Tampere University

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STEPPING TOWARDS INDUSTRY 4.0 SUPPLY CHAIN: ARTIFICIAL INTELLIGENCE FOR SUPPLIER MARKET ANALYSIS.

Faculty of Management and Business
Master of Science Thesis
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ABSTRACT

Md Saidul Islam: Stepping Towards Industry 4.0 Supply Chain: Artificial Intelligence for Supplier Market Analysis.
Master of Science Thesis
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In the current dynamic and fiercely competitive business environment, companies are becoming more and more dependent on an ever-expanding network of suppliers to secure the products and services essential for maintaining a competitive edge. However, navigating this complex web of suppliers can prove to be a difficult task, especially in sectors with a history of rapid change, or non-traditional supplier selection criteria. Procurement professionals have been actively investigating contemporary technologies to improve the effectiveness and efficiency of supplier sourcing as they have become more aware of the need for innovation in the fields of supplier selection and analysis. AI stands out among these technologies as a potent accelerator for transforming supplier market analysis.

This thesis aims to identify the pivotal role played by AI in supplier market analysis, as well as the impacts of modern technologies on procurement management with the goal of establishing an AI powered supplier market analysis for a modern procurement management system. In pursuit of expanding our understanding of the phenomenon, this thesis uses a qualitative interview study, with the aim of eliciting practical experiences and opinions.

At first, the literature review was carried out to investigate past research articles on procurement management based on Industry 4.0 frameworks, supplier market analysis, artificial intelligence, and how AI impacts the supplier market analysis process. Then, the empirical study was conducted by completing a qualitative interview with procurement experts for generating empirical data on AI directing new supplier market study. Finally, a framework for new supplier market analysis was developed using empirical data and the conclusions drawn from the literature review.

The study's conclusion offers an advanced perspective for supplier market analysis supported by AI technologies. The literature review defines new supplier market analysis as a three-step process which are: discovering potential suppliers, initial screening and deep evaluation, and supplier selection. In modern procurement management, each stage of this process incorporates AI technology to increase effectiveness. The result of this study determines AI technologies and their role in every stage of new supplier market analysis. The integration of AI into supplier market study appears to reshape procurement management, transforming it into a competitive practice within an ever-evolving business environment.

In addition to traditional supplier analysis, this master's thesis offers a complete AI driven supplier market analysis framework. As a result, the new supplier market analysis process, and benchmarking AI technologies for each stage of this process can be considered as two remarkable findings of this study. In addition, employing qualitative interviews with procurement experts adds depth to the findings by incorporating their experiences and opinions. An additional finding of the qualitative interviews study is the practitioner's experience with Industry 4.0 technologies to drive modern procurement management.

This thesis unveils new avenues for prospective research, and one of them is exploring the ethical and legal dimensions of implicating AI-driven decision making. However, for practitioners future research can contribute to conducting case studies to understand industry-specific benefits, and challenges of AI adoption in procurement management.

Keywords: Industry 4.0, Artificial Intelligence, Modern Procurement, Supplier Market Analysis, Supplier Discovery, Supplier Selection, Supplier Evaluation.

The originality of this thesis has been checked using the Turnitin Originality Check service.

PREFACE

This thesis focused on leveraging artificial intelligence technologies in procurement management in the relatively unexplored context of supplier market analysis. As the thesis progressed, my knowledge of supplier market analysis generally increased, and I started to get acquainted with modern technology-driven procurement management. In addition, I felt like I learned a lot of new terms and facts about modern procurement. However, it seems that it was a smart idea to pick a thesis topic that was somehow new to me because it helped me learn more about the subject and made the whole journey more exciting. This journey would be very difficult without the support and inspiration of some wonderful individuals. I would like to thank all of you from the bottom of my heart.

I am incredibly grateful to my parents, who have been my pillars of strength throughout my whole life.

The successful completion of this research journey owes a debt of gratitude to my esteemed supervisor, Associate Professor Aki Jääskeläinen. His guidance has been instrumental in shaping this research, and I am privileged to have had the opportunity to work under his supervision. Furthermore, I express my gratitude to Associate Professor Mohammad Moshtari for his insightful feedback.

Finally, I wish to express my love to my dear wife Tahi for being an inspiration to me throughout the entire research process.

Tampere, 27 October 2023

Md Saidul Islam

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LIST OF SYMBOLS AND ABBREVIATIONS

AHP	Analytic Hierarchy Process
AI	Artificial Intelligence
ANNs	Artificial Neural Networks
ANP	Analytic Network Process
AR	Augmented Reality
B2B	Business to Business
CBR	Case Based Reasoning
CV	Computer Vision
eAuction	Electronic form of auction
eCatalogs	Electronic copy of catalogs
eInvoicing	Electronic copy of Invoicing
eSourcing	Electronic form of sourcing
eSupply	Electronic form of supply management
eTenders	Electronic form of tender
FCM	Fuzzy C-Means
HDBScan	Hierarchical density-based clustering applications.
Industry 4.0	Fourth Industrial Revolution
IoT	Internet of Things
MCDM	Multi-criteria decision-making process
NLP	Natural Language Processing
RFID	Radio Frequency Identification
RFx	Request for X
RPA	Robotic Process Automotion
RST	Rough Set Theory
SMA	Supply Market Analysis
VR	Virtual Reality

1. INTRODUCTION

Companies are increasingly depending on new suppliers to find the products and services they need to be competitive in today's dynamic and fierce business environment. However, discovering and assessing potential suppliers can be a challenging endeavor, especially in businesses that are changing quickly or where the usual supplier selection process might not work. Procurement experts have been implementing and evaluating various modern technologies for developing an efficient supplier-sourcing process. Recent advancements in artificial intelligence (AI) bring new possibilities to boost the supplier discovery, review, and selection process. AI tools like big data, machine learning, and natural language processing can offer powerful insights into supplier capabilities, performances, and risks of chosen suppliers and such knowledge enables buying companies to make better decisions and prevent supply chain disruptions.

To that purpose, this thesis examined artificial intelligence (AI) for supplier market analysis, especially how AI can benefit new supplier market analysis. A brief discussion of procurement functions in the era of Industry 4.0 is also done through the available theoretical resources. The target of this study is to come up with a legitimate set of guidelines for procurement experts so that they can utilize AI tools for developing an efficient supplier market analysis process and this study is directed to finalize the Master of Science thesis.

The motivation for this thesis is briefly explained in this chapter, along with research questions and objectives. The last segment of this chapter will describe the construction of this study to make readers completely understand the thesis contents.

1.1 Background and Motivation

Digital technologies affect today's business organizations and put tremendous pressure on organizations to change. As a result of globalization and competition in international markets, supply chain management becomes the most affected division of a business (Agrawal & Narain, 2018). To maintain a competitive advantage and develop a sustainable supply chain, top management should identify digital technologies and their effective implementation for each supply chain segmentation. The whole supply chain process of business starts with searching and choosing the best supplier. As a result, the performance of the supplier market analysis significantly impacts the efficiency of the entire supply chain management. Supplier market analysis is the process that a certain

company carries out to select suppliers for the business. Figure 1 presents a general overview supplier market analysis process.

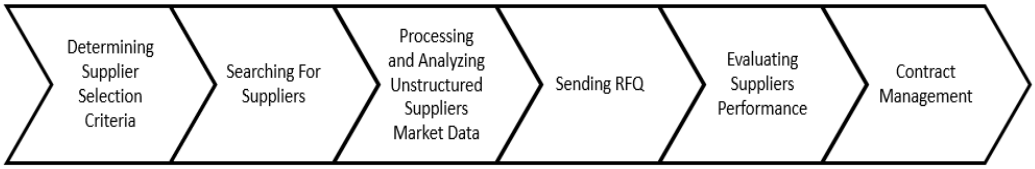

Figure 1. *Overview of supplier market analysis process (Van Der Valk & Rozemeijer, 2009).*

From the above figure, supplier market analysis starts with determining specifications of supplier selection and ends with contract management. Though based on the types of business, and products or services purchased from suppliers selection criteria can vary, the main goal of supplier market analysis should be choosing the best supplier who can deliver the product or service at minimum cost, preferable quality, and within a minimum lead time. For building relations with a specific supplier, the procurement team should go through a process of gathering structured and unstructured supplier data, cleaning and screening the data, and finally selecting the supplier based on evaluating gathered data.

In response to establishing an effective supplier analysis process, top management is moving towards employing digital technologies in supplier sourcing. Technologies that drive modern supply chain management include artificial intelligence, cloud computing, robotics, internet of things (IoT), blockchain, 3D printing, RFID, and Digital twins. (Attaran, 2020 and Choi et al, 2022). Among these technologies, artificial intelligence (AI) is the most impactful for analyzing unstructured data.

Although digital technologies have already started being implemented in all the areas of supply chain management, empirical research on the topic of supplier market analysis is still scarce. Despite some research concentrating on the prospects, constraints, and effects of Industry 4.0 supply chain management; (B. Tjahjono et al., 2017; Choi et al., 2022; Olsen & Tomlin, 2020; Oluyisola et al., 2021; Fatorachian & Kazemi, 2021; Moeuf et al., 2017; and Ivanov et al., 2020), few of them light on supplier market analysis. The purpose of this study is to contribute to determining an effective implementation of AI for supplier market analysis.

In this modern era, 90% of business data are unstructured whereas 10% of data are structured (Gantz & Reinsel, 2011). Business organizations are facing difficulties to determine how to process this large amount of unstructured data. As a result, management is willingly interested in implementing modern technologies in making decisions from unstructured data. For selecting suppliers based on big unstructured data, the procurement decision makers should know what current technologies are available for processing unstructured data and how to analyze unstructured data with the help of modern technologies. It will save a significant amount of time and cost to implement digital supplier market analysis and response to Industry 4.0.

1.2 Research Objectives and Questions

The research objective of this study is to investigate the potential of artificial intelligence (AI) as a supplementary tool for supplier market analysis, as well as also comprehensively examine the effects of contemporary technologies on procurement management within the framework of Industry 4.0. Organizations are progressively adopting digital transformation and incorporating innovative technologies into their supply chain management system. The advancement of Industry 4.0 has ushered in a new era of intelligent and network-based systems, permitting higher operational efficiency throughout numerous domains, enhanced automation, and data-driven decisions.

The following research questions are specified in order to satisfy the research purpose and facilitate the study:

RQ1. How do modern technologies impact procurement management?

RQ2. How can AI support supplier market analysis?

The first question seeks to build an understanding of how current advancements affect procurement management in practice. As a result of the development of technologies, notably robotic process automation (RPA), internet of things (IoT), big data analytics, cloud computing, and artificial intelligence (AI), the procurement landscape has gone through significant changes. Numerous potentials to enhance supply chain visibility, optimize inventory management, and enable seamless collaboration with suppliers are presented by modern technologies. By examining the influence of these technologies on procurement management, this study intends to offer insights into the advantages and repercussions of implementing these technologies in the Industry 4.0 framework.

The latent value of AI in supplier market analysis is the subject of the main focus of the second research topic. As business organizations seek to make data-driven decisions, artificial intelligence (AI) has emerged as a potent tool for assessing massive volumes of data, gaining insightful understanding, and facilitating proactive decision-making. In response to finding new suppliers, assessing their performance, and reducing procurement risks supplier market analysis is crucial. Procurement organizations can enhance their supplier market analysis capabilities and make more intelligent decisions by utilizing AI techniques like data mining, NLP, and machine learning. This thesis aims to explore the many uses of AI in supplier market analysis and to demonstrate the advantages and implications associated with the adoption of AI in this domain.

By addressing these research questions, this thesis intends to broaden knowledge of how current innovative technologies lead to sustainability in procurement management and how AI may improve supplier market analysis within the framework of Industry 4.0 supply chain management. The results of this research will offer valuable insights to practitioners, researchers, and policymakers in the field of supply chain management that will allow them to make well-informed choices on the adoption and integration of cutting-edge technologies and AI in their procurement management system. Additionally, this research indicates to pinpoints prospective areas for development, emphasizes the key success factors, and offers recommendations for businesses appearing to integrate Industry 4.0 and AI into their supply chain operations.

1.3 Thesis Structure

This thesis attempts to utilize a carefully organized documentation for the purpose of constructing a coheren narrative. Thus this thesis has been organized into five chapters, and the overall thesis structure is illustrated in the below figure.

