERSPECTIVE.* Journal of Theoretical and Applied Information Technology. 2020. 98. 1751-1761.

[17] Yannis Poulakis, G.F., George Kousiouris, Dimosthenis Kyriazis. *HOCC: An Ontology for Holistic Description of Cluster Settings*. in *19th International Conference, GECON.* 2022.

[18] Mohammed Abdulaziz Ikram, R.A., Farookh K. Hussain, *Towards Linguistic-based Evaluation System of Cloud Software as a Service (SaaS) Provider.* International Journal of Advanced Computer Science and Applications, 2022. 13(2).

[19] Azubuike Ezenwoke, O.D., Matthew Adigun, *QoS-based ranking and selection of SaaS applications using heterogeneous similarity metrics.* Journal of Cloud Computing: Advances, Systems and Applications. 2018.

[20] Pang Xiong Wen, L.D., *Quality Model for Evaluating SaaS Service*, in *Fourth International Conference on Emerging Intelligent Data and Web Technologies*. 2013. 83-87.

[21] Zbozjoh Tiboh, K.K., Svp, *Research on SaaS ERP service provider selection model of small and medium-sized enterprises based on ELECTRE-IV*, in *International Conference on Frontiers of Robotics and Software Engineering.* 2023. 377-386.

[22] F.H. Barnard, E.v.d.L., *ADOPTION OF SOFTWARE AS A SERVICE: A FUZZY APPROACH TO RANKING THE DETERMINANTS.* South African Journal of Industrial Engineering. 2022. 33(4): p. 32-46.

[23] Sucahyo, Y.G., *Software as a service quality factors evaluation using analytic hierarchy process.* Int. J. Business Information Systems. 2017. 24(1).

[24] Mohammed Abdulaziz Ikram, F.K.H. *Software as a Service (SaaS) Service Selection Based on Measuring the Shortest Distance to the Consumer's Preferences*. in *The 6th International Conference on Emerging Internet, Data & Web Technologies*. 2018.

[25] Chen Yiming, Z.Y., *SaaS Vendor Selection Basing on Analytic Hierarchy Process*, in *Fourth International Joint Conference on Computational Sciences and Optimization*. 2011.511-516.

[26] Yuen, K.K.F., *Software-as-a-Service Evaluation in Cloud Paradigm: Primitive Cognitive Network Process Approach.* A Review of Service Selection in Cloud Computing. 2012.

[27] M. Godse and S. Mulik, "An Approach for Selecting Software-as-a-Service (SaaS) Product," *2009 IEEE International Conference on Cloud Computing*, Bangalore, India, 2009, pp. 155-158.

[28] Ariana Polyviou, N.P., Stamatia Rizou, *Which Factors Affect Software-as-a-Service Selection the Most? A Study from the Customer's and the Vendor's Perspective*, in *Hawaii International Conference on System Science*. 2014. 5059-5068.

[29] J. Repschläger, R. Zarnekow, S. Wind, T.klaus, *Cloud Requirement Framework: Requirements and Evaluation Criteria to adopt Cloud Solutions.* 20th European Conference on Information Systems. 2012.

[30] J. C. Henderson and H. Venkatraman, "*Strategic alignment: Leveraging information technology for transforming organizations,*" in IBM Systems Journal. 1993. 32(1). pp. 472-484.

[31] I. Ahmad, H. Bakht, Cloud Computing - A Comprehensive Definiton. Journal of Computing and Management Studies. 2017.

[32] Alexe, Catalin & Alexe, Catalina & Dumitriu, Dan & Mustata, Cristian. *ONLINE REVIEW MANAGEMENT ON SAAS COMPARISON PLATFORMS: CASE STUDY CAPTERRA.* 2021. 277-283.

[33] Wieringa, Roel. "*Design Science Methodology for Information Systems and Software Engineering*." Springer Berlin Heidelberg .2014.

[34] Zhou, Ping, Zhipeng Wang, Wenjing Li, and Ning Jiang. "Quality model of cloud service." In *2015 IEEE 17th International Conference on High Performance Computing and Communications, 2015 IEEE 7th International Symposium on Cyberspace Safety and Security, and 2015 IEEE 12th International Conference on Embedded Software and Systems*, pp. 1418-1423. IEEE, 2015.

