

Abstract

The fastener industry is significant worldwide as it provides basic components to automotive, aerospace, construction, and other electronic industries. This is an important value proposition that creates severe supplier selection dilemmas for companies in the industry: quality implications, costs, delivery reliability, and compliance with international standards may pull in opposite directions. These challenges compound with issues of international supply chain management, supply and demand of materials, and the volatility of dynamic systems. Hence, the role of this thesis is to explore the characteristics of supplier selection problems in the fasteners industry in a GMS context and supply chain management, material requirements, and in a dynamic market environment.

Due to the exploratory nature of this research that involves interviews with practitioners, the paper looks at other supplier selection attributes and evaluates other models of selection like AHP and scoring models. As much as these methods mentioned in the study fail to capture the specificity within the fastener industry to meet the needs of diverse companies, the study sheds light on how new technologies, including blockchain, and advanced analytics can enhance supplier evaluation and tracking.

This study therefore reveals the need to include the aspect of quality management, cost control, and supply risk management within the supplier evaluation models. Moreover, based on the study, the peculiarities are factors that are unique to the industry mainly concerning the availability of materials, geopolitical risk, and sustainability.

Therefore, this thesis contributes to extending the bodies of knowledge by identifying the gaps or the misalignment between the theories and the facts in the case of the fastener industry. It provides valuable recommendations to manufacturers, suppliers, and policymakers to enhance decision-making and facilitate better SC operations with less risk in a more unpredictable environment.

Key – Words: Fastener Industry, Supplier Selection, Supply Chain Management, Quality Assurance, Sustainability, Emerging Technologies

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Chapter 1: Introduction

1.1 Background of the Study

The fasteners industry plays a strategically important position in the global supply chains as a provider of critical parts and components that make up the final product structures in a lot of segments of industry including automotive, aerospace, construction, and electrical & electronics. Boothroyd (1986), noted that in joining parts with high accuracy required fasteners like bolts, screws, nuts, washers, etc. are most critical where reliability is the keynote crucial for safety, performance, and the part's life. Therefore, supplier selection in this industry rises from being a mere transactional decision to a strategic supply chain management (SCM) decision.

The Role of Fasteners in Modern Supply Chains and Procurement Challenges

Today's supply chain systems are dynamic and because of the material compositions like steel, titanium, and aluminium alloy besides the design needs, fasteners are strategic components. Keeping up or adhering to industrial specifications and guidelines like ISO 898 for mechanical characteristics or ASTM for corrosion performance is crucial so as to achieve a culture for product safety and operating performance (Finnegan, 2001). Failure by its suppliers to meet their obligations to the purchasing organization hinders downstream flow causing delays in production and, at times, expensive recalls.

New technologies on discount shopping, three-dimensional printing, computerized assembly, and a blockchain solution have enhanced the procurement process. According to Abeyratne and Monfared (2016) blockchain increases supply chain accessibility and provides an effective means of examining supplier's adherence to the rules and checking the source of the materials. However, successful adoption entails suppliers who have the technical capability to implement these innovations, which increases the decision-making process of selecting suppliers.

Such tensions remain apparent thus strengthening the idea that the market variability in quality control remains a major issue in procurement. Ordering parts from suppliers in countries with less stringent laws is especially dangerous because it leads to the acquisition of substandard fasteners that compromise product quality (Bai et al., 2017).

The existing difficulties were further compounded by the COVID-19 threat which impacted on production schedules and transported costs (Sabeti et al., 2019). Moreover, unpredictable changes resulting from the protectionism in the form of trade tariffs to steel and aluminum in big markets like the U S has raised the cost of raw materials increasing the importance of supplier selection efficiency (Govindan and Hasanagic, 2018). Since raw material costs are a significant portion of the overall production costs, firms need to use other efficient sourcing strategies such as multi sourcing and supplier diversification in order to mitigate the impacts of supply risks for key suppliers.

Importance of Strategic Supplier Selection

This indicates that supplier selection is more than simply finding the cheapest supplier; quality, delivery dependability, and the supplier's ability to innovate, as well as strategic fit all lie on a spectrum (Carter, 1996). Since fasteners are specified for their accuracy and longevity, the importance of the material and process regularity is considerable. According to Cooper and Ellram (1993), the reliability of these criteria is highly important to the supplier to ensure supply chain stability and operational risk reduction.

AHP multi-suppliers and other criteria methods offer more structured approaches for assessing suppliers based on several given criteria (Saaty, 1996). These methods help manufacturers to make conscious decisions on issues like cost control and quality which are usually and are many times mutually exclusive. However as noted by Das et al. (2000), there is a lack of all these theoretical models' implementation in certain industry sectors particularly fasteners industries, where industry-specific assessment tools are a distinct possibility.

Emerging Trends and Opportunities

The fastener market globally is experiencing more demand for products that are environmentally friendly and have traceability issues due to regulatory compliance requirements and market demands. In this paper, Epelbaum and Martinez (2014) posit that the management of sustainable practices in the supply chain flow can improve the competitive capabilities of the firm. As applied to fasteners, this means choosing suppliers who meet certain environmental criteria, including the use of recycled metal and minimum energy usage in the production process.

Moreover, it was also noticed that digital technologies are changing the ways of supplier evaluation. Saberi et al (2019) the use of blockchain for traceability is an innovation that solves all the trust problems that are characteristic of global supply chains. For instance, digital ledgers can ensure the quality of the fasteners is as expected and follow their progression through the supply chain meaning a reduction of counterfeited or substandard material risks.

Rationale for This Study

Due to the massive problem of supplier selection decisions and its strategic nature in the fastener industry, the following research questions will guide the study to meet its objectives of providing an option for handling some challenging tasks. It thus aims at narrowing other existing gaps in the literature, more particularly those that relate to the areas of quality, cost, and logistics of the theoretical models for supplier selection. Thus, this research will not only advance theoretical knowledge but will also help manufacturers look for solutions to supply chain procurement in a rapidly changing regional and global environment.

1.2 Problem Statement

The fastener industry has two major issues of supplier selection owing to the nature of the global supply chain and business requirements of quality and type of fasteners. Fasteners are used widely in various industries including automotive, aerospace, construction, and electronic industries since fasteners play an important role in holding or joining other components in those industries hence their effectiveness has a direct impact on safety and performance. Although the sector is very important, manufacturers in this industry are facing many challenges through procurement costs that have varying costs, quality, and other global risk factors. All these challenges point towards the fact that Supplier selection is an analytically driven process and is not just confined to selecting a supplier but also includes selecting a supplier which is best suited to meet the specific needs of a business firm.