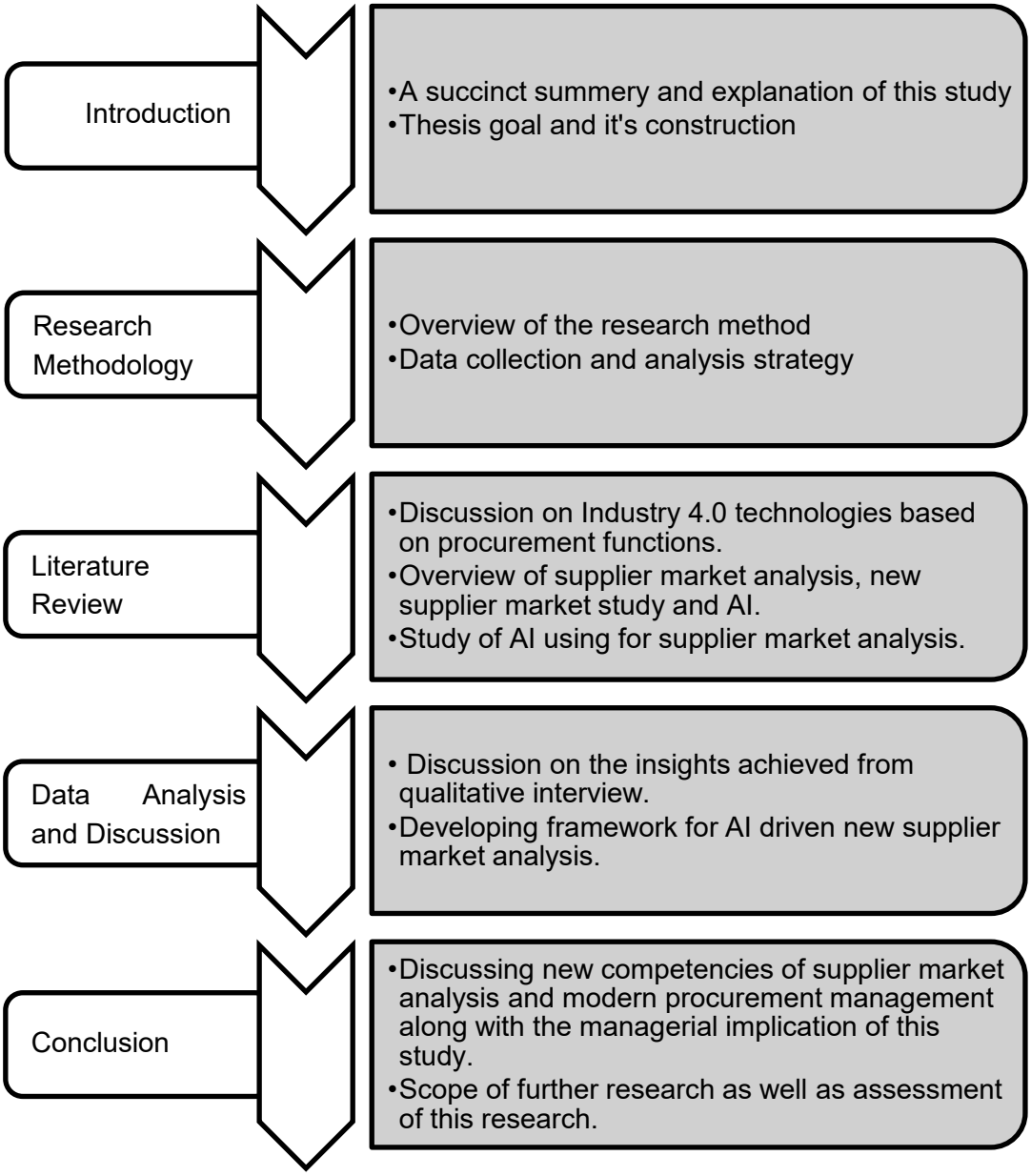

Figure 2. *Thesis structure.*

Figure 2 explains itself, and it clearly shows the construction of this thesis. The left column of the figure contains the name of the chapter, whereas the right column describes the chapter's content briefly. This thesis also contains references and an appendix as well.

2. RESEARCH METHODOLOGY

Research is a systematic inquiry process that requires collecting data, documenting critical information, and analyzing and interpreting collected data and information based on suitable methodologies with a clear purpose (Saunder et al., 2009). According to Goddard and Melville (2001), research is not only considered as a process of data gathering but is more about answering questions that have not been answered before. No matter the discipline, research is complex by its nature because its main goals are to evaluate results and comprehend implications (Adler and Ziglio, 1996; Gustafson et al., 1975).

Focusing on business and management research enables the application of expertise from several disciplines to gain new knowledge for these fields that cannot be attained independently. Additionally, research into business and management must solve business and practical concerns in addition to generating findings that advance knowledge and understanding.

Saunders et al. (2009), stated that the academic researcher have to be conscious of their specific philosophical viewpoint and consider how to apply it to their study methods. In this thesis, the interpretivism philosophy of the researcher is incorporated into research methodologies and explains the business environment around us which supports the goal of the research to contribute by offering additional knowledge. This chapter provides information regarding the specifics of how the entire research was carried out as well as the theoretical justifications for the selected methodologies. In addition, a discussion of data collection techniques, data processing, and the anticipated timeframe will be presented.

2.1 Research Design

According to Saunders et al. (2009), the research design is important for making strategic choices about research methodology and time horizon. Research questions, priorities, available knowledge, time, and resources all influence the selection of a particular research strategy (Saunders et al., 2009). As business and management researchers, Johnson and Clark (2006) noted that we must be concerned about the philosophical commitments we are going to make through choosing a type of research approach because these philosophical commitments will have a substantial impact on both what we will do and how we will interpret the topic we are researching. Saunders et al. (2009), illustrated a research onion for discussing the research philosophies and approaches,

which is presented in the following figure, and each layer of the research onion is defined by a more thorough investigation procedure, which leads to an optimal progression in the methodology to be developed for the research process.

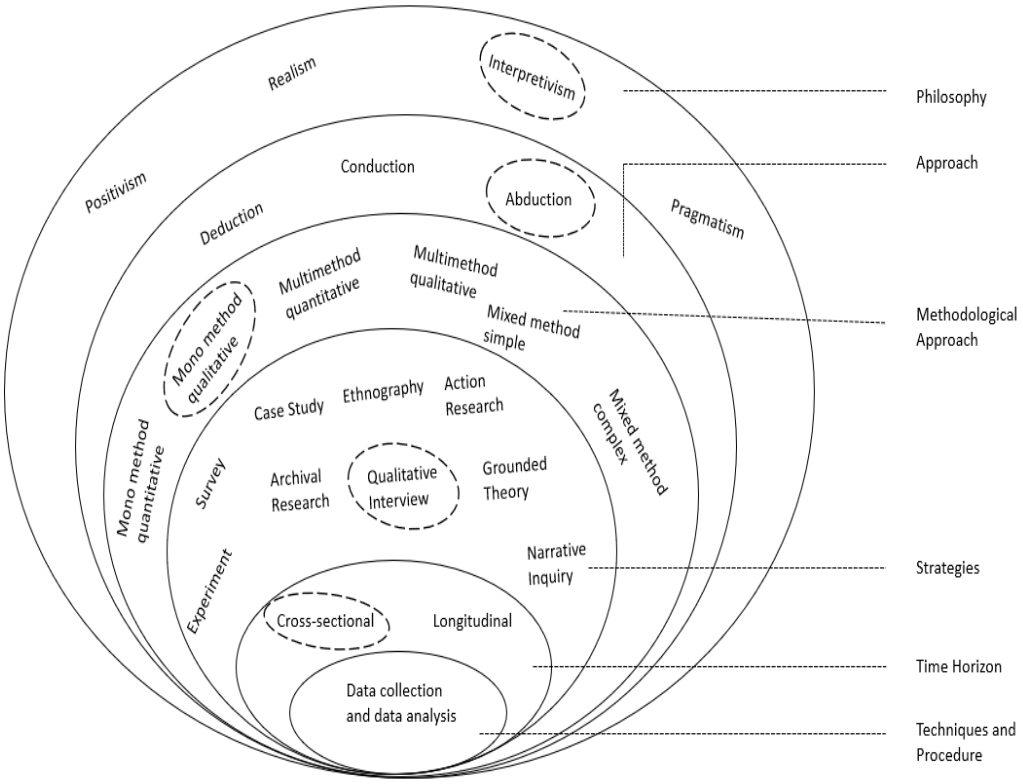

Figure 3. *Research onion (modified from Saunders et al. 2009).*

Figure 3 pictures the research onion illustrated based on Saunders et al. (2009), and the circulated dotted lines parts of this figure present the research design of the empirical research part of this thesis. From the figure 3, the philosophical assumption that guides the researcher's methodology is at the center of the research onion. This layer displays the researcher's point of view and beliefs regarding the nature of reality and knowledge. It contains two main paradigms: positivism and interpretivism. As this thesis study philosophy permits an in-depth examination of the previous research on supply chain artificial intelligence, and subjective experiences and perspectives of the procurement experts, this study follows the interpretivism research philosophy.

The research approach includes deduction, induction, and abduction, which are mainly determined by philosophical assumptions. This thesis follows the abduction research approach. Abductive reasoning is common in research, and this approach begins with

the observation of surprising facts. (Ketokivi & Mantere, 2010). Abduction reasoning is considered a combination of deduction and induction, where researchers apply deduction at one point in their investigation and induction at another stage. A mono method research strategy of a qualitative interview accompanied by a systematic literature review is applied for collecting empirical data for this thesis. The systematic literature review started with a set of research questions and research objectives for developing the framework of the Industry 4.0 procurement system and leveraging artificial intelligence in supplier market analysis which is a deduction approach. This systematic literature review also answers the first research question of how modern technologies impact procurement management and offers the basis for answering the second research question. After developing the new supplier market analysis framework, a qualitative interview of 5 procurement experts was done to build the final framework and shape a new supplier market analysis based on AI technologies, and this expert interview followed the induction research approach.

When research is done based on qualitative data, it is called a qualitative study. Whereas quantitative research frequently tests theories, qualitative research attempts to get a thorough understanding of a situation (Carson et al., 2001). Carson et al (2001), also stated that the questions ”how” and ”why” can be better answered using qualitative approaches, while ”what” and ”how many” are best addressed using quantitative methods. This thesis facilitates an improved comprehension of Industry 4.0 technologies in the domain of procurement management with an emphasis on their application in establishing a sustainable supply chain management system and also explores the utilization of artificial intelligence algorithms in supplier market analysis, illuminating the underlying principles and guidelines involved. Hence, a qualitative research strategy is considered best suited for this thesis.

Mono-method qualitative and multimethod qualitative are the two types of data collection methods for the qualitative study. When one qualitative data collection method and analytical procedure is followed to answer research questions is called mono-method qualitative, and when more than one qualitative data collection method and analytical procedure are followed to answer research questions is called a multimethod qualitative study (Saunder et al., 2009). This thesis goes with the mono method qualitative study, and qualitative interviews were carried out to gather empirical data in a cross-sectional time horizon.

In summary, this thesis is completed based on interpretivism research philosophy by collecting qualitative data from existing research and empirical qualitative data from qualitative interviews of a cross-sectional time horizon and following an abduction research approach.

2.2 Research Process

This thesis was started at the beginning of January 2023 with the initial stages encompassing with selecting topic, formulating the thesis plan, and developing a preliminary understanding of the contextual background of the phenomenon under investigation. At first, it was the author's interest to do a study on the recent technologies employed in supply chain management. After meeting with the professor and reading current supply chain journals and research papers, the scope of the thesis was narrowed down, and the final topic was selected in February 2023. After selecting the research topic, the research questions and research method were fixed within March 2023. Data gathering and analysis based on the previous research was done in the second phase of the study which was completed within July 2023. However, even though business organizations have begun utilizing AI and Industry 4.0 technologies to make their supply chains more data-driven and efficient, it was clear from the very beginning that very few academic studies have been published on modern procurement functioning, especially on supplier market analysis. Hence, to get procurement organizational insight and evaluate the research framework, 5 procurement experts were interviewed. The thesis was finalized by preparing the final report based on the result of qualitative interview and literature study, at the end of October. The Research timeline as well as the research phases are explained in Figure 4 below.

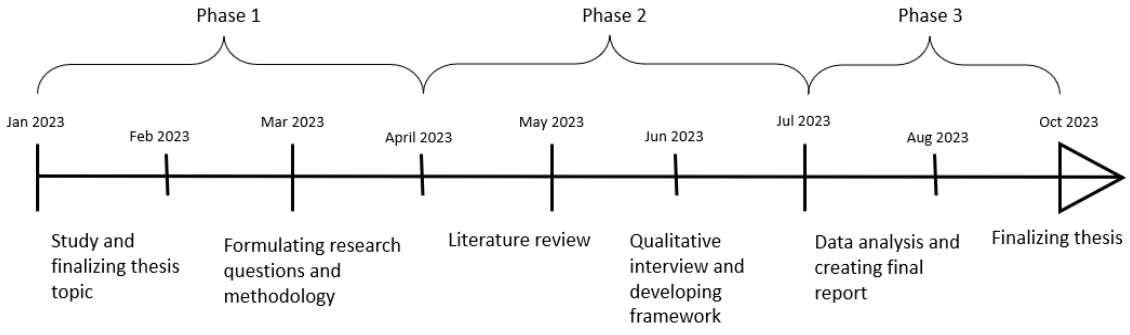

Figure 4. *Research time frame.*

Figure 4 presents the research time frame based on its different phases. The whole research process is segmented into three phases. Phase 1 of the study can be seen as one of the most significant parts as it focused on developing the research topic and formulating the research questions. Deciding the research methodology is also part of Phase 1. Phase 2 incorporates the execution of the literature study to get insights of the past literature, and qualitative interviews, for gathering empirical data. To maintain credibility, specific keywords, and search guidelines were maintained through the information search. During data analysis, a framework for answering the RQ2 was also developed. The research process is illustrated below:

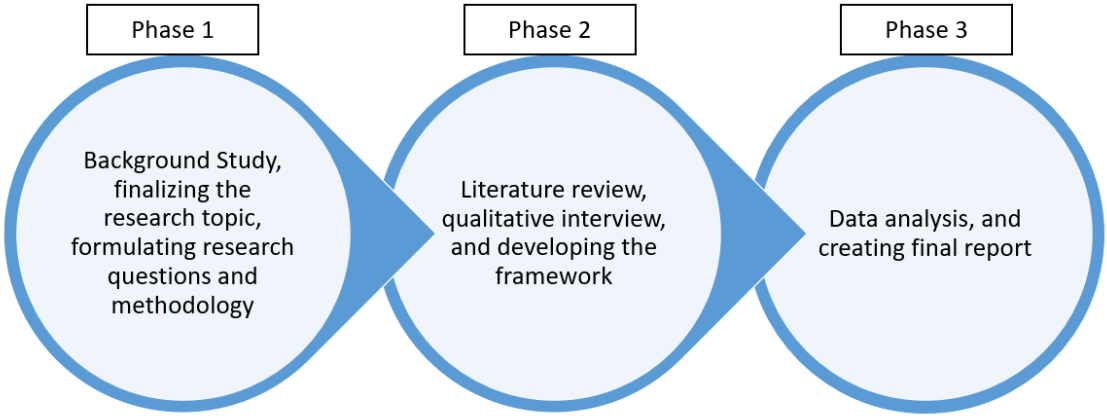

Figure 5. *Research process.*

Figure 5 outlines the research process of this study. Data analysis and creation of the final report were done in Phase 3. In this final phase, the framework developed in Phase 2 was finalized based on AI technologies. The report's main objective was to make sure that any business involved in procurement management could adapt it into an operational strategy.