[35] Alexander, A taxonomy of stakeholders: *Human roles in systems development*. Int. J. Technol. Human Interact. 2005. 1(1). 23–59.

[36] Taherdoost, H.; Madanchian, M. *Multi-Criteria Decision Making (MCDM) Methods and Concepts*. *Encyclopedia.* 2023. *3*. 77-87.

[37] Ahmad, Ishrat. *Cloud Computing - A Comprehensive Definition*. Journal of. Computing and Management Studies.2017.

[38] Sunyaev, Ali, and A. Sunyaev. *Internet computing*. New York, NY, USA:: Springer International Publishing. 2020.

[39] Saaty, T.L. *The Analytic Hierarchy Proces*s McGraw-Hill; McGraw Hill: New York, NY, USA. 1980

[40] Chukwuebuka M U-Dominic, James C Ujam, Nkemakonam Igbokwe. *Applications of Analytical Hierarchy Process (AHP) and Knowledge Management (KM) Concepts in Defect Identification: A Case of Cable Manufacturing*. Asian Journal of Advanced Research and Reports, 2021, pp.9 - 21.

[41] Charnes, A.; Cooper, W.W.; Rhodes, E. *Measuring the efficiency of decision making units*. Eur. J. Oper. Res. 1978, 2, 429–444.

[42] Zadeh, L.A. *Fuzzy sets*. Inf. Control 1965, 8, 338–353.

[43] Charnes, A.; Cooper, W. *Management Models and Industrial Applications of Linear Programming*; John Wiley & Sons: New York, NY, USA, 1961; Volume 1.

[44] Hwang, C.-L.; Yoon, K. *Multiple Attribute Decision Making: Methods and Applications—A State-of-the-Art Survey*; Springer: New York, NY, USA, 1981; Volume 186.

[45] Wu, Z.; Abdul-Nour, G. *Comparison of Multi-Criteria Group Decision-Making Methods for Urban Sewer Network Plan Selection*. *CivilEng* 2020, *1*, 26-48.

[46] H. Arslan, *CURRENT CLASSIFICATION OF MULTI CRITERIA DECISION ANALYSIS METHODS AND PUBLIC SECTOR IMPLEMENTATIONS*. 2017.

[47] Zulqarnain, Rana Muhammad & Saeed, Muhammad & Ahmad, Nadeem & Dayan, Fazal & Ahmad, Bilal. *Application of TOPSIS Method for Decision Making*. Biomedical Journal of Scientific & Technical Research, 2020. 7. 76-81.

[48] Rakesh Ranjan Kumar and Chiranjeev Kumar, *Designing an efficient methodology based on Entropy-TOPSIS for evaluating efficiency of cloud services*. In Proceedings of the 7th International Conference on Computer and Communication Technology (ICCCT-2017). Association for Computing Machinery, New York, NY, USA, 2017, 117–122.

[49] Umathay, Ashwin & Sinha, Aunindra. *User Experience Strategy for white labeling a software product*. In Proceedings of the 8th Indian Conference on Human-Computer Interaction (IndiaHCI '16). Association for Computing Machinery, New York, NY, USA 2016.102- 110.

[50] F. Silva, R. Souza and I. Machado, "Taming and Unveiling Software Reuse opportunities through White Label Software in Startups," *2020 46th Euromicro Conference on Software Engineering and Advanced Applications (SEAA)*, Portoroz, Slovenia, 2020, pp. 302-305.

[51] Cann, R. & Brinkkemper, Sjaak. *White-labeling software products*. 14th IBIMA Conference, 2010. 2. 951-960.

[52] Jingwen Huang, "*Combining entropy weight and TOPSIS method For information system* selection," *2008 IEEE International Conference on Automation and Logistics*, Qingdao, China, 2008,1965-1968,

[53] Zhang, L., Chen, W. Multi-criteria group decision-making with cloud model and TOPSIS for alternative selection under uncertainty. *Soft Comput* 2022. 26, 12509–12529.

[54] Zhu, Yuxin & Tian, Dazuo & Yan, Feng. (2020). Effectiveness of Entropy Weight Method in Decision-Making. Mathematical Problems in Engineering. 2020. 1-5.