Choosing a supplier in the fasteners industry is further constrained by factors like supply chain management disruption, variations in the price of raw materials, and the requirement of international standards. For instance, disruptions of the unprecedented COVID 19 pandemic have exposed the weaknesses of most supply chain activities with propositions in globalization impact with manufacturers complaining of delays in their

raw materials arrival, increased transport costs and shortages of raw materials. Furthermore, geopolitical risk and an upswing in tariffs such as steel and aluminum increased cost pressure thereby pushing organizations to look at more sustainable and lower cost models for procurement. In the same regard, they must satisfy requirements like the mechanical requirement ISO 898 and the corrosion resistance ASTM to further reduce the number of suppliers. These considerations suggest that companies should employ multiple criteria decision making method where suppliers satisfying all the quality, cost, and compliance criteria as well as the flexibility and resilience of operations, should be selected.

1.3 Research Aim and Objectives

Research Aim

The main objective of this paper is to establish a personal supplier selection model suitable for the fastener industry. Due to the nature of the requirements and issues involved in the context of this sector, the research aims to consider the primary criteria that might be important for supplier selection and evaluate the applicability of the AHP and scoring models methodologies. Therefore the a need to address industry-specific requirements, to redress the abstraction in theory-based research. In other words, the findings of this study are meant to be practical for improving decision-making, proposing effective procurement, and improving the supply chain in an uncertain and competitive business environment.

Research Objectives

To achieve this aim, the study is guided by the following specific objectives:

1. Identify the Key Supplier Selection Criteria in the Fastener Industry:

Consideration should be made to identify the most critical decision factors that decision-makers, especially in manufacturing industries subjected to qualities and reliable delivery of products used to evaluate a prospective partner in supplies. This objective will also provide an understanding of the factors and issues of the procurement specialists in the sphere of fasteners.

2. Examine Challenges in Supplier Selection:

Enumerate some of the usual issues that come about when deciding on the materials to purchase from suppliers for example, Material availability issues, political Instability and war, compliance and outstanding issues, and pandemic conditions including the recent COVID-19 breakout. In this analysis, both the external and internal environmental perspectives of the factors that influence procurement decisions will be also brought out.

3. Evaluate Existing Supplier Selection Methods:

Assess constructively the applicability, or otherwise, of the current supplier selection models such as the AHP and scoring models adopted by fastener industries. Therefore, the next objective of the paper is to evaluate the several strategies employed based on their relevance to the various requirements of the various sectors.

4. Propose a Tailored Supplier Selection Framework for the Fastener Industry:

Integration of a framework that will focus on supplier selection for the fastener industry region. It will adopt such selection criteria, enhance evaluation models like AHP and scoring models, as well as the contemporary technologies like blockchain, AI, and big data as proposed in this study. The purpose is to develop a useful and sectoral instrument for improving supplier assessment activities, aiding in major procurement choices, and responding to the difficulties constituent of fastener producers.

5. Provide Practical Recommendations for Industry Stakeholders:

Offer specific suggestions to the manufacturers, the procurement managers, and the policymakers who wish to guide the procurement of the fasteners based on the existing issues of supplier selection. This encompasses issues such as risk control practices and inclinations toward cost reduction and supplier interaction strategies.

Alignment with the Study's Scope

Emphasis is placed on interest in this research – the fastener industry – as being unique and highly relevant to the current global supply chain systems. This work differs from other research that takes a broad look at supplier selection while paying attention to factors such as quality, cost, and logistics that are specific to fasteners only. Therefore, this research seeks to fill the identified gaps within the existing literature and offer

interventionist solutions that may serve the dual purpose of enriching the body of knowledge and supporting utilization in the advancement of the supply chain toughness and sustainability of the fastener.

References Supporting Research Objectives

Supplier Selection Criteria: The criteria include costs, quality, and delivery as acclaimed by Carter (1996) especially in industries where detail and accuracy are of the essence.

Challenges in Supplier Selection: External challenges can be analyzed in the context of views identified by Saberi et al. (2019) on geopolitical tension and global disruptions' impact on procurement decision-making, which gives a starting point for the analysis of external factors in the fastener industry.

Existing Methods: this paper will critically review decision-making tools such as AHP which is thoroughly discussed by Saaty (1996).

Emerging Technologies: Abeyratne and Monfared (2016) examine the role of promoting blockchain in improving perishability and supplier accountability, an area of interest in this study.

By relating these objectives to existing literature, this research maintains scientific rigor in achieving the specific goals related to the supplier selection of the fastener industry.

1.4 Research Questions

This research seeks to contribute to understanding multiple related research questions that focus on relevant challenges, methods, and opportunities inherent in the fastener industry in relation to supplier selection.

1. What criteria can be used to assess suppliers in the fastener industry?

This research question focuses on the evaluation elements that are most important in the supplier selection process, such as cost, quality, delivery reliability, conformity to international standards, and supplier sustainability. The purpose aspires to establish how these criteria are prioritized and how they differentiate from manufacturing segments. For example, the fastener industry pays close attention to material characteristics and compliance to practices such as the ISO 9001, modest for product safety and performance (Finnegan, 2001).

2. What key questions do manufacturers in the fastener industry address when selecting their suppliers?

This question tries to find out what challenges have been experienced especially in sourcing odd fasteners in relation to cutthroat supply chain challenges and volatile markets. It considers factors ranging from availability and price of materials, political climate, and regulations, and disruptions occasioned by situations like the current coronavirus outbreak. These challenges have a major influence on procurement strategies, according to Saberi et al. (2019).

3. How suitable are those current supply selection approaches for the fastener industry?

This question also assesses the usefulness and drawbacks of most of the originally developed supplier selection methods like AHP and scoring models. It goes further in asking if such methodologies meet the needs of the fastener industry as they are or if they must be enhanced to assume the roles needed by the sector (Saaty, 1996; Das et al., 2000).

4. In what ways will emerging technologies improve the assessment of suppliers in the fastener industry?

This question focuses on the application of up-to-date sophisticated tools and technologies, including blockchain, Artificial Intelligence, and sophisticated analytics to enhance supplier evaluation. These technologies may provide solutions to issues such as trace and traceability of materials, counterfeit products, and risk as reported by Abeyratne and Monfared (2016), and Epelbaum and Martinez (2014).

5. What approaches can be used to enhance supplier selection in the fastener industry?

This question sums up the findings so that it can give recommendations for the enhancement of the supplier selection methods. It looks at the implementation of state-of-the-art decision-making techniques, the use of new technologies, and ways of handling issues like costs, quality, and supply disruption.

In answering these questions, this study seeks to provide a solid foundation for sound knowledge on the supplier selection within the fastener industry of specific suggestions where problems relating to enhanced decision-making arose.

1.5 Significance of the Study

The fastener business is a key segment of world manufacturing that requires accurate, high-performance items that maintain the strength and reliability of constructions and equipment in many different uses. Supplier selection for this sector requires more than just evaluation of several factors, but also dynamism in this volatile industry, and meeting several strict international tests. The value of this research therefore rests with the capacity to handle these issues and offer a coherent and practical framework for supplier selection that has a direct impact on the welfare of the industry and its stakeholders.