2.3 Data Gathering and Analysis

The comprehensiveness of the data collecting process and the precision of the data analysis techniques are very important for the quality and validity of the research findings. According to Baxter & Jack (2015), compiling research data is akin to gathering pieces to a puzzle, where every single piece of information serves to fortify and enhance the author's comprehension of the phenomenon, ultimately leading to a more comprehensive understanding. Gummesson (1993), proposed five principles of data gathering

methods that are used in qualitative research, and these five qualitative data collecting methods include existing materials (journal papers, books and reports), qualitative interviews, questionnaire surveys, observation, and action research. In addition to the use of past research articles, and journal publications, this thesis also utilizes qualitative interviews of procurement experts to gather empirical data on the real-world implications of artificial intelligence in procurement related functions.

According to the current state of the literature, there is a lack of a cohesive framework and fragmentation in the knowledge about the use of artificial intelligence (AI) in supplier market analysis, particularly in supplier discovery, and supplier screening. Nonetheless, it is worth noting that certain noteworthy contributions can be discerned within the realm of research dedicated to Industry 4.0 procurement. The literature review is a distinguished form of research that allows scholars to contribute to the body of knowledge by systematically collecting and synthesizing existing research findings (Durach et al., 2017). A literature review was done in this thesis to answer the RQ1 and develop the framework of RQ2. The data-gathering process for a systematic literature review starting with defining research questions, mentioned by Durach et al. (2017), is followed in this thesis. The steps of the literature review are defined in the below figure:

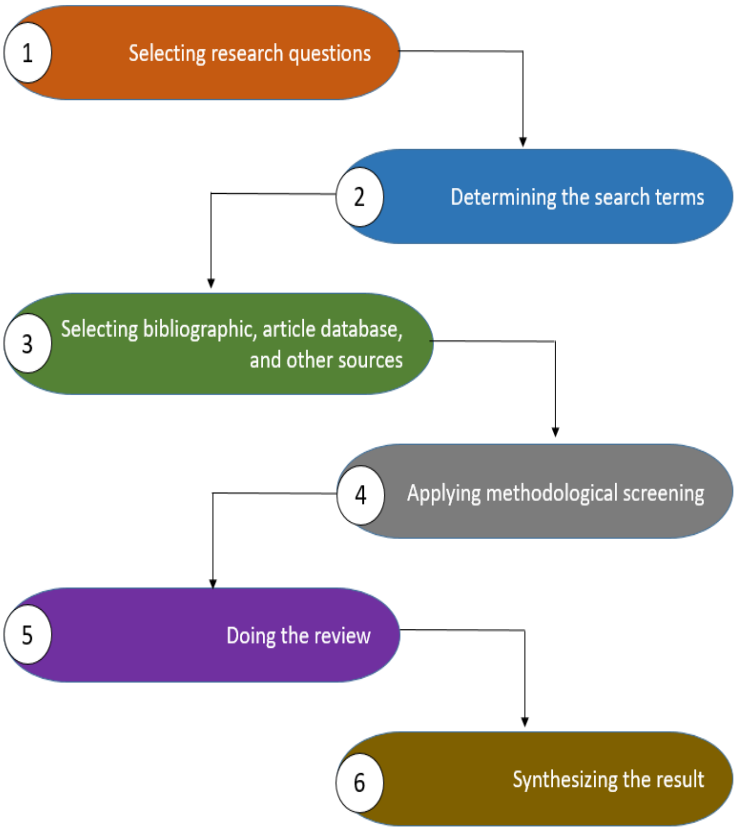

Figure 6. *Steps of a systemic literature review (adopted from Durach et al., 2017).*

The above figure lists the steps that were followed for the literature review part of this thesis. The search terms were determined after defining the objective and forming the research questions. Incorporating phrases like “Supply Chain Intelligence”, “Digital Supply Chain”, “Artificial Intelligence (AI) in Supply Chain Management”, “AI in Supplier Market Analysis”, “AI in Supplier Discovery”, and “AI for New Supplier Finding” different combinations of terminologies have been used as search phrases. When searching these search terms in different databases, the gathering of reliable data was given the utmost importance. Throughout the study, it has been reassured that every piece of used information comes from verified sources. As a primary source of scholarly research, the research journal databases ScienceDirect, Scopus, and Web of Science were utilized, while sources such as MIS Quarterly, Journal of Purchasing and Supply Management, IEEE, Boston Consulting Group, Supply Chain Management Review, Supply Chain 24/7, Supply Chain Trend, Supply Chain Insights, and Supply Chain Shaman were given prioritized for collecting data pertaining to the digital supply chain management. In accordance with selection criteria, emphasis was placed on the inclusion of academic papers, articles, and news written in English, and therefore, those not meeting this criterion were deliberately excluded from consideration. In line with the study’s methodology, research papers that were not published in peer-reviewed journals, such as conference proceedings, book chapters, and working papers were excluded. Thirdly, to ensure no material was selected from predatory journals, only articles published in journals listed in AJG (Academic Journal Guide) were included. Subsequently, papers that addressed business intelligence and/or artificial intelligence but did not specifically focus on any supply chain procurement management function were also excluded from the analysis.

The multistep coding qualitative content analysis is applied for the data gathering from past literature. At first, basic information like the publication year, journal, and applied methodology were coded. After that, the paper’s unit of analysis depicts the division of the supply chain management that is examined in a study. In the final stage, the full text of the articles was reviewed and coded to answer RQ1 and develop the framework for RQ2. For answering RQ1, Industry 4.0 technologies and their corresponding implementation in procurement management were coded. For RQ2, a framework for the supplier market analysis was built with coding the application of artificial intelligence in the supplier market analysis. The whole research protocol of the literature review is summarised in the below table.

Table 1. *Research Protocol (adopted from Cantrill et al., 1996).*

RESEARCH PROTOCOL	DETAILED DESCRIPTION
Research Database	ScienceDirect, MIS Quarterly, JMR, IEEE, Boston Consulting Group, Supply Chain Management Review, Supply Chain 24/7, Supply Chain Trend, Supply Chain Insights, Supply Chain Shiman, and Case Company's Website
Publication Type	Journal, Articles, Online News Paper, Blogs, and Reports
Language	English
Date Range	July 2003 – December 2019
Search Terms	Combination of Artificial Intelligence, Industry 4.0, and Supply Chain terms, like AI in Procurement, Industry 4.0 Procurement Management, AI in Procurement, Supplier Discovery, Supplier Selection, eProcurement, Supplier Market, Supplier Screening, Supplier Evaluation, Digital Procurement System, and AI in Business.
Inclusion Criteria	Articles describing digital procurement management, Industry 4.0 technologies for procurement management, and AI for procurement management.
Exclusion Criteria	Articles that are not in English, do not have valid sources, and describe artificial intelligence or business intelligence but do not pay attention to the supply chain procurement functions.
Data Extraction	Information needed for developing Industry 4.0 procurement and building a framework for the implication of AI in supplier market analysis.
Data Analysis and Synthesis	Qualitative content analysis, and author's experience.

Table 1 encompasses the research protocol of the literature review part of this thesis.

After gathering data from previous research, the research interview was conducted to collect empirical data for answering the RQ2. Brinkmann and Kvale (2008), described research interview as a strong method to collect data of an individual's situation. The research interview can be executed in one of three ways: structured, semi-structured, and unstructured, based on how strictly it is seen important to maintain pre-determined questions (Saunders et al., 2009). Research questions are carefully maintained in a structured interview, whereas the research subject is explained based on the theme of key questions in a semi-structured interview (Saunders et al., 2009). However, for un-structured interviews, there are no specific interview questions, instead interview is done like a spontaneous discussion on the research subject (Saunders et al., 2009). For this thesis, the research strategy was chosen a semi-structured interview of the procurement technology experts who already have the experience of the phenomenon. To confirm that interview covers all important facts, it was intended that the research interview should be supported with some key research questions. Based on the above discussion, the overall data gathering flow of this thesis can be presented like:

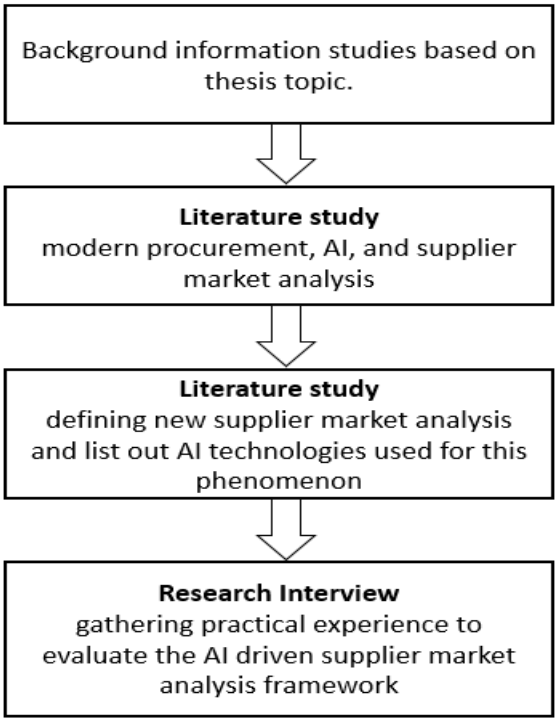

Figure 7. *Overall data gathering flow.*

Figure 7 visualizes the flow of overall data gathering. From the figure, at first background information related to the thesis topic was studied. Then the data related to modern pro-curement, AI, and supplier market analysis was gathered from the existing literature. As

an outcome of this literature study, the author determined the new supplier market analysis and a list of AI used for this analysis process. However, as there is a limited number of research on this topic, the qualitative interview was chosen as a method of gathering empirical data for establishing a sustainable framework for AI driven supplier market analysis. Before the interview, questions are selected and the listed AI technologies from the literature review as included in the interview questions.

When the author started approaching procurement experts for the interview, it was desired to have interviewees from manufacturing companies, service companies, university professors, and supply chain solution building companies. Authors approached more than 90 procurement experts from different regions including Finland, USA, and Bangladesh through email for the interview and 5 of them replied. Table 2, codes the interviewee's background.

Table 2. *Interviewee background.*

Interviewee	Interviewee role	Years of experience	Industry	Time
A1	Product Specialist	6 - 10 Years	Procurement Solutions Provider	Aug-23
A2	Senior Consultant	6-10 Years	Supply Chain Solutions Providing	Jul-23
B1	Category Specialist	1-5 Years	Machinery and Equipment Manufacturing Company	Aug-23
B2	Procurement Analyst	1-5 Years	Manufacturing Company	Aug-23
C1	Professor	11-15 Years	University	Aug-23

Table 2 shows that five interviewees were from three different industries. Interviewees were contacted by email, and two interviews were done by responding answers in Google form format, and three of them were conducted as one-to-one sessions, via Zoom, and empirical data was first gathered in Google form. One set of interview questions is added as Appendix 1.

Qualitative analysis has two steps two steps: data encapsulation, and data refinement. According to Anttila (2014), the assessment of qualitative data frequently involves the systematic processing and organization of data in alignment with the theoretical framework of the research and the thesis questions. However, a qualitative analysis also involves a critical evaluation of the data and an interpretation of the results. When the primary attention is on the information's content instead of language expression qualitative content analysis seems to be an appropriate method for data analysis, as well as by categorizing the information into categories and classes, the qualitative content analysis seeks to capture the core of the topic (Anttila, 2014). This thesis utilizes the qualitative

content analysis approach for assessing the interview data, since it is well suited to the research strategy of this study.