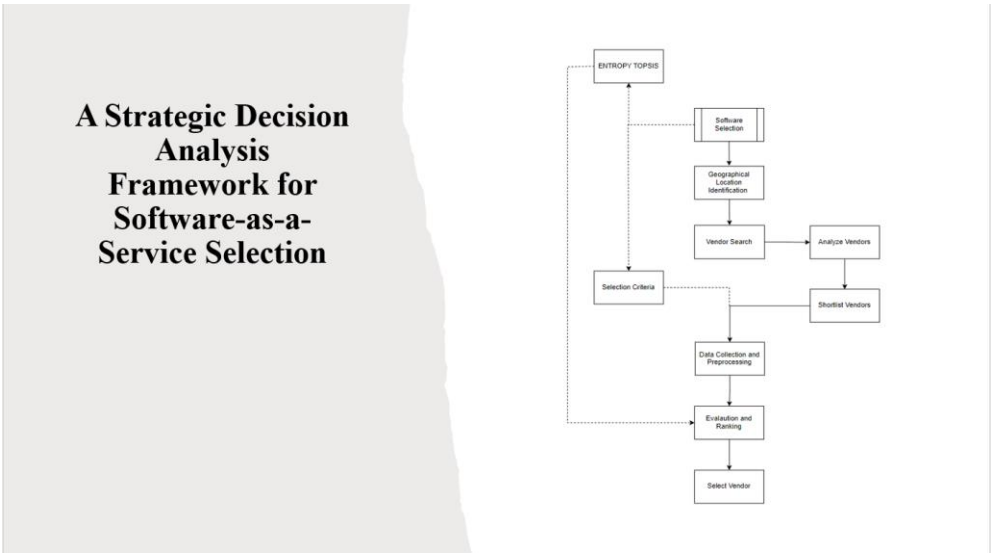
[55] Shannon CE. A Mathematical Theory of Communication. Bell Syst Tech J 1948; 27: 379–423.

[56] Odu, Godwin. Weighting methods for multi-criteria decision making technique. Journal of Applied Sciences and Environmental Management. 2019. 23. 1449- 1457.

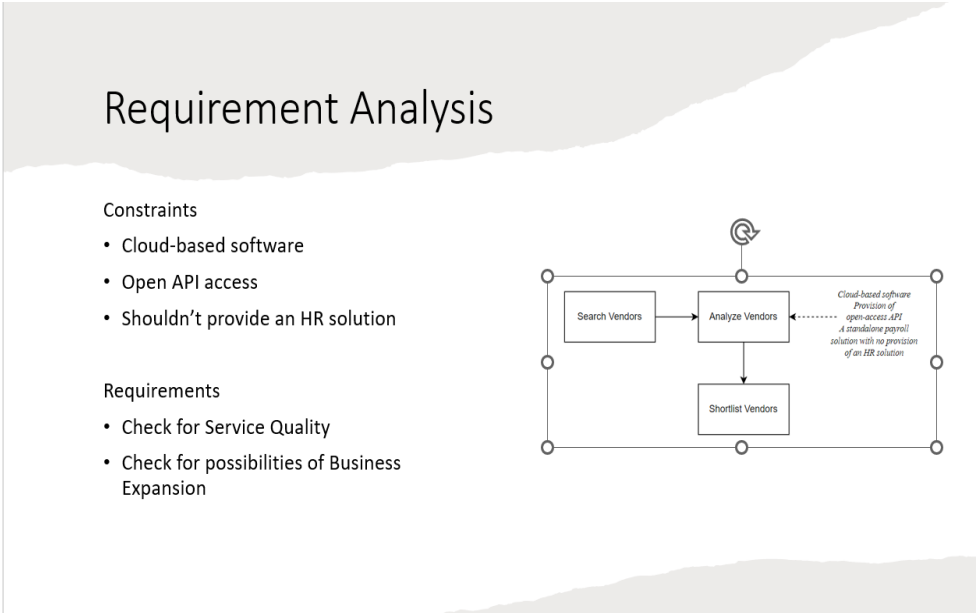
Appendices

Chapter A – Presentation for Validation

This chapter presents the slides that were shared with the internal stakeholder of the company for validation of software selection framework.



A 1. Overview of the proposed software selection framework.