Improving the Decision-Making Process in Supplier Selection

A significant preliminary advantage of this research is to provide better frameworks and methodologies to help manufacturers in the fastener industry with supplier selection. Present decision-making methodologies apply industrial generic models that do not meet the specifics of this industry, for example, the requirements for material that has to meet ISO898 and ASTM standards, or the requirement for enhanced traceability (Finnegan, 2001). This work ascribes supplier evaluation frameworks exclusively for the fastener industry to offer instruments that can help make better and more precise choices about procurement.

Meeting Global Supply Chain Management Issues

Globalization has increased the interaction of the supply chain networks and both the chances and the threats for manufacturers have increased., Saberi et al. (2019) pointed out that such disruptions and forces of trade tensions, tariff volatility, and the COVID-19 pandemic have highlighted the risks associated with sourcing strategies in industries such as fasteners industries and raw materials input such as steel. This research work covers these challenges in detail and makes recommendations mainly on how to minimize risk such as using multiple sources of supply, utilizing local suppliers, or adopting innovative technology like the blockchain solution to reduce supply risks and guarantee quality.

Bridging the Gap Between Theory and Practice

Although a lot of documented information is available on supplier selection methodologies which include AHP and other multiple criteria decision-making techniques the same in the case of the fastener industry is not explored to a much extent (Saaty, 1996; Das et al., 2000). This paper fills this gap by assessing these models against fastener procurement and providing modifications that consider sector trends. Thus, it does not only generate academic contributions but also practical guidance for those who work within the industry.

Supporting Industry Standards and Compliance

Certification is important with international standards since standards in the fastener industry are highly valued and there should be mere failure to any of its products. Violation of such requirements is inevitable in business operations, operations disruption, loss of reputation, and penalty. This work elaborates on the need to include compliance criteria in the supplier assessment system while also pointing at the ability of technologies such as blockchain to improve the level of transparency and adaptability (Abeyratne & Monfared, 2016). All these developments help the manufacturers to ensure that they meet international standards as they work on improving their procurement strategies.

Promoting Sustainability and Innovation

The fastener industry, like many industries, has ongoing pressure to become more sustainable. According to Epelbaum and Martinez (2014), integrating sustainability in supply chain management is not only a way of meeting legal and customer requirements but also a way of making the supply chain more competitive in the future. This paper aims to analyze the way that manufacturers evaluate supplier sustainability in services like energy efficiency in production or usage of recycled materials. Also, the research explores the readiness and applicability of other emerging technologies such as artificial intelligence and advanced analytics in designing novel supply chain approaches to supplier selection and management.

Practical Benefits for Stakeholders

This research provides actionable recommendations that can benefit a wide range of stakeholders in the fastener industry:

- **Manufacturers:** Suppliers Forgings, End-users can obtain optimized frameworks that improve supplier selection effectiveness and reliability thereby minimizing occurrences of counterfeit or substandard materials and parts, long lead times, and consignments that are late for delivery.
- **Suppliers:** Recognize new demands and standards of manufacturers, to enhance the practice and the position of the companies in the international environment.
- **Policymakers:** Use knowledge of issues in specific industries to create effective rules and norms for the supply chain that will allow for it to be more sustainable over the long term.
- **Moving the Needle:** A Roadmap to Strengthen the Future of the Fastener Industry

As the world is facing advancements in technologies and uncertainties in the global markets, falling supply chain robustness has emerged as a significant issue. Hence, this study addresses the opportunities and risks in the choice of suppliers and brings a positive effect to the fortification of the fastener industry's ability to respond effectually to the fluctuations in the market and to provide business continuity. The application of modern decision support systems, compliance systems, and corporate sustainability shows the industry's long-term prospects in a world that is becoming more diverse and interconnected.

1.6 Structure of the Thesis

This thesis comprises six chapters and is planned to offer a strategic study of supplier selection in the fastener industry. For this study, the background of the study, problem statement, research aim, objectives, and questions are presented in Chapter 1. It sets the background of the study and identifies general research fundamentals together with the difficulties and deficits existing in the field.

Chapter 2 provides a literature review of supply chain management, supplier selection criteria, and methodologies particularly for the fastener industry. It also reveals the main issues and discusses the weaknesses of existing literature and research. The method used in the study is described in Chapter 3 and the justification for choosing the qualitative approach, the general interview techniques used in the study, and the techniques that were used in the analysis of the findings are also described.

Chapter 4 discusses the findings from the interview data and provides general information on the supplier selection criteria, methods, and specific concerns of the fastener industry. The results of the research are introduced in Chapter 5, focusing on a review of the literature, which specifies which elements support or contradict the prior findings and stresses their practical relevance. This chapter also presents and discusses the study's contributions to research such as industry-based insights on supplier selection issues, the use of methods, and its implications for supply chain preparedness and sustainability. In conclusion, Chapter 6 outlines distinct conclusions from this research analysis to the existing literature and continuing findings that deepen understanding of the supplier selection process in the fastener industry. Lastly, it examines the limitations that characterize the study before making recommendations for future research and how the findings from the study can be applied practically.

Chapter 2: Literature Review

2.1 Overview of Supply Chain Management

SCM is an embedding activity in the current industrial process of acquiring raw materials for manufacturing final products and delivering them to the customer's doorstep. Cooper and Ellram (1993) defined SCM as a systematic approach to managing the flows of materials, information, and money between the buyer and the supplier starting from the raw material supplier up to the end user customer with an overall goal of achieving supply chain management goals and costs objectives in the shortest time and at least cost possible. This paper has focused on managing the supply chain for machinery industries especially the fasteners industry that undergo higher precision. Four key operational fields of SCM include demand planning, supply planning, supply chain inventory management, and supply chain transportation management. These principles ensure that; The supply chain system is integrated, in this way value is not degraded & interruptions are done away with. Supply chain management should not only view in terms of cost reduction perspective as Mundy stated that there should be better attempts to build strategic value for the firm and the customers according to Fawcett and Fawcett (1995). They mean the capacity to specify and ensure suppliers provide high-quality products, function at the minimal possible expenses, and ensure timely delivery of the fasteners.

Where once SCM was a tactic confined to the strategic level planning to keep costs down simply, modern SCM thinking revolved around integration with other departments, incorporating reliability and sustainability into the organization's goals. In support of the above realization, Saberi et al. (2019) proposed that innovations such as blockchain and digital analytics have given the supply chain a vision of a supply chain that is real-time decisions, predictive, and more transparent. For instance, how fastener industries can track and ensure that the raw materials used are standard and do not contain any fake parts through the help of blockchain? Trends in the supply chain are new, and specifically suitable to the fastener industry since the field contains many strictures on accurate supply chain and fundamental necessities. There are different examples of using predictive analytics in the manufacturing industry: as a result of demand and inventory management coupled to predict the demand and avoid possible disruptions of production and hence reduce costs. These tools make manufacturers not only lean supply chains but strong supply chains capable of responding to such advent events.