To identify the interviewee codes, a thematic coding method was applied. At first, the interview transcription was segmented into four segments including Industry 4.0 procurement, supplier discovery, supplier screening and evaluation, and supplier selection. Then analysis of the codes started based on these four segments. The qualitative interview data was first collected in the Google Doc form and then the data was transferred into an Excel spreadsheet from google docs. Prior to entering the data into Excel, the data must first be categorized in accordance with the interview questions and the framework that was developed from the theoretical background to reach the final outcomes. As the theoretical framework was developed before gathering the empirical, it was easy for the author to categorize the data according to that framework. After that, differences and similarities among 5 interview data and past literature needed to be identified. For this, the interview data were copied to another Excel tab, and the data was rearranged accordingly to find the differences and similarities. As the data are analysed and processed, conclusions are beginning to be built. The conclusions are then organized into a reportable form based on accepted theory, and the findings are presented.

3. LITERATURE REVIEW

This chapter will describe existing literature in Industry 4.0 procurement management, supplier market analysis, and artificial intelligences. This chapter will also light on the implications of artificial intelligences in supplier market analysis.

3.1 Procurement Management in Industry 4.0

Purchasing is a crucial aspect of supply chain management, which incorporates the actual buying of materials and/or services from outside vendors (Mangan et al., 2020). Although the main goal of the purchasing department is to deliver the right amount of raw materials, parts components and/or services with standard quality to the actual location at a minimum cost price, another essential responsibility of the purchasing department is searching and selecting suppliers for needed products.

Purchasing is a narrower term than procurement. According to Weele (2005) and Mangan et al. (2020), procurement encompasses the entire purchasing process, as well as supplier evaluation, supplier relationship management, transportation and logistics, and quality control of the raw materials. Figure 8 presents a general overview of procurement processes.

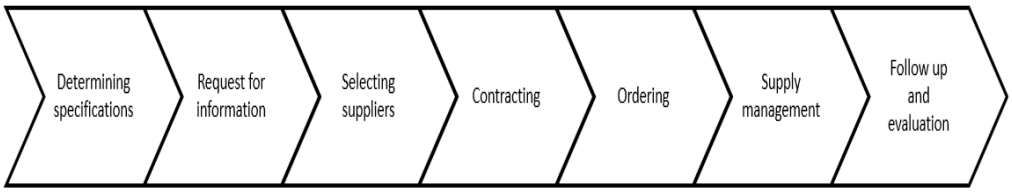

***Figure 8**. Overview of procurement processes (Van Der Valk & Rozemeijer, 2009).*

Above figure shows the procurement process according to Van Der Valk & Rozemeijer (2009). An organization should decide the necessity for purchase before starting the procurement process. After being confirmed about the need for purchasing, the procurement team list out the specification of the needed goods/services and look for convenient suppliers. After listing out several prospective suppliers, the responsible member of the procurement team sends a request for information to all of the listed suppliers and based on

suppliers' feedback, the procurement team finalizes the vendors. After that, an agreement is signed between the buyer and supplier where the responsibilities of both parties are stated (Lysons & Farrington, 2006). At the ordering stage procurement team determines the order quantity and delivery time. The purchasing functions' job is to track and manage the ordered booking after it has been ordered. As a final task, the whole purchasing process as well as the result of a specific order should be followed and evaluated (Weele, 2005).

Combining automation, information and communication technology to support procurement can be defined as procurement 4.0 (Nicoletti, 2018). According to (Choi et al., 2021), artificial intelligence (AI), robotics, internet of things (IoT), blockchain, 3D printing, digital twins, and augmented reality (AR) are the technologies that are leading the industry 4.0. Therefore, procurement 4.0 means employing these technologies in any procurement function. Based on the utilization of technologies Klünder et al. (2019), grouped Procurement 4.0 technologies into four technology domains, which are presented in the figure below:

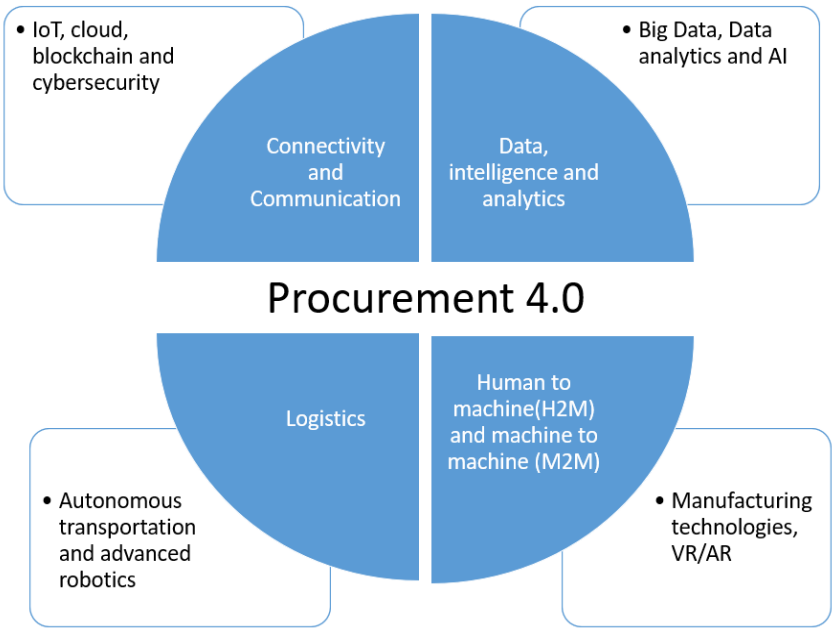

Figure 9. *Technologies in Procurement 4.0 (Klünder et al. 2019).*

Figure 9, presents four domains of Procurement 4.0 and respective technologies for each domain. Blockchain technology is a strong accelerator of the procurement industry's digital revolution. A shared database is needed between different parties engaged in a procurement process. According to Nicoletti (2018), blockchain not only help to improve

the visibility of shared data but also offer an authentic communication channel to support the business supply ecosystem.

Internet of things (IoT) is a rapidly emerging class of sensing and data-capturing devices, that helps supply chain decision-makers by providing real-time data. A GPS device along with sensor data for goods in transit would allow the buyer to discover the location and condition of the shipment which would help the procurement team to mitigate the transportation risk (Osmonbekov & Johnston, 2018). IoT can help in developing an automatic procurement reordering system by providing current material stock data (Rejeb et al., 2018).

Any business organization generates a significant amount of unstructured data. By implementing big data and analytics business organizations can transform unstructured into helpful data (Rejeb et al., 2018). According to Petersen et al. (2005), big data analytics can be implemented for supplier evaluation, cost modeling, cost reduction, category management and spend analysis.

Cui et al. (2021) stated that artificial intelligence (AI) can be applied in two distinct ways for greater intelligence in sourcing. Automation of the procurement process is considered as the first one and the second one is using AI-powered tools for collecting and analyzing market strategies. Papa et al. (2019) presented that an international energy corporation reduced its procurement labor costs by 39% with the help of AI-powered chatbots by automating the procurement process. However, purchasing management may also employ AI to find new suppliers (Cui et al., 2021).

The implication of procurement 4.0 can be derived from electronic procurement (eProcurement). Particularly the idea of eProcurement can be described as the emplication of internet technologies to accelerate the operational procurement processes, such as sourcing activities like web-based supplier searching, bidding, and ordering (Tai et al., 2010). In the area of eProcurement, while eAuctions, eTenders, and RFx tools work as eSourcing tools (Teich et al., 2004; De Boer et al., 2002), eCatalogs, eInvoicing, and workflow management applications are categorized as eSupply tools (Puschmann & Alt, 2005).

It can be summarized that procurement 4.0 is the future of procurement management. With the utilization of Industry, 4.0 technologies modern procurement offers many benefits to business organizations from sourcing new suppliers to enhancing customer satisfaction.

It is important to define more precise actions to better understand the potential benefits of new technologies in procurement. The profitability and effectiveness of procurement

operations strongly rely on the presence of adequate vendors. Therefore, the procurement team must devote resources and evaluate sustainable technologies for supplier market analysis.

3.2 Supplier Market Analysis

Understanding the market dynamics of suppliers, as well as their strengths, weaknesses, opportunities, and threats is a crucial component of procurement management. The supply market analysis that intends to comprehend a given market and its aspects including trends, main suppliers and competition can be used to get this knowledge. Van Weele (2010) stated that supplier market analysis can be defined as collecting and analyzing important supply chain information that impacts procurement decisions. Keith et al. (2015), considered supplier market study as the basis of the sourcing strategy. To a large extent, a comprehensive understanding of the supplier's market determines the success of purchasing process.

Lobermeyer and Kotzab (2010), discussed a framework named SMA-framework (Supply Market Analysis framework) which presents various factors that need to be taken into account when executing a supplier market analysis. The SMA framework which is presented in figure 10, has categorized different factors into existing supplier markets; products, new markets, and buyer markets.

Figure 10. *The SMA framework (Lobermeyer and Kotzab, 2010).*

Figure 10, presents the supplier market analysis framework offered by Lobermeyer and Kotzab (2010). In this SMA framework, existing supplier market analysis consists of key supplier evaluation, external analysis, and market environment analysis. According to Lobermeyer and Kotzab (2010), existing supplier market analysis starts with evaluating main market players and their strengths and weaknesses. However, industry trends, supply market size, and supplier market share are also important for existing supplier market analysis. Supplier performance data analysis is one of the methods of existing supplier analysis.

Cost-price of the products, quality, technological, and material development belong to the products division. Jones and Barner (2015) mentioned cost-price analysis as a method of product analysis that includes investigation of direct cost, indirect cost, and profit margin. Lobermeyer and Kotzab (2010) argued to consider product innovation when analyzing product characteristics.

On the other hand, buyers' behavior and competition are examined in the buyer markets segment. Buyer's behavior analysis does not only include buying volumes fact analyzing, and product switching cost analysis but also includes forward and backward integration.

In the new markets division, the sourcing manager analyses the opportunity for new materials or products and new geographic supplier markets. Because of disruption risks and uncertainty, companies are focusing on international sourcing. As a result of finding this alternative sources of products or services are becoming more essential for business sustainability. Brannestam and Josefsson (2018), cited the State of Queensland (2017) stated that to establish less risky and more competitive supplier markets, buying organizations should focus on substitutes and supplements of materials and searching for new suppliers. The process of searching for new suppliers is divided into two phases; the collect function and the search function (Kang et al., 2011). In the collect function, companies mainly list out the capabilities needed from the supplier of a specific product/service. After specifying supplier requirements, supplier searching starts. In the supplier searching phase, buying organizations analyze their sourcing of information regarding supplier companies. In the past era, advertising in trade publications, sales literature, newspaper publication, and trade associations were used as a source of supplier information (Moriarty & Spekman, 1984), and searching for new suppliers was mainly hand-operated. Although after revolutionary improvement in the internet, companies prefer to use electronic media as sources of supplier information, discovering new suppliers by reviewing electronic media is also a hand-operated process. Once a list of suppliers is discovered then comes analyzing and selecting from the new supplier's list.

3.3 Supplier Selection Process

Supplier selection is considered as the first step of strategic sourcing. According to Solanki et al. (2016), supplier selection is a decision-making process by which prospective vendors are analyzed, assessed, and selected to take part in an organization's supply chain. Due to taking considering a range of factors, evaluating, and selecting suppliers become a complex and critical decision-making issue (Omurca, 2013 & Humphreys et al., 2003). A supplier selection process which is adapted from Solanki et al. (2016), is presented below,

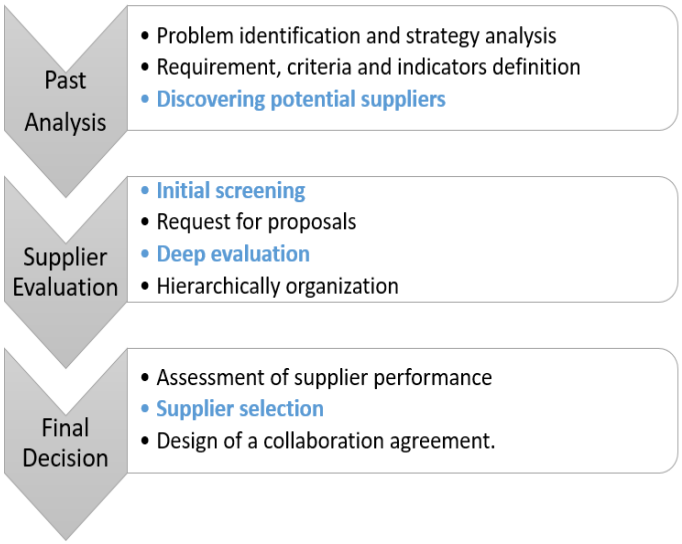

Figure 11. *Supplier selection process (Solanki et al., 2016).*

Figure 11 briefly describes the supplier selection process (Solanki et al., 2016), and highlights the task needed for new supplier market analysis. The supplier selection process starts with past analysis which includes discovering potential suppliers, then initial screening and deep evaluation are done under supplier evaluation, and in the end, suppliers are selected in the final decision stage.