A 2. The constraints and requirements for selecting software

Quantification of Criteria

- $Functionality = \frac{Number\ of\ features\ matched\ by\ the\ product}{Number\ of\ features\ required}$
- $Security = \frac{Number\ of\ built-in\ security\ features\ guaranteed}{Number\ of\ features\ required}$
- $Reliability = \frac{Number\ of\ failures}{month}$
- $Availability = \frac{Number\ of\ successful\ invocations}{Total\ number\ of\ invocations}$
- $Response\ Time = Total\ time\ taken\ to\ respond\ for\ a\ request\ of\ a\ process\ that\ the\ software\ is\ intended\ to\ do.$

$Scalability = \frac{Response\ Time}{Load}$

A 3. Methods of quantification for the criteria

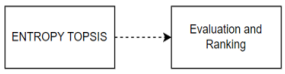
Quantification of Criteria

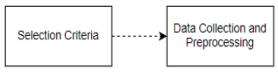
- $Support = \frac{Number\ of\ support\ services\ guaranteed}{Total\ number\ of\ support\ services\ required\ by\ customer}$
- $Reputation =$ *Number of existing clients of the vendor.*
- $Compliance = \frac{Number\ of\ possession\ of\ required\ compliance\ certificates}{Total\ number\ of\ required\ compliance\ certificates}$
- $Usability = \frac{Number\ of\ usability\ features\ present\ in\ the\ product}{Total\ number\ of\ usability\ features\ required}$
- *White-labeling = Number of white-labeling projects involved*
- *Co-selling = Number of co-selling projects involved*
- *Cost = Subscription price per month/year*

A 4. Methods of quantification for the criteria

Selection Methodology

- Selection Criteria
- Selection Technique - Multi-Criteria Decision Making
- Ranking of software - TOPSIS(Technique for Order of
- Preference by Similarity to Ideal Solution)
- Weighting method – Entropy Weighting Method

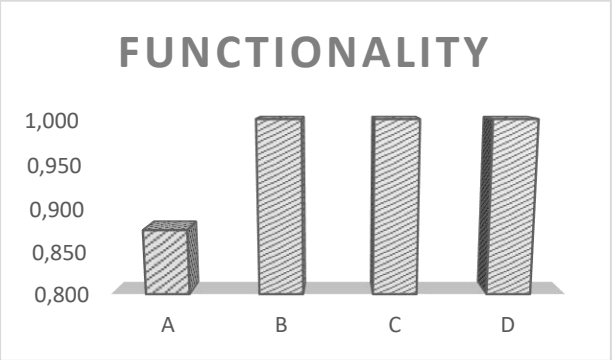




A 5. Overview of the techniques that will be incorporated at each step of decision-making

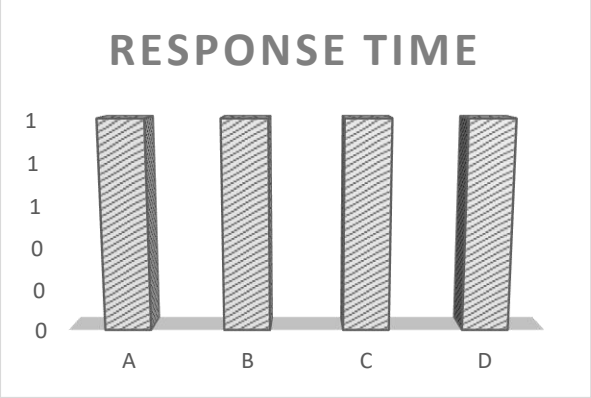
Chapter B – Data Collected for Criteria

This chapter presents the visualization of the data collected for each criteria against the alternatives to provide a comprehensive understanding.