Globalization has acted as a trigger to the emergence of major challenges in supply chain management. On the positive side it has offered chances to source from many suppliers and affordable prices. On the other hand, it has several drawbacks such as Political risks Tariffs, and other trade baroness and measures Regarding regulations. As noted by Bai et al., (2017) this global supply chain is thus rightfully considered as being weak because disruption events like the COVID-19 pandemic are disruptive to many supply chains. These challenges are rather acute for the fastener industry that operates several strategic products including steel raw materials. Tariff changes on specific materials and availability interchangeability are famous for bringing in high variability of the costs and time factor, which affects procurement and working schedules. Such risks indicate that this sector's manufacturers require strategies to factor sustainable supply chain risk management to help minimize risks like supplier diversion and using technology to enhance visibility and traceability (Abeyaratne and Monfared, 2016).

Supplier selection and supplier management are two of the most strategic processes in SCM. Another finding was positive supplier relations as this ensures quality, timely delivery, and costs as revealed in the report. According to Burt and Soukup (1985), the purchase decisions involve strategic choices as to the design for products and services to be made available in the market, costs to be incurred in making products and

providing services, and the positioning strategy to enable competitiveness. As is the case of any sector of industry, including the fastener one these supplier relations and strategic partnerships are best based on trust, transparency, as well as strategic fit that is aligned with the common goals and objectives. In the same breath, strategic partnerships enhance greater innovation smoother running, and quality consistency in operation and products. For instance, the advanced form of communication technology, and constant evaluation of performance measures, assist in the comparison of the supplier's capabilities with the expectations of organizational production.

Supply Chain Management is a rather important and continuously developing area, which can contribute to the operative functioning of such industries as, for example, fasteners. The roles that it performs in coordinating processes, handling global issues, and enhancing flexibility and openness of technology for maintaining competitiveness in a fast-changing business world cannot be overemphasized. To provide further explanation of the importance of supplier selection in the activities of SCM, the subsequent sections of this work will outline the general elaboration of the concept including the specifics of the fasteners industry as well as the effects on quality, costs, and sustainability.

2.2 Supplier Selection in Supply Chain

The patterning of the supplier refers to the key supply chain management aspect because it determines the effective, cost-efficient, and reliable supply chain. According to Cooper and Ellram (1993), supplier selection decision is not just confined to the procurement transaction but are carried out within an organizational context that determines operations performance, product quality, and customer satisfaction. This is especially important in sectors like fasteners where quality standards, from the supplier, have to be uncompromised.

To companies facing or managing a supply chain, suppliers are not only just a source of supply of goods, products, or services but also the key players and partners that determine successful competitive strategies. Purchases are significant inputs in all organizations and choosing the right supplier affects the quality of inputs, regularity and freeness of supply as well as the cost of the inputs required. According to Burt and Soukup (1985), supplier selection is a critical factor in achieving company objectives

of procurement more so where technological needs are extensive, as the case is with fasteners.

Supplier selection's strategic value is therefore that it deals with many facets of supply chain performance, such as cost, quality, reliability of supply, and innovation. For example, quality failures and supply disruptions as a result of poor supplier decisions adversely impact on the supply chain as the organization's market position and customer trust suffer. The importance of these aspects has been buoyed by disruptors such as the COVID-19 pandemic that illuminated weaknesses in conventional supplier schemes (Abeyratne & Monfared, 2016).

The procurement selection process has long been described as a selection step where the supplier is assessed on certain parameters. Such criteria can include cost, quality, delivery, capacity of the supplier to meet production standards, and more and more firstly, on issues such as cost and appeal to the quality standards. In such an industry, such as fastener manufacturing, such evaluation is critical as products especially require compliance with international standards such as ISO and ASTM for purposes of compliance for structural holding and operational safety (Finnegan, 2001).

Selecting suppliers in the context of global supply chains adds another layer of complexity. Some of the macro environmental factors include location, political risks, cultural factors, and transportation among others. In the fastener industry, these factors are magnified since the basic input is metals that are plagued by erratic prices and insecurity of supply due to acts of protectionism (Govindan & Hasanagic, 2018). Manufacturers must therefore use total and procedural measures in establishing supplier capability and performance with both qualitative and quantitative measures used in the assessment.

Supplier evaluation is one of the most difficult activities due to an even trade-off between cost and quality. While buying from suppliers with a lower price level may seem like a benefit, such suppliers can be problematic due to quality fluctuations or compliance and/or timely delivery concerns. Bai et al. (2017) noted that to achieve high reliability and performance in the long run, it is more beneficial to give importance to lifetime cost rather than the initial cost, especially in safety-critical industries.

Furthermore, the implementation of new technologies like the blockchain and digital analytics in the supplier selection process is a breakthrough. Blockchain technology creates trust and increases the effectiveness of supply chain management through the availability of knowledge to producers on the origin and status of their products. This becomes apparent in the fastener industry, as fake products or different materials will cause critical problems. On the opposite side digital analytics support appropriate decision-making for the manufacturers to evaluate the supplier's performance and to anticipate the future risks (Sabeti et al., 2019).

Relational strategies are also emerging in supplier procurement and management as well. Developing long-term cooperation with suppliers brings about trust and many players in a relationship since it becomes easy to solve problems together as well as improve on solutions. This is especially useful in the fastening industry because of technological change and market trends that are always shifting in the field. In line with Burt and Soukup (1985), strategic cooperation with suppliers is responsible for ensuring competitive advantage and hence a proper connection between procurement directions and general business objectives.

In conclusion, supplier selection can be defined as a strategic decision-making process that determines supply chain performance and robustness. The nature of the fasteners industry does not permit shortcuts and improvisations in this regard as quality, reliability, and compliance are critically important factors. The effective application of enhanced technologies and strong cooperation with suppliers provide important chances to improve decision-making and fulfill the demands of the fastening industry.

2.3 Supplier Selection Criteria

The choice criteria of suppliers have a significant impact on procurement choices and the value system of the supply chain. In the context of the fastener industry, these criteria play an essential role because this sector is used and produced high-quality material, and it is required to provide compliance with international standards. Like the perspectives described in Carter (1996), the criteria that are applied for conducting the conduction of suppliers should take into account a set of priorities such as cost, quality, delivery reliability, and innovation to gain competitive advantage.

Price is always another crucial selection criterion, which has been the quintessential cornerstone of costs in any given supply chain. The purchase of steel, aluminum, or any other material comprising a fastener's components represents a major part of production costs for manufacturers in the fastener industry. However, according to Bai et al. (2017), the best way may not be the most effective way especially if the focus is on quality and reliability. The present challenge for fastener manufacturers is to evaluate whether potential suppliers can possess sustainable prices for fasteners that will not fluctuate significantly over the period while ensuring that their quality and delivery lead times are not compromised.

Quality is also a non-negotiable factor characteristic of the fastener industry. Screws, bolts, and washers are also subject to mechanical and chemical requirements to assure their safety and functionality to meet ISO 898 and ASTM. According to Finnegan (2001), defects, product recalls, and loss of reputation can originate from very trivial differences in the material or manufacturing tolerance. Performing regular audits and using material traceability tools in quality management systems of intensive suppliers are important to ensure that they conform to the above-mentioned high standards.