Price, quality, and time were the primary three considerations at the beginning of supplier selection history. Researchers described the supplier selection process as a multi-criterion decision-making (MCDM) process (Vahdani et al., 2012; Cavalcante et al., 2019; Su and Chen 2018). Multi-criteria decision-making process works by stating essential requirements and then sorting out the best-fitted suppliers based on the predefined re-

quirement. A list of potential vendors is needed though before any supplier can be chosen. As a result, in an extensive supplier selection process, prospective suppliers are first found, screened, and then evaluated.

Based on the discussion above, the new market factor of supplier market analysis starts with discovering new potential suppliers, and then analyzing and selection processes take place. After examining the new market factor of supplier market analysis with Figure 11 of supplier selection process, the below picture can be drawn for new supplier market analysis.

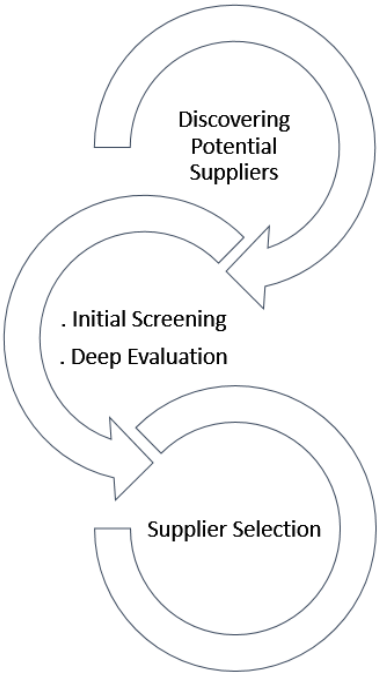

Figure 12. *New supplier market analysis modified from the supplier selection process of Solanki et al., (2016).*

Figure 12 offers the framework for new supplier market analysis. As discovering new potential suppliers, initial screening and deep evaluation impacts the overall result of supplier selection and supplier market analysis, business management and researchers are emphasizing the use of artificial intelligence for analysing new supplier market.

3.4 Artificial Intelligence

Artificial Intelligence (AI) has become the most influential among Industry 4.0 technologies for the modern business era. Researchers of every branch are working on how to maximize the efficiency of their specific tasks by implementing artificial intelligence. AI

carries a long history dating back many years. McCarthy used the term “artificial intelligence” at the Dartmouth conference in 1956, which sparked a coordinated effort in this research area that is still going on today (McCarthy et al., 2006). Researchers define artificial intelligence as a part of computer science that focuses on intelligent activities performed by a computer. According to McCarthy (2020), artificial intelligence is the science and engineering of creating intelligent machines, mainly intelligent computer programs for understanding human intelligence in repeating tasks by using computers. Hilker (1986), defined artificial intelligence as a field of computer science that allows a computer to execute intelligent activities including recognition, reasoning, and learning. According to Simon (2019), basic technologies that have been bounded by artificial technologies are;

1. Machine Learning

Due to its capacity to automate complicated activities and generate predictions based on data, machine learning is a rapidly expanding area that has become more popular in recent years. Machine learning is a discipline of computer science that is concerned with computer programs that learn from past experience and thus improve performance over time (Russell & Norvig, 1995). According to Li (2014), machine learning and predictive analytics are closely related since academics frequently use machine learning techniques to evaluate current data to estimate the likelihood of uncertain outcomes. Artificial neural networks, decision trees, support vector machines, naive Bayes, and *K*-means clustering are the most common machine learning algorithms. Depending on the efficiency, machine learning algorithms may generate automated outcomes that closely resemble decisions that a person in a similar situation would have made, as a reason of this machine learning is considered as a part of artificial intelligence.

2. Deep Learning

One of the most impressive machine learning methods is deep learning, and it has had considerable success in a variety of applications including text understanding, audio recognition, and image analysis (Zhang et al., 2018). Deep learning can be defined as a group of machine learning approaches that make use of multiple non-linear information processing layers to extract and transform either supervised or unsupervised features and to analyze and classify patterns (Deng, 2014). Deep learning algorithms are pilled in a hierarchy of increasing complexity and abstraction, as opposed to conventional machine learning algorithms, which are linear. The first layer receives the sensory data

and each layer's output serves as the input for the next layer (Najafabadi et al., 2015). As a result of this, deep learning becomes one of the most significant technologies for big data analysis solutions (Chen & Lin, 2014). According to Zhang et al. (2018), the four most classic deep learning models which have been used for big data feature learning are, stacked auto-encoder, deep belief network, convolutional neural network, and recurrent neural network.

3. Computer Vision

The area of computer science that is concerned with measuring the visual information content of digital images is called computer vision (CV) (Szeliski, 2011). Computer vision trains machines on a lot of visual data using pattern recognition techniques, after then the machine or computer detects patterns in the items it has labeled and labeled. Visual examination, part recognition, process monitoring, and autonomous guiding systems are some of the industrial applications of computer vision (Golnabi & Asadpour, 2007).

4. Natural Language Processing

Natural language processing (NLP) has become a potent tool for evaluating unstructured text data in several functions of today's supply chain. A set of approaches that allow computers to examine, try to interpret, and generate one or more human languages is called natural language processing (Otter et al., 2021). It employs several different techniques such as question answering, machine translation, sentiment analysis, named entity identification, and text classification. Sentiment analysis is considered as one of the significant subfields of natural language processing, and it refers to the finding, extraction, and classification of emotions, feelings, and beliefs observed in unstructured data (Liu & Zhang, 2012). Sentiment analysis has essential applications in marketing and sentiment analysis. Another important NLP task is named entity recognition, which includes locating and categorizing named entities in text, such as individuals, groups, and places (Mikheev et al., 1999). In recent research, different deep learning models for both sentiment analysis and named entity recognition have been the focus, and as a result of this, natural language processing has been implemented in different supply chain subfunctions.

3.5 Artificial Intelligence in Supplier Market Analysis

Artificial intelligence is a growing trend in procurement functions from identifying new suppliers, evaluating supplier performance, assessing supplier risk and finally selecting suppliers. For discovering new suppliers, analysing potentialities, initial screening, and supplier selection numerous multi-criteria decision-making methods have been discussed in the past research including case-based reasoning (CBR), analytic network process (ANP), analytic hierarchy process (AHP), fuzzy set theory, artificial neural networks (ANNs), and multi-objective programming.

Few scholars have focused on using artificial intelligence in supplier searching, despite the fact that many existing studies emphasize the use of AI in supplier performance evaluation and supplier selection. Intelligent software agents were suggested by Nissen & Sengupta (2006), to automate the process of finding potential suppliers through online catalogs, assessing suppliers in terms of a variety of criteria, identifying qualified suppliers, and completing the purchase order. The results of this study present that incorporating software agents in supply chains have significant potential for improving the performance of procurement tasks. While conducting research Nissen & Sengupta (2006), compared the decision making level of computer agents and humans based on the ambiguity level of tasks. The research found that software agents outperformed human agents in low and moderate ambiguity tasks for supplier discovery, although the effectiveness of software agents is limited in high ambiguity tasks.

Haanpää (2019), applied natural language processing (NLP) in the field of supplier discovery, especially for extracting information from text-based purchase order descriptions for identifying potential suppliers. In this thesis, fastText and HDBScan, two machine learning techniques were utilized to successfully mine supplier transaction data from procurement ERP systems. FastText was applied for creating word vectorizations and HDBScan was used for clustering word vectors. The outcome demonstrated that fastText and HDBScan were effective at obtaining relevant findings and uncovering new suppliers from text data. The practical implications of this paper are that companies that have plenty of procurement data saved in their data warehouse may apply natural language processing (NLP) techniques to extract information from text-based purchase order descriptions to discover potential suppliers. However, the lack of descriptive information in the purchase order descriptions limits the algorithms' accuracy.

In order to generate sophisticated profiles of present and prospective consumers, B2B organizations can utilize artificial intelligence (AI) to analyze both structured and unstructured customer-generated data including demographic and web browsing history (Meire

et al., 2017, Baesens et al., 2004). Meire et al. (2017), show that by implementing a data mining approach to social media, the sales process can be enhanced by discovering potential customers. Søilen (2016), discussed that a massive amount of social media data can be gathered and analyzed by AI to produce insightful data for B2B businesses about their consumers, including their preferences, online behaviors, requirements, and attitudes. Data mining of social media and analytics can also be applied for discovering potential suppliers. Kang et al. (2011), proposed an eXtensible Dynamic Form (XDF) architecture for automating the supplier discovery process and making it more efficient. The main objective of implementing XDF is to gather supplier profiles in the supplier discovery stage. J. H. Lee et al. (2014), discussed a semantic web-based supplier discovery process. The system uses ontology building, reasoning, and semantic matching to represent the buyer's requirements and the supplier's capability information. Implementing semantic matching results in increasing the number of suppliers in the supplier discovery stage and allowing buyers to leverage suppliers' power.

Lee & Ou-Yang (2009), offered a forecasting model that used ANNs for helping decision makers in the supplier selection process by offering negotiation and recommendations support. The findings of this paper demonstrate that the artificial neural network method can be applied as an adaptive tool for assisting difficult and sophisticated supplier selection processes in order to accomplish the buyer's desired outcome.

Vahdani et al. (2012) presented an efficient artificial intelligence method to enhance procurement decision-making by predicting the supplier's performance in the cosmetics industry. The result of this paper introduced a LLNF model which is trained by a locally linear model tree (LOLIMOT) learning algorithm.

Omurca (2013), tried to develop an intelligent system that is a hybridization of fuzzy c-means (FCM) and rough set theory (RST) techniques for supplier evaluation, selection, and development. Using this intelligent system suppliers are first clustered using the FCM algorithm, and then the outputs of clusters are shown by their early versions used to label the clusters. The main features or core assessment criteria of the vendors are identified at the forthcoming modeling stage by employing RST and deriving selection rules for classifying the data.

Cavalcante et al. (2019), generated a hybrid method that combines machine learning and simulation to support data-driven decision-making in a resilient supplier selection process by analyzing risk rating of supplier performance under unpredictable conditions. The findings of the research present how and when to create digital supply chain twins, which boost resilience by combining simulation and machine learning.

Su and Chen (2018) presented a Twitter Enabled Supplier Status Assessment (TESSA) software based on text mining that can help companies in global supplier selection operations by identifying possible risks. The most common microblog Twitter gets utilized by TESSA to extract necessary data regarding a target supplier before using text mining to determine any possible risk or uncertainty related to that supplier. Purchasing organizations can be benefited by implementing this TESSA tool in this big data era.

As a way to improve supplier collaboration, Li et al. (2018), established a semantic-augmented MAS (OMAS) architecture to remove business interoperability problems in shipyards. A high-level ontology (HLMO4MAS) that is part of OMAS enables intelligent computer-aided supplier selection and supplier resource connection. Whereas, a potential support vector machine combined with a decision tree to handle supplier selection problems like multiclass classification and feature selection is introduced by Guo et al (2009).

Humphreys et al. (2002) discussed a knowledge-based system (KBS), to help manufacturing organizations in response to make or buy decisions by assessing supplier performance, analyzing internal and external capabilities, and total cost of ownership analysis. The result of this research shows that this knowledge-based system (KBS) can help the procurement team for improving cooperation between suppliers and purchasing team members by offering feedback to vendors and continuously reviewing vendors against performance benchmarks. Moghadam et al. (2008) presented a unique idea of choosing optimal suppliers depending on the forecasted demand and material planning with the help of an intelligent tool that used a fuzzy neural network and a genetic algorithm.

Overall, in the area of supplier market analysis, supplier selection has received a lot of academic attention compared to supplier discovery. In the table below, current AI technologies applicable for various objective of supplier market analysis based on the above study is listed down:

Table 3. *Artificial Technologies (AI) in supplier market analysis.*

AI Technology	**Purpose in Supplier Market**	**Study Reference**	**Context**
Intelligent software agents	Supplier discovery and assessment	Nissen & Sengupta (2006)	Supplier discovery
Natural language processing	Supplier information extraction and text-based supplier discovery	Haanpää (2019)	Supplier discovery
Data Mining and Analytics	Customer analysing for B2B organizations	Meire et al. (2017)	Customer discovery
Data Mining and Analytics	Discovering potential suppliers	Kang et al. (2011)	Supplier discovery
Semantic Analysis	New supplier finding	J. H. Lee et al. (2014)	Supplier discovery
Artificial neural network	Assisting supplier selection process	Lee & Ou-Yang (2009)	Supplier selection
Locally linear neuro-fuzzy (LLNF) model	Supplier performance prediction	Vahdani et al. (2012)	Supplier evaluation
Fuzzy c means	Supplier evaluation and selection	Omurca (2013)	Supplier evaluation and selection
Machine Learning	Supplier selection	Cavalcante et al. (2019)	Supplier selection
Intelligent softawre agents	Risk assessment in global supplier selection	Su and Chen (2018)	Supplier selection
Big data analysis	Supplier collaboration and resource connection	Li et al (2018)	Supplier selection

AI Technology	Purpose in Supplier Market	Study Reference	Context
Support vector machine	Supplier selection	Guo et al. (2009)	Supplier selection
Knowledge-based system	Supplier performance analysis	Humphreys et al. (2003)	Supplier evaluation
Artificial neural network	Supplier selection	Moghadam et al. (2008)	Supplier selection

Table 3 illustrates the AI technologies that have been primarily utilized in supplier market analysis. The left column of the table mentions the name of AI technologies featured in the literature and the right column mentions the context of the respective literature. Artificial neural networks, and machine learning are commonly employed in the supplier selection process. On the other hand, for supplier discovery processes natural language processing, text mining, and intelligent software agents are commonly implemented.