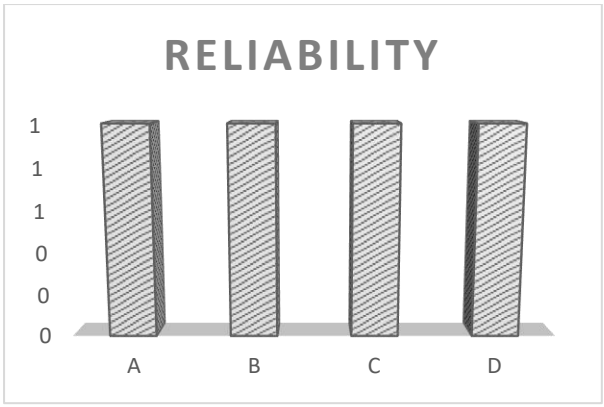


B 1. Alternatives-Functionality Plot

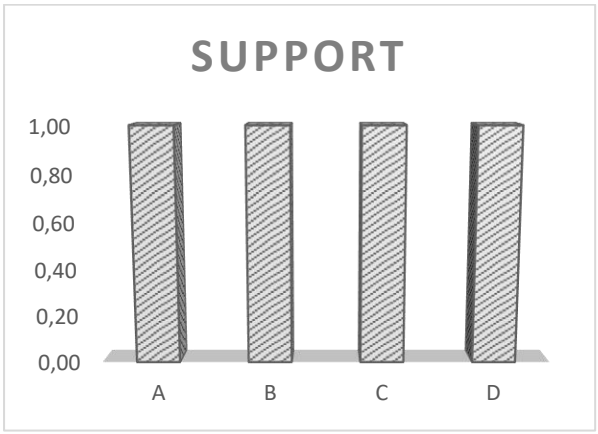
B 2. Alternatives-Availability Plot



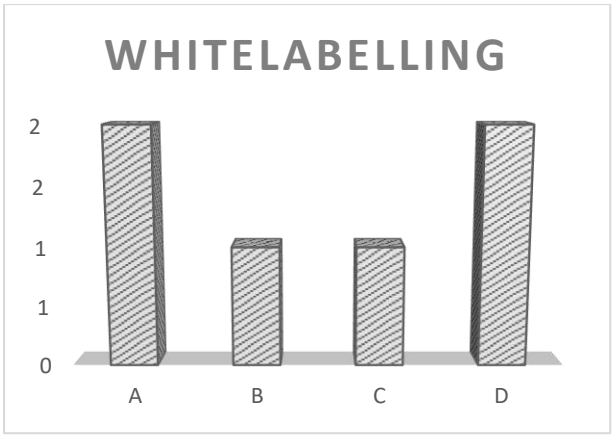
B 3. Alternatives-Response Time Plot



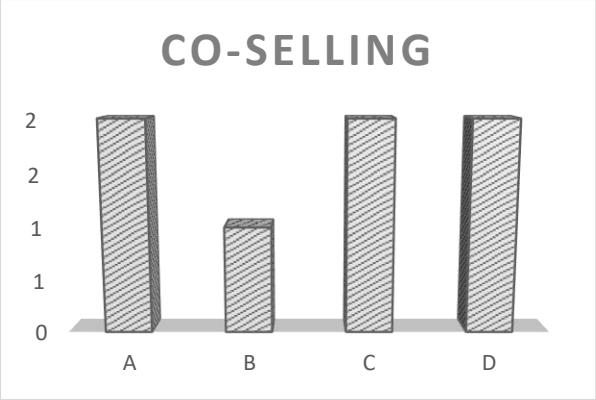
B 4. Alternatives-Reliability Plot



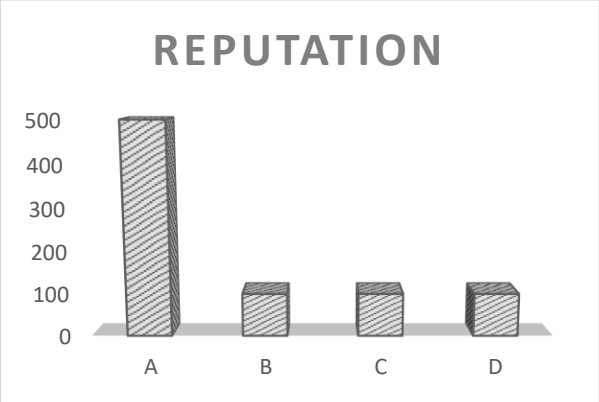
B 5. Alternatives-Support Plot



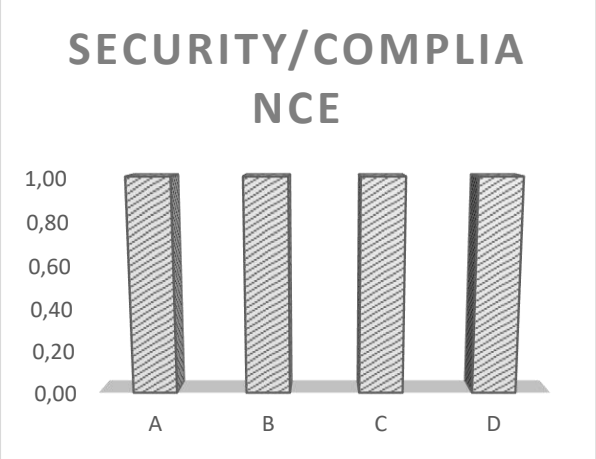
B 6. Alternatives-White-labeling Plot



B 7. Alternatives - Co-Selling Plot



B 8. Alternatives-Reputation Plot



B 9. Alternatives-Security/Compliance Plot

Chapter C – Analysis of the Case Study

This Chapter presents the extended discussions of the results of the case study.

The data collected for Reputation and Functionality remains the same. However, the processing method for both criteria has been changed as discussed in Section 6.3. The resultant weightages did not have any impact proving that weightages are assigned based on the variability in values within the criteria. Figure C1 shows the updated values of Reputation and Functionality. Figure C2 can be compared with Figure 21.

ENTROPY TOPSIS									
Vendor	Functionality	Security/Compliance	Availability	Response Time	Reliability	Support	Whitelabelling	Co-selling	Reputation
A	7,000	1,00	99,9	1	1	1,00	2	2	5
B	8,000	1,00	99,9	1	1	1,00	1	1	1
C	8,000	1,00	99,9	1	1	1,00	1	2	1
D	8,000	1,00	99,9	1	1	1,00	2	2	1

C 1. Updated values of Reputation and Functionality

ENTROPY									
Vendor	Functionality	Security/Compliance	Availability	Response Time	Reliability	Support	Whitelabelling	Co-selling	Reputation
A	-0,3360174	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,366204096	-0,357932277	-0,2937523
B	-0,34956017	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,298626578	-0,277987164	-0,2599302
C	-0,34956017	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,298626578	-0,357932277	-0,2599302
D	-0,34956017	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,366204096	-0,357932277	-0,2599302