Supplier reliability is as vital when it comes to judging the delivery services being provided by the suppliers. The fastener industry particularly strongly uses just-in-time inventory systems, meaning that even the slightest pause in supply can cause problems in production timescales which are expensive. Cooper and Ellram showed that reliability is determined by the supplier's capacity to deliver products on time and in full, abbreviated as OTIF. This criterion has further been magnified due to the recent COVID-19 outbreak that exposed the risks with supply chain susceptibility and the significance of utile supplier arrangements (Abeyratne & Monfared, 2016).

Sustainability and regulatory compliance are one of those trends that are gaining importance for supplier selection gradually. According to Epelbaum and Martinez (2014), there is more to supply chain sustainability than compliance with regulations because such processes improve corporate image and supply chain resilience in the future. For fastener manufacturers, some of the aspects addressed when assessing the credentials of suppliers are sustainable raw materials, energy consumption utilized in the production line, and methods used to handle manufacture waste. Also, it is essential to meet IT and tariff rules and regulations as failure to do so attracts legal and financial

repercussions, especially for those companies that source raw materials from countries with stringent regulations.

Supplier capacity and technological capability are comparable to cost and quality when considering supplier evaluation. It was found that suppliers also must be committed to delivering parts in sufficient volume, and reliable quality, as well as adaptability in changes to product design. It is especially important in the fastener manufacturing industry in which requirements may be made for individual parts for particular uses. They further assert that suppliers with complex technological resources like the application of automated manufacturing systems or the capacity to implement blockchain in tracking add a great deal of worth by exercising influence on efficiency gains and innovation.

Secondly, the current assessment of suppliers' financial viability and capacity to continue operations when implementing projects is relevant to the development of sustainable relations. To support this, Govindan and Hasanagic (2018) point out that financially vulnerable suppliers are likely to be disrupted, and this disrupts the supply chain. It is an important concern that has implications for the financial position of the fastener maker directly and of its key suppliers, the capacity of the latter to remain credit-worthy in the face of events of varying kinds: cyclical, global, political, or natural disasters, for instance.

Finally, the level of supplier management of collaboration and innovation is increasing steadily. The partnership lets manufacturers and suppliers cultivate a new product refining processes and solve problems conjointly. According to Burt and Soukup (1985), it is possible for such partnerships to yield both cost savings, as well as quality and innovation.

In conclusion, strategic supplier selection factors for the fastener industry are costs, quality, delivery, reliability, compliance capacity, and innovation. These criteria need to be assessed rigorously regarding suppliers, it is also important for achieving basic requisites as well as for long-term strategic planning. When these factors are prioritized, the manufacturers of fasteners construct strong, effective, and competitive supply chains.

2.4 Methods of Supplier Selection

Supplier evaluation involves the determination of the best suppliers to be used in the procurement process, this being a decision process that needs to be planned and systematic since it often involves the management of conflicting objectives such as cost, quality, and reliability of delivery. How suppliers are assessed in a fastener manufacturing company in which precision, reliability, and, meeting of strict standards is paramount, greatly determines the effectiveness and reliability of the supply chain. Standard methods including AHP, the scoring models, and other analytical tools are systematic thereby guaranteeing the comprehensive and accurate evaluation of the suppliers.

Similarly, there is another widely accepted approach known as the Analytic Hierarchy Process (AHP) which is a multiple-objective decision-making approach that allows an organization to compare and select from amongst several alternatives by structuring criteria hierarchically. According to Saaty (1996), AHP enables a decision-maker to decompose an overall problem into several sub-problems and come up with fractional measures that represent the relative importance of a criterion to those of the other criteria in the same problem. When used in the fastener production system, AHP can be used to assess suppliers against material quality, material cost, conformity, and delivery efficiency. For instance, a manufacturer would consider material qualification very important, and compliance with ISO 9001 and ASTM standards which are cardinal concerns in this industry – safety and reliability (Finnegan, 2001).

Another common classification type is scoring models, which are very popular due to their relative simplicity and compatibility with many spheres of business. These models involve putting value ratings on the suppliers about their performance against set standards. Carter (1996) has stated that the scoring models are most suitable for supplier evaluation and for judging the suppliers and choosing the right supplier in industries that have specialized technical needs such as fasteners. Through means like calculating the index of flaw frequency, delivery efficiency ratio, and cost viability ratio, the scoring models have a direct method of measuring suppliers and making a correct verdict.

Experts in procurement report that methods based on data analysis such as big data analytics or predictive analytics are being used for supplier selection. These methods can help reduce the effort it takes to sort through vast amounts of data and make better projections for suppliers and manufacturers. According to Saberi et al. (2019), robust technologies like blockchain and artificial intelligence can be used to improve supplier evaluation, especially in the aspects of modularity, control, transparency, and risk management. For instance, blockchain systems can increase confidence in the origin and quality of raw materials by providing evidence that fastener suppliers have met international requirements. Like traditional decision-making structures, machine learning algorithms can analyze records of suppliers and their performance to determine the future performance of suppliers which aids manufacturers in identifying areas of risks and disruptions.

Another useful method is the Weighted Criteria Model which enables the decision-makers to appraise the criteria respectively according to the value they will add to the goals of the organization. In the case of the fastener industry, where matters such as compliance and material quality are so important, the approach proposed in this paper guarantees that such factors are accorded the attention they deserve by the firms when identifying the most suitable suppliers. As mentioned by Das and others in 2000, weighted models indeed afford different sorts of welcomes to adjust to date industry needs, and that makes them highly appropriate for most sectors that contain multifaceted and dynamic specifications.

Even though structured methods like the AHP and the scoring models offer sound methodologies for supplier selection, they are not without some drawbacks. For instance, AHP is time-consuming to develop and, when evaluating many suppliers, can become unwieldy. In the same way, scoring models can shortcut the complicated nature of decision-making since supply chain relationships are dynamic and interdependent (Carter, 1996). Considering these challenges, there is an increasing use of mixed-methods research that involves the use of several methodologies. When used with other analytical models, mathematical scorecards, or supplemented with blockchain-based traceability, AHP approaches create a more detailed and complex evaluation of suppliers for manufacturers.

In the fastening industry, tasks are characterized by precision and reliability, and therefore, the use of more optimized approaches to supplier selection is highly desirable. As the types of information accessed and analyzed in supply management have evolved from purely financial data to diverse qualitative data, manufacturers can compare suppliers with increased efficiency and establish supply chain networks that are not only efficient but also sustainable. The approaches chosen for the buying process should reflect the objectives of its strategic plan and seek to have the supplier support value creation and organizational sustainability.