4. EMPIRICAL RESULTS

The details of employing artificial intelligence in the supplier market analysis, especially for every step of the new supplier market analysis process are clarified in this chapter. This chapter includes four sub-chapters; 4.1 AI for supplier discovery, 4.2 AI for supplier screening and evaluation, 4.3 AI for supplier selection, and 4.4 Results. In the first three sub-chapters, empirical data from the expert interviews and previous studies will be analyzed, and in the last sub-chapter based on the analysis, the resulting framework will be built and discussed.

4.1 AI for Supplier Discovery

Business organizations are continually searching for new strategies to maintain a competitive edge in this time of rapid globalization, dynamic market shifts, and evolving consumer choices. The idea of ”new supplier discovery” is one of the essential tactics that have evolved in the procurement landscape. This proactive method of vendor identification and engagement has gained substantial attention due to its potential to unlock unprecedented opportunities, enhance operation effectiveness, and spur strategic growth. The emergence of the digital age resulted in an explosion of information from various sources, including websites, social media, business reports, and more. The analysis of this vast volume of both structured and unstructured data aimed at discovering new suppliers introduces a significant challenge, given the consideration of time consumption and result precision. In response, procurement technology leaders are engaged in research endeavors focused on utilizing cutting-edge technologies to optimize and expedite this intricate task.

The integration of AI tools into identifying potential suppliers process is considered as a nascent and innovative approach. Five industry experts were the subjects of a research interview to elucidate the implication of AI tools in supplier market analysis. Responses to the interviews are visualized in the below table:

Table 4. *Interview responses of AI used for supplier discovery.*

Inter-viewee	Interviewee Role	Background Industry	Reported Implementation of AI Tools for Supplier Discovery
A1	Product Specialist	Procurement Solutions Provider	Web Scrapping, and Natural Language Processing
A2	Senior Consultant	Supply Chain Solutions Providing	Natural Language Processing and Semantic Analysis
B1	Category Specialist	Machinery and Equipment Manufacturing Company	No
B2	Procurement Analyst	Manufacturing Company	No
C1	Professor	University	No

Table 4 presents the empirical data of implemented AI tools for discovering new suppliers. From the table it is visible thta two respondents professionals; one of them working in procurement solutions providing company and another one in supply chain solutions providing company reported that applying AI techniques for searching new suppliers is familiar to them and confirmed the adoption of AI-enabled techniques within their respective firms for supplier discovery purposes. This adoption of AI indicates a progressive shift away from the conventional supplier identification process. Three respondents, on the other hand, affirmed that their organizations have not yet implemented any kind of AI tool in their supplier-finding process. Instead, these entities continue to adhere to traditional ways of procuring information pertinent to new supplier identification. In accordance with expert perspectives and the extant corpus of prior research, the tripartite aspects of supplier discovery that are streamlined by the incorporation of AI methodologies are the unveiling of hidden opportunities, unleashing insights from textual data, and unraveling contextual meanings.

Web Scraping: Unveiling Hidden Opportunities

Web scraping is an AI technique applied for extracting information from websites, and it has become an essential tool in the arsenal of current procurement professionals. Web scrapping automates the extraction of supplier-related data from many online sources, speeding up supplier discovery and letting businesses cast a wider net when searching for potential partners (Ansel, 2023). The potential of web scrapping in supplier discovery is reflected in the following answer: *"Our AI generated supplier discovery solution used web scrapping for getting crucial information of suppliers like product specification, supplier rating and so on." (A1)* Web scrapping allows the acquisition of information from numerous supplier websites regarding products offering, pricing structures, and customer reviews from various supplier websites. After being aggregated and analyzed, this data

offers invaluable insights into the capabilities and competitiveness of different supplies. Web scraping also makes it possible to watch the market trends and changes in supplier dynamics, allowing organizations to make wise decisions based on current knowledge (Ansel, 2023).

Natural Language Processing: Unleashing Insights from Textual Data

The way that procurement organizations extract insights from textual data has been transformed by NLP, a field of artificial intelligence that focuses on the concentrates on interaction between computers and human languages. In the context of supplier discovery, NLP is capable of going through a vast database of supplier-related documents, including product descriptions, contracts, and customer reviews, to extract key information and categorize it systematically (Haanpää, 2019). According to interviewee A2, ”*NLP can be used to assess customer perceptions of different suppliers, and this can actually help organizations in spotting potential prospects for cooperation.”* For describing the benefits of NLP in supplier discovery interviewee A1 replied, ”*Utilizing NLP algorithms may contribute to identifying and categorizing vendors based on their offering related attributes.”* These potentials of NLP enable procurement organizations to develop a comprehensive supplier database, advancing an effective and focused supplier selection.

Semantic Analysis: Unravelling Contextual Meaning

Semantic Analysis is an AI technique that delves into the contextual meanings of words and phrases, and this AI tool has elevated supplier discovery to a new level of precision (J. H. Lee et al. 2014). Interviewee A2 said, ”In some cases *semantic analysis is applied with NLP for finding differences in supplier capabilities and offerings*.” Furthermore, A2 also stated, ”*Semantic analysis may apply to map supplier competencies to particular organizational requirements.”* These kinds of potentialities allows organizations to make choices that resonate with their strategic objectives and values.

4.2 AI for Supplier Screening and Deep Evaluation

Once a thorough collection of supplier-related data from different sources has been completed, preliminary screening and evaluation of the collected data becomes an es-

sential application. The widespread adoption of different AI techniques for supplier screening and evaluation in contemporary procurement methods has grown more and more frequent. Respondents' industry experts confirm a notable familiarity with the implementation of AI tools for the aspects of supplier data filtration, screening, and evaluation. Their responses are presented below:

Table 5. *Interview responses of AI used for supplier screening and evaluation.*

Interviewee	Interviewee Role	Background Industry	Reported Implementation of AI Tools for Supplier Screening and Evaluation
1	Product Specialist	Procurement Solutions Provider	Collaborative Filtering, and Intelligent Software Agents
2	Senior Consultant	Supply Chain Solutions Providing	Collaborative Filtering, and Data Mining
3	Category Specialist	Machinery and Equipment Manufacturing Company	Intelligent Software System
4	Procurement Analyst	Manufacturing Company	Intelligent Software System
5	Professor	University	Collaborative Filtering and Data Mining

Table 5 reports the interviewees responses regard to supplier screening and evaluation stage. From the table it is understanadble that procurement and supply chain solution providing companies are applying collaborative filtering, and data mining with their intelligent software systems for supplier screening and evaluation, whereas procurement team of manufacturing companies mainly rely on intelligent software system for intitial screening and evaluation of supplier data. The infusion of AI technologies empowers organizations to efficiently navigate through large and complex datasets, make data-driven decisions, and harness collective insights. As AI continues to evolve, its potential to amplify the efficacy of supplier screening, and evaluation remains an invaluable asset in the dynamic landscape of the modern procurement process. Central to this paradigm are three discernible domains within supplier screening, and evaluation wherein AI exerts substantial influence – unearthing hidden gems, elevating decision-making, and harnessing collective intelligence.

Data Mining: Unearthing Hidden Gems

Discovering valuable patterns, correlations, information, or knowledge from large and complex datasets is called data mining (M. Chen et al., 1996). Interviewee C1 responded, ”*Data mining might considered as the core of today’s supplier screening and evaluation and by applying data mining methodology, a huge amount of datasets can be explored and analyzed in order to find patterns, correlations, and trends that could other-*

wise remain undiscovered." In regards to the benefits of data mining respondent A1 discussed that "*With the help of data mining technology we can look deeper, and extract critical datasets from diverse sources such as supplier profiles, transaction histories, and financial records."* Therefore it can be stated that the procurement team can determine vendors who have a record of sustained performance, financial stability, and adherence to quality standards through the use of data mining techniques. In addition, data mining facilitates proactive risk reduction by enabling procurement professionals to spot potential red flags. "*Data mining can determine abrupt shifts in business operations and can stimulate signals, that require further study before establishing supplier partnerships* (C1)." Based on the above discussion it can be said that data mining does not only allow the procurement team to look deeper into suppliers profiles and capabilities but also to generate signals of unexpected risks.

Intelligent Software Systems: Elevating Decision-Making

Intelligent software systems present a base for AI-driven supplier screening and evaluation (Su and Chen, 2018). Interviewee B1 stated, "*Intelligent Software Systems help us build an effective supplier screening by quickly analyzing supplier credentials against predetermined criteria."* As a result, intelligent software systems are time efficient in decision making. B2 responded that "*The software system we are using can assess our supplier's performance across various dimensions, like product quality, and lead times"*. So, an intelligent software system offers continuous monitoring that facilitates ongoing evaluation and guarantees that supplier relationships remain aligned with organizational objectives. Moreover, intelligent software systems can facilitate predictive analytics, and accelerate the identification of optimal partners.

Collaborative Filtering: Harnessing Collective Intelligence

Collaborative filtering is an AI tool that is used in recommendation systems and data analysis to predict a user's preferences or interests by leveraging the preferences and behaviors of a group of similar users (Herlocker et al., 2000). It works based on the idea that those who have agreed in the past tend to agree again in the future. Interview A2 discussed "*Suppliers that are consistent with the preferences and experiences of similar businesses can be identified by collaborative filtering by examining historical data from various sources, like customer feedback, reviews, and industry assessments*". According to C1 "*Collaborative filtering is a powerful method for enhancing supplier screening and evaluation*". With the help of this approach, procurement professionals are able to utilize

collective intelligence and make more informed decisions based on the successes and challenges of others. For describing the implications of collaborative filtering A1 said ”*In case of evaluating suppliers in industries where intangibles such as reputation and customer satisfaction play a pivotal role, collaborative filtering is very efficient”.* Business organizations can gain a comprehensive understanding of prospective suppliers by considering the experiences of peers and industry experts and mitigating the risks associated with unproven partnerships.

4.3 AI for Supplier Selection

From Figure 11, supplier selection is defined as the last stage of new supplier market analysis. After the thorough compilation of extensive supplier market data, the procurement team then conducts the initial screening and evaluation, which leads to the final supplier selection stage. Notably, a distinct trend has emerged reflecting a positive direction for the use of AI-facilitated supplier selection technology. The application of AI technologies in the supplier selection phase within the larger scope of the procurement management process is widely acknowledged among the cohort of responding procurement experts. AI methodologies empower procurement to deal with complexity, derive beneficial insights, and make informed decisions aimed at improving efficiency and competitiveness. The positive aspects linked to the adoption of AI technologies for supplier selection activities are of noticeably significant importance. Mitigating risks, making decisions quickly, and improving effectiveness are the notable advantages cited by the respondents. Interviewee responses regarding leveraging AI for supplier selection are summarised below:

Table 6. *Interview responses of leveraging AI for supplier selection.*

Interviewee	Interviewee Role	Background Industry	Reported Implementation of AI Tools for Supplier Selection
1	Product Specialist	Procurement Solutions Provider	Intelligent Supplier Scoring, Artificial Neural Network, and Data Analysis
2	Senior Consultant	Supply Chain Solutions Providing	Intelligent Supplier Scoring, Artificial Neural Network, and Data Analysis
3	Category Specialist	Machinery and Equipment Manufacturing Company	Data Analysis
4	Procurement Analyst	Manufacturing Company	Intelligent Supplier Scoring and Data Analysis
5	Professor	University	Artificial Neural Network and Data Analysis

Table 6 presents the interview data of applying AI for supplier selection process. From the table, it can be stated that data analysis is the most common practicing AI tools for supplier selection. However, Table 6 also shows that intelligent supplier scoring system and artificial neural networks are also applied for supplier selection. Based on the expert interviews and prior researches, three most important aspects of implementing AI in the supplier selection process are unveiling hidden insights, quantifying supplier value, and emulating human decision making

Data Analysis: Unveiling Hidden Insights

At the center of AI-driven supplier selection lies the powerful AI tools of data analytics. To extract meaningful patterns, trends, and correlations from data, large and diverse data sets must be systematically analyzed. About data analysis C1 said, *" Data analysis allows the procurement team to build up an instinctive decision-making framework and foundation of supplier selection based on a wide range of data sources."* Data sets encompass, but are not limited to, historic supplier performance data, evolving market fluctuations, and important insights based on customer feedback. Respondent procurement expert B1 claimed, *"Recent time heavy machineries manufacturing companies like us are working on building an evidence-based supplier selection process for making strategic decisions, and data analytics make it easy to build an evidence-based supplier selection process."* However, B2 responded, "*Data analytics can be used for an extensive assessment of supplier attributes, like product quality, cost-efficiency, delivery, and innovation performance."* The combined effect of these multidimensional views lets enterprises come up with decisions that are not only objective but also quantitative in the realm of supplier selection. Furthermore, incorporating predictive analytics supported by data analysis, provides a prospective viewpoint on future supplier conduct, improving the risk assessment for proactive decision-making activities.