	-1,38469791	-1,386294361	-1,38629436	-1,386294361	-1,3862944	-1,386294	-1,329661349	-1,351783994	-1,0735428
Entropy value	0,99885	1	1	1	1	1	0,95915	0,97511	0,77440
Divergence	0,00115	0	0	0	0	0	0,04085	0,02489	0,22560
Weight	0,003937071	0	0	0	0	0	0,139665158	0,085107531	0,77129024

C 2. Display of unchanged weights

The data for the white-labeling criterion has been processed so as to increase the variability between the values(Figure C3) which has impacted the weightage assigned to white-labeling and the other criteria(Figure C4).

ENTROPY TOPSIS									
Vendor	Functionality	Security/Compliance	Availability	Response Time	Reliability	Support	Whitelabelling	Co-selling	Reputation
A	0,875	1,00	99,9	1	1	1,00	10	2	500
B	1,000	1,00	99,9	1	1	1,00	1	1	100
C	1,000	1,00	99,9	1	1	1,00	1	2	100
D	1,000	1,00	99,9	1	1	1,00	10	2	100

C 3. Updated white-labeling values

ENTROPY									
Vendor	Functionality	Security/Compliance	Availability	Response Time	Reliability	Support	Whitelabelling	Co-selling	Reputation
A	-0,3360174	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,358389709	-0,357932277	-0,2937523
B	-0,34956017	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,14050193	-0,277987164	-0,2599302
C	-0,34956017	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,14050193	-0,357932277	-0,2599302
D	-0,34956017	-0,34657359	-0,34657359	-0,34657359	-0,3465736	-0,346574	-0,358389709	-0,357932277	-0,2599302
	-1,38469791	-1,386294361	-1,38629436	-1,386294361	-1,3862944	-1,386294	-0,997783278	-1,351783994	-1,0735428
Entropy value	0,99885	1	1	1	1	1	0,71975	0,97511	0,77440
Divergence	0,00115	0	0	0	0	0	0,28025	0,02489	0,22560
Weight	0,002165059	0	0	0	0	0	0,526887984	0,046802005	0,42414495

C 4. Updated weights of the criteria

Equal Weights have been assigned to check the sensitivity of the rankings. Figure C5 shows the weights assigned and Figure C6 shows the impact of the rankings of the alternatives.