2.5 Challenges in Supplier Selection

The supplier selection process itself is dealing with numerous challenges that could affect supply chains' efficiency and robustness. These challenges are particularly well-expressed in the fastener industry as their production is characterized by high requirements for product quality, heavy dependence on international supply chains, and increased sensitivity to geopolitical and market shifts. To overcome these challenges, one needs to understand internal and external environment factors that have impacts on supplier selection.

Another core difficulty is the problem of quality assurance with suppliers. As pointed out by Finnegan (2001), small decaying differences in substances such as steel or aluminum may cause failure in fasteners, thereby undermining safety and reliability. This is an even bigger problem in global sourcing since there are variations in the measures of regulation and manufacturing. The fastener industry depends much on suppliers that can harmonize with the International Organization for Standardization such as ISO 898 and the American Society for Testing and Materials such as ASTM and the challenge of checking compatibility across numerous suppliers located in different regions has remained a challenge.

Geopolitical risks and practical restrictions on trade also remain rather serious problems. Taxes, especially on Basic materials, such as steel and aluminum, have affected supply chains in some markets by raising procurement costs and altering relations between buyers and suppliers (Govindan & Hasanagic, 2018). For instance, trade wars and protectionism have affected the raw material supply and costs and some of the available

materials have become scarce while fastener makers have been compelled to reconsider their supply sources.

Disruptions of the supply chains resulting from events like the COVID-19 pandemic have also revealed weaknesses in suppliers. As identified by Saberi et al., (2019), the pandemic led to delays, shortages, and an increase in the cost of transportation and all the above triggered the need for supplier resilience selection. Stakeholders in the fastener production industry kept on complaining of time delays in the delivery of raw materials which affected production schedules and customers.

Fluctuating costs and prices are other issues that contribute to volatility in supplier selection for raw materials. Using data from Burt and Soukup (1985) it is clear that cost efficiency is one of the key parameters that determines the choice of the supplier but due to reliance on materials such as steel, the fastener industry can be greatly affected by cost fluctuations. These fluctuations are, consequently, due to factors outside the company's control, including global demand and supply, natural disasters, or political instability. Suppliers must also be assessed based on their costs and stability, though the two often tend not to go hand in hand.

Another risk is in the counterfeit and substandard products in global markets due to perhaps a lack of stricter enforcement of quality standards. According to Bai et al. (2017), it is about traceability and transparency to help overcome this challenge. To mitigate these problems, new technologies such as blockchain, for example, assert real-time confirmation of the origin and compliance of the materials.

Some of the potential difficulties that emerge within selecting the supplier, include the assessment of multiple criteria is also another challenge. Such techniques in supply management as the Analytic Hierarchy Process (AHP) and scoring models take time and the skills of the analyst, especially when more than two sources of supply or multiple tiers must be evaluated (Saaty, 1996). Also, the fact that many supply chain relations are short-term, and the method of supplier evaluation is quite limited in using models that cannot adapt to change.

CSR pressures have therefore shifted new dimensions in supplier evaluation. According to Epelbaum and Martinez (2014), sourcing decision-makers require manufacturers to

consider the environmental and social factors. This entails rating suppliers on the energy they use, the amount of waste they generate and how they manage it, and their following legal environmentalism. Although these criteria are fundamental for attaining sustainable long-term development, they put opposing demands on cost and time restraints, which pose further difficulties for manufacturers.

Finally, the unsophisticated application of certain technologies in some supplier markets restricts the possibility of complete transparency and optimization of supplier assessment. For instance, based on the literature review by Saberi et al. (2019), artificial intelligence and blockchain can provide opportunities for supplier selection to deepen analytics and improve supply chain visibility. However, implementing these strategies demands a huge commitment of resources and the level of sophistication of a supplier is not easily compatible with the fastener industry.

Concisely, the tasks in SCP are complex including quality issues, geopolitical factors, costs, sustainability, and technology-integrated challenges. There are a few challenges that need to be tackled when it comes to the fastener industry. To overcome these challenges the fastener industry must embrace flexibility and put in place effective risk management measures, embrace technological development, and form long-term relationships with vendors. While recognizing and managing these challenges, manufacturers can create better supply chain solutions that will guarantee the competitiveness of their companies within a global environment continuously changing and developing.

2.6 Research Gaps

Although prior literature comprises a vast coverage of supplier selection in the context of supply chain management, the associated research gaps are substantial when applied to the fastener industry. Specifically, the nature of this sector, which requires high quality, builds products with precise components, and is vulnerable to upstream disruptions, requires special attention that generic supplier selection research fails to address adequately. These are important gaps that need to be identified to move research and practice forward in the field.

One of the biggest difficulties is the lack of use of the existing theoretical frameworks in analyzing the issues related to a particular industry. Other powerful techniques

include the Analytic Hierarchy Process (AHP) and weighted scoring models, some of which are discussed in the literature (Saaty, 1996; Das et al., 2000). However, their application to the fastener industry, especially where precision, cost, and regulation form a delicate propeller, is not fully understood. In the current state of research, several crucial criteria for this industry are omitted: the adherence to international standards including the ISO 898 standard and ASTM specifications; and the assessment of suppliers' ability to satisfy custom design and precision needs (Finnegan, 2001).

One of the gaps relates to the incorporation of hi-tech elements in supplier selection. New techniques such as blockchain and the use of artificial intelligence are known to improve the transparency of the manner and predict the performance of suppliers respectively (Saber et al., 2019; Abeyratne & Monfared, 2016); however, their application is limited in the fastener industry. Interestingly, very few cases exist in the literature that empirically investigate how these technologies can resolve such concerns including counterfeits, traceability of materials, and interactive risk evaluation in the fastener supply line.

Other research directions include analyzing the effects of global disruptions regarding the supplier selection process. The global impacts of such disruptions such as COVID-19 have been explored extensively (Saber et al., 2019), yet their impact on supplier evaluation in the fastener industry is lacking in extant research. Some of the concerns including fluctuating freight charges, raw material availability, and manufacturing lead-time are some of the challenges showing the need for sustainable and flexible supplier selection systems appropriate in this industry.

Another area that has gained little attention in the fastener industry is the study of sustainability in supplier selection. Although researchers have shown a rising interest in sustainability in global supply chain management in general (Epelbaum & Martinez, 2014), published literature in the fastener procurement context mostly discusses environmental management at the minimum level. It is necessary to develop more advanced assessment models that will consider such criteria as energy performance, waste management, and supplier's approaches to the circular economy, particularly as the sector uses many resources, including steel and aluminum.

Also, strategic supplier relationship management is not a major topic in the fastener industry literature. The literature that currently exists tends to focus mainly on the simple aspect of cost and time with partner suppliers though this has strategic value. According to Burt and Soukup (1985) developing a good relationship with suppliers means that you are going to co-develop products, and innovate in processes besides strengthening your supply chain, especially in industries where precision and quality are an issue.

Lastly, the supplier selection issue has the aspects of geopolitics and regulations unresolved sufficiently. Even comparatively contemporary works, like Govindan and Hasanagic (2018), stress the role of geopolitical factors in supply chain management and trade policies, however, their detailed role in the fastener industry, for instance, in the regulation of tariffs on the purchase of raw materials or the compliance with export standards, remains insufficiently studied.