Intelligent Supplier Scoring: Quantifying Supplier Value

Intelligent Supplier Scoring applies AI algorithms, in order to present possible suppliers quantitative scores depending on the established criteria and key performance indicators (Choy et al., 2002). This strategy promises a structured and homogeneous evaluation process, permitting objective supplier assessments. B2 stated that "*Supplier scoring strategy may consider a number of facts like supplier firm's financial condition, product sustainability, and customer review, and intelligent supplier scoring accelerates the supplier selection process by evaluating the cross sectional data."* Besides accelerating

the evaluation process, this technique fosters accountability as well as transparency within the decision-making framework. In response to the question of the benefits of intelligent supplier scoring, A1 said ”Intilligent supplier scoring helps buyer companies to allocate resources more effectively by selecting more significantly potential suppliers.” This AI method further promotes the establishment of supplier partnerships that suit the organization’s broader strategic goals.

Artificial Neural Networks: Emulating Human Decision-Making

Artificial Neural Networks (ANNs), which work based on the neural architecture of the human brain, are an essential part of the AI-driven supplier selection process (Golmohammadi et al., 2009). For answering the implication of ANNs interviewee C1 replied that ”*Procurement team needs to train ANNs on previous supplier data, that will empower procurement organizations for developing predictive models that anticipate supplier performance and assist the supplier selection process.”* Interviewee A2 replied, ”*ANNS make it easier to recognize hidden patterns as well as complicated interdependencies that are very difficult to detect with manual analytics procedures.”* As a result, ANNs offer higher precision in the supplier selection process, as well as mitigate risk and bias.

4.4 Summarizing the Results: AI-Powered New Supplier Market Analysis

The inclusion of AI in supplier market analysis shows a significant development that handles the difficulties that corporate organizations are facing resulting from increased globalization, market shifting, and changing customer choices. By synthesizing the key insights of the previous sections, this part portrays the future of new supplier market analysis with the help of AI technologies. The literature review pictures three steps of new supplier market analysis: discovering potential suppliers, initial screening and deep evaluation, and supplier selection. As a consequence, new supplier market analysis can be stated as a process that starts with discovering potential suppliers' data by extracting a large amount of data set from various sources, then initial screening and deep evaluation of this vast amount of data become needed, and finally, potential suppliers are selected. Based on the expert interviews, web scraping, NLP, and semantic analysis are the AI tools impacting the supplier discovery process, whereas data mining, intelligent software systems, and collaborative filtering are the AI methods facilitating the initial screening and deep evaluation of supplier data, and data analytics, intelligent supplier scoring and artificial neural networks are helping for supplier selection decision-making. Hence, after

adding responding AI tools in the specific segments of the new supplier market analysis, AI-powered new supplier market can be presented as:

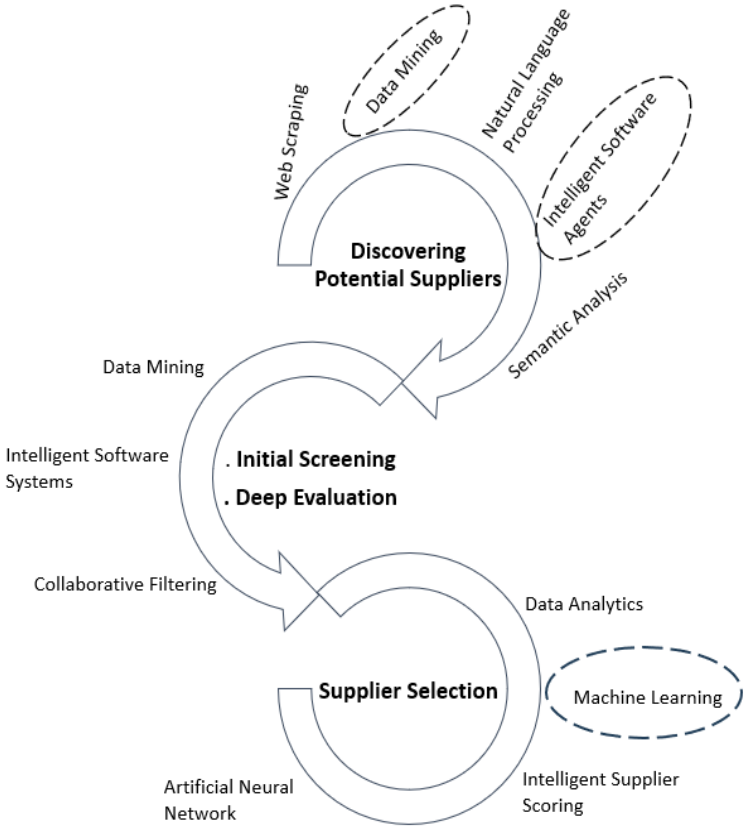

Figure 13. *AI-powered new supplier market analysis.*

Figure 13 illustrates the framework of AI driven new supplier market analysis. This figure is built upon the empirical (interview) data and literature review data (Table 3). The AI technologies that are benchmarked supported by both, empirical data and literature review, except the dotted circulated part. Although, applications of data mining and intelligent software agents (circulated by dotted line) for supplier discovery were discussed in past literature, during the research interview procurement experts did not mention these two technologies for supplier discovery purposes. However, one surprising difference in the findings of the literature review and empirical data is that although existing research highlights on the use of machine learning algorithm for supplier selection, the interview data do not recognise it.

AI technologies facilitating data-driven supplier-finding process is a response to the data explosion in the digital age. Nowadays, several sources generate a very vast amount of supplier data and the efficiency of discovering potential suppliers depends on the efficient

extracting of data from these sources. Web scrapping is a notable AI tool that expands the scope and speed of supplier discovery by facilitating automated extraction of source-related data from online sources like different websites. NLP streamlines the study of textual data and enhances decision-making by detecting and deriving necessary details from available supplier documents. However, semantic analysis boosts the accuracy of supplier discovery by identifying minor differences in supplier capabilities and aligning them with particular business standards. This integration of AI technologies in the supplier discovery process not only accelerates the process but also makes the supplier identification process more precise.

Preliminary supplier screening and deep evaluation extensively rely on AI technologies. In this stage, AI technologies help the organization to navigate the vast datasets gained from the supplier discovery stage more efficiently, make data-driven decisions, and leverage collective insights. Data mining accelerates revealing hidden patterns of a large data set extracted from various sources for making informed decisions. Intelligent software systems are used for analyzing real-time vendor credentials that assist efficient and quick supplier screening. However, collaborative filtering advances supplier evaluation by utilizing collective intelligence for forecasting suppliers' behaviors based on experience.

The concluding phase of supplier management, particularly the intricate aspect of supplier selection has been influenced significantly by artificial intelligence (AI), which has a pioneering function. With the help of data analytics, intelligent supplier scoring, and artificial neural networks, AI permits procurement organizations to make decisions from selected suppliers based on quantitative analysis and empirical evidence. Expert interviews and literature studies emphasized the significant positive effects of AI integration, including lowering risk, fast decision-making, and better efficiency. AI-driven supplier selection requires utilizing data analytics, which paves the way for evidence-based choices by analyzing multiple data sets. Intelligent supplier scoring establishes a structured evaluation procedure by quantifying supplier value that aligns with organizational goals. By spotting complex patterns and links in supplier data, ANNs enhance the precision of supplier selection.

Following that, the incorporation of AI in supplier market analysis is transforming procurement management into competitive practices in a continuously changing business environment. AI improves decision-making, risk mitigation, and precision by uncovering opportunities in supplier discovery, as well as by implementing informed evaluation and

quantitative selection. By harnessing AI's power, procurement management can accomplish strategic growth, sustainable partnerships, and excellence in supplier relationships.

5. DISCUSSION AND CONCLUSION

5.1 Results in Relation to the Literature

The aim of this study was to investigate various artificial intelligence methods impacting the supply chain management with the framework of supplier market analysis, as well as to investigate the Industry 4.0 technologies that are impacting different divisions of supply chain management. A literature review was carried out first, then research interviews and results were analysed to answer the research questions. The answers to the research questions are then discussed for generating a synthesis that bridges the theoretical underpinnings with the findings of the interview research.

Impacts of modern technologies in procurement management (RQ1)

Procurement management includes the comprehensive spectrum of activities within the purchasing domain, as well as supplier evaluation, supplier relationship management, transportation and logistics, and quality control of the raw materials (Mangan et al. 2020). According to the theory, a range of Industry 4.0 technologies like IoT, cloud, blockchain, cybersecurity, big data, data analytics, autonomous transportation, advanced robotics, 3D printing VR, and AR are applied in modern procurement (Choi et al., 2021, and Klünder et al. 2019). Even so, theoretical research on Industry 4.0 procurement technologies is still limited, and empirical studies argue that the practical implications of Industry 4.0 technologies in procurement functions are not yet very widespread. The responses to the interview study on Industry 4.0 procurement are presented below:

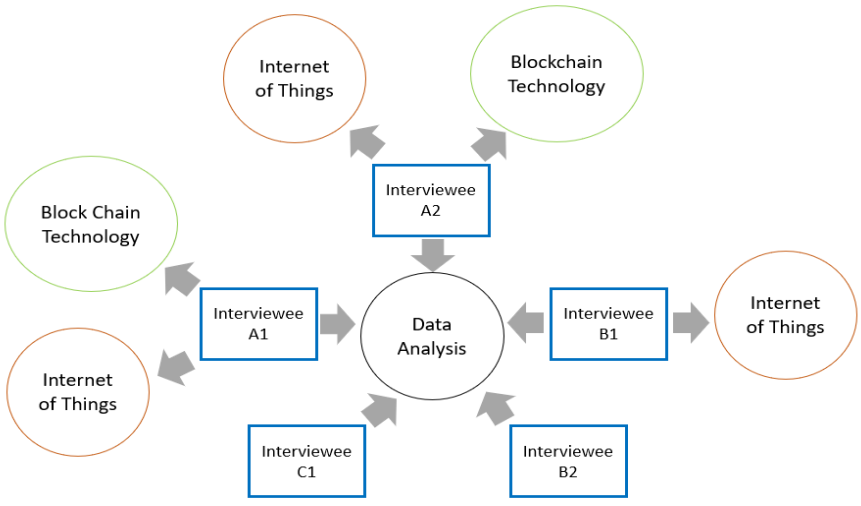

***Figure 14**. Reported Industry 4.0 procurement technologies.*

Figure 14 presents the empirical data of implemented Industry 4.0 technologies in procurement management. Arrow from the each interviewee represents the reported technology. From the figure, data analysis is the most widely implemented Industry 4.0 technology in various sub-segments of procurement management. Getting real-time data for establishing a transparent supply chain management is becoming more important for companies. As a result of this blockchain technology and internet of things are becoming popular as procurement technology (A1, B1, C1). Furthermore, empirical studies have argued that Industry 4.0 technologies like autonomous transportation, advanced robotics, 3D printing, VR and AR have not yet attained widespread adoption and deployment within the context of procurement management functions.

According to empirical studies, connectivity and communication among different shareholders of procurement management are highly advanced as a result of employing modern technologies. Interviewees A1 and A2, both asserted that, getting GPS data of the goods which are in transit is important for the procurement team to make anticipating decisions, and IoT devices are used for gathering GPS data of the goods. This real-time GPS data also helps the procurement team to reduce transportation risk. Theoretical studies, as well as empirical data, supported that, blockchain technology and cloud technology help procurement teams to build a common database that is shared by different parties involved in procurement management, as well as ensure a secure way of procurement financial transactions.

One interesting finding of the empirical study is that Industry 4.0 technologies are creating new scopes in the realm of procurement management. As an example, category management is an emerging feature of procurement and its emergence is intricately tied to the pervasive influence of data analysis (B1). The combination of data-driven insights with category management emerges as a compelling paradigm, one that encourages informed decision making and the optimization of the procurement process. Procurement data analysis offers better supplier performance evaluation, better benchmarking, procurement process cost analysis, and better risk mitigation (A1, A2, B2, and C1).

It can be summarized that Industry 4.0 technologies like data analysis, IoT, and blockchain technologies have an impressive impact on procurement management which is supported by both previous research and empirical studies. Moreover, the implication of recent technologies in procurement management does not only result in eProcurement (Tai et al., 2010), it also opens new doors like category management in the area of procurement management (B1).

AI for supporting supplier market analysis (RQ2)

Supplier market analysis is the comprehensive process of gathering and analyzing critical supply chain data, which significantly influences procurement decisions and forms the foundational basis for shaping an organization's sourcing strategy (Van Weele, 2010 and Keith et al., 2015). Theoretical study suggested four divisions of supplier market analysis which are existing supplier market, products, new markets, and buyer markets (Lobermeyer and Kotzab, 2010). For establishing less risky and more competitive supplier market analysis, the procurement management team should focus on substitutes and supplements of materials and searching for new suppliers. The process of finding new suppliers consists of two phases which are the collect function and the search function (Kang et al., 2011). Focusing on the supplier selection process of Solanki et al., (2016), a theoretical study supports a three steps new supplier market analysis process, and the steps are discovering potential suppliers, initial screening and deep evaluation, and supplier selection. Previous research supports the implementation of different artificial intelligences in every step of new supplier market analysis. However, empirical data argue that the implementation of AI technologies in the supplier discovery phase is a very new dimension for procurement management.