ENTROPY TOPSIS									
Vendor	Functionality	Security/Compliance	Availability	Response Tim	Reliability	Support	Whitelabelling	Co-selling	Reputation
A	0,875	1,00	99,9	1	1	1,00	2	2	500
B	1,000	1,00	99,9	1	1	1,00	1	1	100
C	1,000	1,00	99,9	1	1	1,00	1	2	100
D	1,000	1,00	99,9	1	1	1,00	2	2	100
	0,111	0,111	0,111	0,111	0,111	0,111	0,111	0,111	0,111

C 5. Sensitivity Analysis using Equal Weights

Vendor	Functionality	Security/Compliance	Availability	Response Tim	Reliability	Support	Whitelabelling	Co-selling	Reputation	Sk+	Sk-	Pk	Rank
A	0,050101071	0,055555556	0,055555556	0,055555556	0,055555556	0,055555556	0,070272837	0,06	0,104990131	0,007	0,096	0,9307	1
B	0,057258367	0,055555556	0,055555556	0,055555556	0,055555556	0,055555556	0,035136418	0,03	0,020998026	0,096	0,007	0,0693	4
C	0,057258367	0,055555556	0,055555556	0,055555556	0,055555556	0,055555556	0,035136418	0,06	0,020998026	0,091	0,032	0,25788	3
D	0,057258367	0,055555556	0,055555556	0,055555556	0,055555556	0,055555556	0,070272837	0,06	0,020998026	0,084	0,047	0,36017	2
t_i+	0,057258367	0,055555556	0,055555556	0,055555556	0,055555556	0,055555556	0,070272837	0,061633355	0,104990131				
t_i-	0,050101071	0,055555556	0,055555556	0,055555556	0,055555556	0,055555556	0,035136418	0,030816678	0,020998026				

C 6 Rankings of Alternatives after Equal Weight Split Up

The weights are split with 60 percent assigned to the business goals criteria and 40 percent slit up among the rest QoS criteria. The split-up is shown in Figure C7 and the ranking is shown in Figure C8.

ENTROPY TOPSIS									
Vendor	Functionality	Security/Compliance	Availability	Response Time	Reliability	Support	Whitelabelling	Co-selling	Reputation
A	0,875	1,00	99,9	1	1	1,00	2	2	500
B	1,000	1,00	99,9	1	1	1,00	1	1	100
C	1,000	1,00	99,9	1	1	1,00	1	2	100
D	1,000	1,00	99,9	1	1	1,00	2	2	100
	0,057	0,057	0,057	0,057	0,057	0,057	0,300	0,300	0,057

C 7. Sensitivity Analysis using 60-40 split of weights

Vendor	Functionality	Security/Compliance	Availability	Response Time	Reliability	Support	Whitelabelling	Co-selling	Reputation	Sk+	Sk-	Pk	Rank
A	0,025766265	0,028571429	0,028571429	0,028571429	0,028571429	0,028571429	0,18973666	0,17	0,053994925	0,004	0,133	0,973143	1
B	0,02944716	0,028571429	0,028571429	0,028571429	0,028571429	0,028571429	0,09486833	0,08	0,010798985	0,133	0,004	0,026857	4
C	0,02944716	0,028571429	0,028571429	0,028571429	0,028571429	0,028571429	0,09486833	0,17	0,010798985	0,104	0,083	0,444133	3
D	0,02944716	0,028571429	0,028571429	0,028571429	0,028571429	0,028571429	0,18973666	0,17	0,010798985	0,043	0,126	0,745061	2
t_i+	0,02944716	0,028571429	0,028571429	0,028571429	0,028571429	0,028571429	0,18973666	0,166410059	0,053994925				
t_i-	0,025766265	0,028571429	0,028571429	0,028571429	0,028571429	0,028571429	0,09486833	0,083205029	0,010798985				

C 8. Rankings of Alternatives after 60-40 split of weights

UNIVERSITY OF TWENTE
Drienerlolaan 5
7522 NB Enschede

P.O.Box 217
7500 AE Enschede

P +31 (0)53 489 9111

info@utwente.nl
www.utwente.nl