Regarding the limitations of the emerging research themes, the identified gaps are as follows: the application of theoretical models for fastener industries; the insufficient usage of emerging technologies; the lack of research on resilience frameworks to cope with global disruptions; and the insufficiency of supply chain relations focusing on supply chain sustainability; the need to focus on long-term relations with suppliers; and the impact of geopolitical factors. Filling these gaps will contribute to the practical benefits for academics and business users as there is an opportunity to form more efficient and specific approaches to selecting the supplier.

Chapter 3: Research Methodology

3.1 Research Design

The approach used in this study is the qualitative research method since determining the choice criteria of suppliers in the fastener industry may present a sequence of complex processes. The method is selected over the quantitative approach because the latter is not always sensitive to context, especially when it comes to an intricate and contingent process like supplier selection. Quantitative research reveals variables and hypotheses and is not as useful for the “why” and “how” when studying decision-making compared to qualitative research which is most useful in this situation (Creswell, 2014). This approach is well suited to the research objective of identifying

myriad criteria for supplier selection, the insights from manufacturers, and evaluating the effectiveness of existing methodologies. The decision to use qualitative design is further supported by its flexibility which allows capture of the nature of attitudes, perceived factors, and perceptions from professionals in the industry, which is extremely important in determining other subliminal factors that affect supplier selection.

The research methodology is kept rather simple since it is explorative research focusing on a field of academic research that has already been developed quite well, the supplier selection theories of the fastener industry in particular. Bryman and Bell (2015) posited that exploratory research is most appropriate when the topic under consideration is not well understood or when there is interest in obtaining a prior and different point of view on processes that have already been explored. Exploratory research is suitable for application here in the sense that it allows the researcher to conduct a comprehensive analysis of the existing literature and the details of organizational issues unique to the fastener industry, including supplier evaluation systems. In line with the gaps identified in this research, this design allows for the integrated evaluation of the specifications of the various industry demands, standards, and approaches to the supplier selection decision.

The first source of data collection is based on conducting semi-structured interviews with the key stakeholders from the fastener industries, including procurement managers, supply chain analysts, and fastener suppliers. Semi-structured interviews were used because they provide a high degree of standardization yet, at the same time allow respondents to expound on their views. Compared to other kinds of interviews such as structured and unstructured ones, semi-structured interviews in this case strike the middle ground as to the response depth. This method is chosen intentionally because of its versatility as far as obtaining a wealth of information and overall purpose when comparing the participants (Patton, 2002, p. 443). In this context, it is possible to ask questions related to specific areas of interest, for instance disruptions happening all over the world or the impact of organizational technologies while at the same time giving the respondent the freedom to give a perspective on the same since the interview questions are semi-structured.

The study also employs a purposive sampling procedure in the selection of participants who have relevant knowledge and backgrounds in the fastener industry. Sources of supply of telecommunications equipment": Because purposive sampling targets participants who perform specific supplier evaluation and procurement activities in their organizations, the data is accurate and pertinent. It is quite different from other types of sampling such as random sampling which may comprise people who are even inexperienced on the topic of discussion (Bryman & Bell, 2015). Thus, the companies guarded the reliability and significance of the collected data since participants assess and purchased supplier products within their organizations (Bryman and Bell, 2015). This research considers the participants across different organizational positions and geographically to cover more ground on the issues and actions that surround the supplier selection for manufactured fasteners.

Evaluation of the data is done thematically, and this method is splendidly perfectible in identifying patterns and themes in the qualitative study. From the words of Braun & Clarke (2006), thematic analysis is a method whereby codes are used to categorize data into topics, arranging these topics into themes and attempting to make sense of the findings about the research questions. This method suits the main objectives of this study particularly well due to its ability to both recognize known and novel factors influencing supplier selection. The thematic analysis approach is also appropriately flexible to capture the detailed, industry-related data collected in this study to maintain both systematic and profound analysis of the results.

The following are some basic ethical considerations that have informed the proposed research design to enhance the reliability of the study. Respondents have explained the purpose of the research and are then asked whether they agree to be interviewed. Both participants and observers are told that their data will only be used for the research and that their identity will not be revealed incidentally in any findings. Procedures on ethical consideration are very much implemented to avoid any biased results and to maintain the credibility and in turn reliability of the participants since they will produce genuine data Bryman & Bell (2015). The respondents' identities are concealed to ensure that their information is not used for purposes other than research (Bryman & Bell, 2015).

Therefore, through the process of cross-sectional research design and using the purposive sampling technique, the study has employed the qualitative research

technique known as the semi-structured interview and more particularly the thematic analysis of the results to grasp the broad concept of supplier selection in the fastener industry. Because participants who were involved in the study were selected from the industry, the study unveils invaluable information that enhances both practical and theoretical understanding of supplier evaluation. The use of these methods and approaches guarantees that the research meets the industry-specific issues and practices of the fastener industry while providing valuable insights into the overall studies of the supplier selection discipline.

3.2 Data Collection Methods

The first method of data collection for this research is through conducting semi-structured interviews with the participants in the fastener industry. Semi-structured interviews were selected because they lie midway between the highly structured and the highly unstructured and are best suited to investigate complex processes such as the selection of suppliers. In comparison to structured interviews that only allow participants to give certain answers, semi-structured interviews are more thorough but not completely divergent enough that comparisons cannot be made between participants' responses (Patton, 2002). They also are more structured than unstructured interviews – this might be because having no structure to the interview could pose problems when trying to analyze the data that has been gathered. It facilitates the evaluation of the various aspects of supplier selection processes and issues and highlights research propositions from the eyes of the practitioners.

Among the respondents are procurement managers, supply chain analysts, representatives of sectors supplying primary production and manufacturing products, and commercial companies. This diversity guarantees that the data collected involves all the phases of the supply chain that participate in the supplier selection process. The multisource design enhances the models' ability to address the linked issues and practices based on the multiple roles and organizational levels characteristic of the fastener industry. As a result, this research combines the perspectives from international markets and the raw material industry sector to target the particulars of the fastener sector.

The interview was conducted formally to reduce schedule influence since it also provides flexibility that may consist of more important information as expressed by the participants on the topic of concern. This protocol implies the identification of carefully selected questions that reflect the context of the research and guarantees that certain research objectives will be met although the participants are free to expand and give examples. The protocol includes a structured set of core questions, aligned with the research objectives, covering the following themes:

- A case of how the choice of supplier affects the supply chain and the need to choose carefully.
- Methods used for performance evaluation and selection of suppliers.
- Accounting applicable theories & examples: Examples of bad supplier selections & the results.
- Position of the development of additional technologies such as blockchain and artificial intelligence in supplier assessments.
- Possible measures that can be taken to minimize risks that arise when conducting supplier selection.