Theoretical studies support the application of a number of artificial intelligence tools in supplier discovery phase. Nissen & Sengupta (2006), discussed leveraging intelligent software agents to automate the process of finding potential suppliers through online catalogs, whereas Haanpää (2019) proposed to apply natural language processing (NLP) in the field of supplier discovery, especially for extracting information from text-based purchase order descriptions for identifying potential suppliers. Past research also supports the implementation of data mining and analysis, as well as semantic analysis for supplier discovery from web browsing, social media data (Meire et al., 2017, Baesens et al., 2004, Søilen, 2016, and Kang et al., 2011).

However, empirical data reported only the application of web scrapping, natural language processing, and semantic analysis in the supplier discovery phase (A1, and A2). Web scrapping is used for getting crucial data of suppliers like product specification, and supplier rating, whereas NLP can be applied for assessing customer perception of different suppliers, as well as identifying and categorizing vendors based on their locations, offerings, and other relevant attributes. Application of semantic analysis with NLP offers a more efficient supplier discovery process. Although supply chain and procurement solution providing companies experiencing with different AI tools for the supplier discovery phase, not all the manufacturing companies started leveraging AI for their supplier discovery. Interviewees B1 and B2, both of them confirmed that the insufficiency of reliable

sources of data is the main concern behind not applying AI for their supplier discovery process, and they are still following the traditional way of meeting a new supplier.

The application of different AI tools, including but not limited to a locally linear neuro-fuzzy model, fuzzy c-means, intelligent software agents, and knowledge based systems, within the ambit of supplier screening and deep evaluation process has been discussed in theoretical studies. However, empirical evidence accentuates the adoption and application of collaborative filtering, data mining, and intelligent software systems during the supplier screening and evaluation stage. Data mining technology helps the procurement team to look deeper into supplier profiles and extract critical information from diverse sources like suppliers' transaction histories and financial records. Intelligent software system offers a very efficient way of supplier screening. According to empirical data, intelligent software system helps the procurement team for establishing an effective supplier screening by quickly analyzing supplier credentials against predetermined criteria, as well as offer continuous monitoring of supplier performances. On the other hand, collaborative filtering can be applied to recognizing suppliers who are consistent with the preferences and experiences of similar businessess by examining historical data from various sources like customer feedback, and reviews. Collaborative filtering is very efficient in the case of supplier evaluation, where reputation and customer satisfaction are very important.

Procurement researchers defined the supplier selection process as a multi-criterion decision making process (Vahdani et al., 2012; Cavalcante et al., 2019; Su and Chen 2018), where AI may have a great impact. Past research discussed the implimentation of artificial neural networks, machine learning, intelligent software, and data analysis in the phase of supplier selection. Empirical data presents that leveraging AI for supplier selection tasks is a very common practice in industries. Empirical data emphasize the utilization of data analysis, intelligent software scoring and artificial neural networks for supplier selection. Data analysis does not only help the procurement team to build an instinctive decision-making framework and foundation of supplier selection based on a wide range of data sources, but also applies for assessments of suppliers based on their attributes like product quality, delivery and innovation performance, and cost-efficiency. Intelligent supplier scoring is applied to establishing a quantitative scoring system for supplier selection, and it helps buying organizations to allocate resources more effectively by deciding on more significantly potential suppliers. When artificial neural networks are trained on previous supplier data, it offers higher precision of the supplier selection process, as well as mitigates risk and human bias.

One of the surprising findings of the empirical data is that procurement and supply chain solution providing companies already started implementing AI tools like web scrapping NLP, and semantic analysis in their supplier discovery solution (A1, & A2), whereas manufacturing companies are still concerned about reliable sources of data before applying AI for finding new suppliers (B1, & B2). However, empirical data visualizes the practical scenario of how different procurement related industries are accepting and implementing artificial intelligence in their supplier market analysis process.

In summary, artificial intelligence can be utilized for establishing a time-efficient supplier market analysis, which can discover potential suppliers, do the initial screening and deep evaluation and finally select suppliers from a vast amount of data for mitigating risk and reducing human bias.

5.2 Concluding Remarks

As delineated by both theoretical research and empirical findings, the integration of artificial intelligence tools across various elements of procurement management is becoming increasingly popular. However, artificial intelligence has not been used in many procurement contexts yet, and it has not yet been applied in many procurement scenarios. Therefore, research on this subject has been considered important.

The objective of this research was to comprehensively investigate the potential of artificial intelligence as a supplementary tool for supplier market analysis, as well as examine the effects of contemporary technologies on procurement management within the framework of Industry 4.0. Besides, the purpose of this investigation was to have a deeper and extended awareness of the subject. To accomplish the goal, the thesis questions were chosen accordingly. Moreover, a qualitative interview study was selected as the research strategy in accordance with the thesis questions, and qualitative content analysis was used to examine the data.

The theoretical framework was completed depending on digital procurement, and supply chain management literature, where modern procurement and artificial intelligence were discussed. Furthermore, the theoretical base was aggregated by the theories of supplier market analysis, supplier selection process, and AI in procurement management. As a result, new supplier market analysis emerged as an important part where AI may play an important role.

The main contribution of this thesis was to build a framework of AI-powered new supplier market analysis for enhancing the efficiency of the procurement management process. Application of web scrapping, NLP, and semantic analysis in the supplier discovery

phase allows the procurement team to identify potential suppliers by analyzing a vast amount of data from a number of sources within a very short period of time. After discovering suppliers and collecting supplier-related information preliminary screening and deep evaluation of the collected data become important. Data mining, collaborative filtering, and intelligent software systems are the AI tools that improve the preliminary supplier screening and deep evaluation process. The final stage of new supplier market analysis is considered the supplier selection phase. The implication of data analytics, artificial neural networks, and intelligent supplier scoring permit procurement management to make decisions from selected suppliers based on quantitative analysis and empirical evidence. In summary, the integration of AI in supplier market analysis is leading procurement management into competitive practices in a continuously changing business environment. As AI improves decision-making, and mitigates risk, by establishing AI-powered supplier market analysis procurement management can accomplish strategic growth, sustainable partnerships, and excellence in supplier relationships.

5.3 Managerial Implications

The study's practical goal was to accelerate the application of AI technologies in the future to improve effectiveness of the procurement process. Studying the background of artificial intelligence in the context of procurement management will increase the knowledge of how AI-powered procurement processes can be applied in business management. Moreover, researching the implication of Industry 4.0 technologies in procurement management can lead to strategic growth of procurement development.

It has been identified that based on the implication of Industry 4.0 technologies, the procurement process is divided into four domains, which are connectivity and communication, data intelligence and analytics, human to machine (H2M), and machine to human (M2H), and logistics (Klünder et al., 2019). Figure 8 also lists the suggested Industry 4.0 technologies in each segment, which may direct business organizations to establish sustainable procurement processes. On the other hand, Figure 13 presents the Industry 4.0 technologies that have already been implemented in procurement management functions. The result of this thesis can gradually be represented in the context of Industry 4.0 procurement management by enhancing the literature with real-world examples.

The final result of this thesis contributes to building an efficient supplier market analysis. The presentation of a thorough list of AI technologies within the framework of new supplier market analysis serves as a pivotal tool for procurement management, mainly facilitating the discernment of which technology holds the most significant impact on each

respective phase of the new supplier market analysis process. Figure 12, presents the implemented AI technologies in different stages of new supplier market analysis supported by empirical data and literature review, and the procurement management team can start establishing their AI powered supplier market analysis by implementing these technologies. Furthermore, it presents the importance of AI for the strategic transformation of procurement management which leads to efficiency enhancement, data-driven decision making, risk mitigation, and strategic growth.

5.4 Assessment of the Research

The extensive theoretical section at the beginning of the thesis was to both introduce the reader to the study framework and validate interview questions utilized for gathering empirical data Finally, the qualitative interview performed very good as a research strategy to deepen comprehension via experience. In addition, all methodological selections were provided, explained, and extensively described in the research methodology part to strengthen the validity of the analysis and interpretations. The results were also presented in a transparent manner.

Research validity is defined as the capacity of the selected study method, data collecting process, and research strategy to examine the aspect under study (Anttila, 2014). Anttila (2014) also said that for a qualitative study to be considered valid, the theoretical results and empirical findings have to make sense in relation to each other. The intent of this thesis was to address the research questions as effectively as possible, consequently, the research methodologies were chosen accordingly. Furthermore, to collect accomplishments and empirical perspectives on the facts, the interview participants were chosen carefully, and the interview questions were properly and precisely formulated. But even if generalizability in a qualitative study with a small number of respondents was not great, the findings were nevertheless helpful for improving comprehension and implementation of AI-powered procurement management.

Although the validity of qualitative research is the main criterion for evaluation, assessing the reliability of the study is also necessary, and reliability is defined as the ability of the study methodology, data collection techniques, and analyzing procedure to gain reproducible results (Anttila, 2014). Baxter & Jack (2008) stated that to completely comprehend the findings and increase the reliability of the findings, the author should compare empirical outcomes with each aspect of the existing literature and data. In this study, the risk of repetition in qualitative study was mitigated by ensuring that the interview questi-

ons were clear, and understandable, by presenting the findings in an appreciable manner, and by contrasting the empirical findings with the existing studies. However, acknowledging several constraints that impact the scope and generalizability of the research findings is considered important.

One of the primary limitations of this research is the relatively small sample size of interviewees. Five procurement experts in all took part in the qualitative interviews. Although each participant provided a distinct perspective to the study, the sample size may not adequately reflect the variety of practices across different industries and sectors.

The interviewee's level of experience in AI modeling is another significant drawback. While all interview participants were highly knowledgeable in procurement and supply chain management, none of them had specialized expertise in building AI models. This constraint affects the depth of insights gained on the technical aspects of AI implementation, such as algorithm selection, data preprocessing, and model evaluation. A more diverse group of experts, including those with technical AI skills, might provide a more in-depth understanding of AI's application in supply chain management.

Overall, an organized and open description of how the research was conducted assured the reliability and validity of the research as a whole. On the other hand, citations from the interviews were also included in the reporting of the results to contextualize the interpretations. However, a small number of interviewees and their level of experience in AI modeling can be considered as significant limitations of this research.

5.5 Future Research Suggestions

As it is already described, the goal of this thesis was exploratory. Furthermore, the study intended to advance our knowledge of establishing AI-powered supplier market analysis, as well as to enhance strategic growth of procurement management. As a result, the study offers an expanded view of the implemented AI technologies in procurement management, mainly focused on new supplier market analysis. The thesis is, however, constrained by the comparatively less number of interview participants. Hence, it would be advantageous to expand the research to other procurement functions in order to establish the study.

It would be worthwhile to further examine the implication of the most recent AI tools, like GPT in different procurement functions. Due to the limited prior study, there is still interest in further exploring the implementation of various AI tools in different procurement functions. In addition, the ethical and legal dimensions of AI in procurement can be conside-

red as the areas of increasing importance. Future research can explore the ethical implications of AI-driven decision making, such as concerns of bias, fairness, and transparency.

For professionals, researching the subject of the ethical challenges and dilemmas procurement practitioners face when applying AI technology, particularly in scenarios involving supplier relationships and negotiations could be considered useful. Business organizations are becoming more concerned about the ethical challenges of AI. However, AI's impacts on procurement may vary based on industries. In this manner, future research can contribute to conducting case studies to understand industry-specific benefits, and challenges of AI adoption in procurement management.

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APPENDIX 1: FRAME OF THE RESEARCH INTERVIEW

Background of the interviewee:

1. At the beginning, can you please describe your background including your current job role, what kind of industry you are working in, and years of experience in procurement or supply chain management?

Industry 4.0 Procurement Management:

2. How familiar are you and your organization with the term ”Industry 4.0 procurement management”?
3. Has your company been utilizing any Industry 4.0 technology for procurement management functions?
    i. If yes, could you mention what are the Industry 4.0 technologies that have been applied in your company?
    ii. What kind of impacts do these mentioned technologies have in your procurement system?
    iii. If not, what can be the reason for not applying?

AI for Supplier Market Analysis:

4. How familiar are you with applying AI in overall supplier market analysis?

Here is the list of AI tools used for supplier market analysis according to the existing literature: (Web Scrapping, Semantic Analysis, Intelligent Software System, Natural Language Processing, Collaborative Filtering, Intelligent Supplier Scoring, Data Mining, Machine Learning, Artificial Neural Network and Data Analysis)

5. Do you / your company apply AI tools for new supplier discovery?
    i. If yes, can you mention what are the AI techniques you are applying for supplier discovery from the listed techniques above?
    ii. What potentialities might they bring in your supplier discovery phase?
    iii. If not, then what might be the reason behind not applying AI tools for supplier discovery?
6. Do you / your company apply AI tools for new supplier screening and evaluation?
    i. If yes, can you mention what are the AI techniques you are applying for supplier screening and evaluation from the listed techniques above?
    ii. What potentialities might they bring to your supplier screening and evaluation process?
    iii. If not, then what might be the reason behind not applying AI tools for supplier screening and evaluation?
7. Do you / your company use AI tools for new supplier selection?
    i. If yes, can you mention what are the AI techniques you are using for supplier selection from the listed techniques above?
    ii. What potentialities might they bring to your supplier selection process?
    iii. If not, then what might be the reason behind not using AI tool for supplier screening and evaluation?