Interviews can be, therefore, face or online depending on the participant's availability or even geographical location. This flexibility makes it possible to overcome such problems as geographic dispersion of participants and other logistics issues complicating data collection. All the interviews are recorded on a cassette (with the participant's permission) to make sure the information is not missed in transcription and for further analysis of the interviews. The interview discussions recorded on the device ensure that data is not lost while the data analysis also becomes more accurate. Employees/stakeholders of the organization are also interviewed or interviewed to capture the impression made while participating and other valuable points of discussion noticed by the participants.

Since this study aims to target the active participants in supplier selection and procurement, a purposive sampling technique is used. Since purposive sampling focuses on certain experiences and expertise of the volunteers, it guarantees the collected data is useful for the given research objective (Bryman & Bell, 2015). In contrast to the Random Sampling technique, which may sample participants without adequate information about supplier selection, purposive sampling allows the study to

capture information from participants directly involved in procurement decisions. The method used ensures the information obtained is as accurate as possible and the participants are conscious of some of the aspects involved in the fastener business since they are professionals doing business in the market. The selection criteria include:

- Roles that are more connected with the procurement tasks and suppliers' assessment.
- Position themselves from sourcing raw materials, production, and marketing companies.
- Prior experience in managing international suppliers and the general foreign supply chain environment.

To strengthen the quantitative data, secondary data sources comprising industry reports and forced performance supplier performance data are used in the study. These sources are also important to bolster the findings being proposed from the interviews to ensure authentic ones. Secondary data complement primary data in the event of perceived gaps by providing trends and practices of the fastener industry. These sources provide background information and probably can be used to support data collected from interviews that was the main data-gathering approach in the study.

Ethical matters are very central, especially in the process of data collection. The participant gets to receive information about the study and the objectives from the researcher and gives their permission to be interviewed. Participants are given the guarantee that they and anyone they identify in the study cannot be identified by the researcher, and responses will only be used for research purposes. Such an approach is very helpful in providing accurate information because participation is real and truthful. Of-record communication and/or anonymity are used to have respondents candid about their perception for purposes that cannot be discussable in this context. Precautionary measures are taken to ensure that the recordings, the transcriptions, and all other information that may be gathered during the study are protected (Bryman & Bell, 2015).

Hence, the principal data collection method of this research is informal interviews with respondents in tandem with purposive sampling and post-hoc data compilation. It is recommended to adopt a multiple approach to get a rich picture of the supplier selection and to avoid single-source bias. The combination of primary and secondary data in the

research underscores the fact that the findings closely represent the nature and extent of the practices and difficulties particular to the fastener industry. This approach ensures that data particular to supplier selection processes will be collected as articulated by the aim of the research and the specifics of the fastener industry.

3.3 Interview Design and Sampling

The interviews and the sampling method being used in this study are relevant in the same way because they enable the collection of proper and sufficient information. The interview schedule is deliberately constructed to achieve the research aims and objectives but allows ample independence to the subjects. This approach makes sure that research objectives are met throughout the period, but participants also get to explain their different experiences in detail, hence enriching the outcomes. It also helps to adopt the concept of collecting more relevant and accurate data as opposed to the herding effect where the researchers, professionals, etc., of the fastener industry gather more similar opinions and perceptions.

The interviews are mainly carried out with a set of questions; some of which are structured since they have set answers while others are semi-structured since they are usually general to encourage elaborate answers. This means of organization allows a routinized structure to take place yet allows for enough deviation as needed to probe the discovery of potentially useful ideas during the discussion (Patton, 2002). The interview protocol is designed around key themes, including:

1. The role of supplier selection in the context of the fasteners industry and its impact on supply chain efficiency.
2. The tools and techniques applied to assessing suppliers and choosing a supplier, with examples of good and bad choices.
3. Potential offered by technological tools, for example, blockchain and AI, in enhancing supplier rating systems.
4. Problems and threats faced in the supplier selection process, such as political risks, which encompass political instability, cost fluctuations, and quality control mechanisms.
5. Some ways in which these challenges may be addressed and long-term supplier relationships fostered.

The protocol is useful practice in enhancing order in interviews and not limiting the participants as much as they can elaborate on aspects they hold as important in their observation. The formal structure helps to maintain the comparability of responses across interviews and facilitates comparison. However, the informal framework lets the participants discuss real-life events and instances hence adding richness to the findings. It is meant to facilitate the flow of detailed consideration while at the same time does not occasion much relinquishing of participants' precious time since each of the interviews will perhaps last up to forty-five minutes to an hour.

To offer feasible examples in addition to the data and to enhance the research material, participants are invited to offer examples, stories, personal experiences, or recommended practices relating to supplier selection in the fastener industry. This technique increases the validity of the data because it brings concrete realities and links them to the theoretical debates. This is a tactic used for one to seek elaboration on topics of concern considered by either of the parties to be prototypical or surprising.

A purposive sampling technique is employed to select participants in purchasing activities and supplier selection of the fastener industry. Therefore, the purposive sampling method was used because it enables the selection of people with specific characteristics that can provide information relevant to the study goal and objectives and would thus provide informative and actionable data (Bryman & Bell, 2015). This strategy is particularly useful to ensure that the attained sample offers the required depth and variety of experience required in the study. The following criteria guide the selection of participants:

- **Professional Roles:** Participants must be supplying chain personnel such as procurement managers, supply chain analysts, and operations managers with responsibility for supplier assessment.
- **Sector Representation:** Targets are selected from different segments of the fastener value chain, focusing on raw material suppliers, manufacturers, and commercial users, ensuring a comprehensive supply chain view.
- **Experience:** Special attention is paid to candidates with relevant experience in supplier selection, particularly in dealing with international suppliers and managing complex supply chains.

This concerns customers with the sample taking an inclusive cross-section of both domestic and international markets due to the multination of fastener chain supplies. This diversity leads to the fact that the results obtained also provide an understanding not only of the regional differences but also of the problems and opportunities of the fastening industry of the entire world. Proper attention is paid to everybody's participation, both big firm participants and the small and medium enterprises participants included.

The participants are asked through organizations, associations, and recommendations. When outlined, they are contacted through mail or various business networks such as Linked In, with clear explanations of the research, the purpose of the research, and issues regarding the research subjects. The survey is completely anonymous and the audience that is targeted is assured of their anonymity and privacy to get back their response. This is particularly important to enhance participation by encouraging researcher-participant cooperation based on mutual understanding.

Later, there are standard ethical procedures required to be followed all through the interview process. Informed consent is used in which participants are given written documents containing the outlines of the study project, how the information gathered is going to be used, participants' rights and they have an option to withdraw at any time. Since all observations made are kept secret, the presentation of results also protects the identity of individuals (Bryman & Bell, 2015). These ethical measures are important in ascertaining the validity of the study and safeguarding the participant and or subjects.

Therefore, the design of an interview and its sampling ultimately is planned in a manner as to achieve enough significant and reliable information. It allows obtaining large amounts of qualitative data at the same time making the interviews roughly formatted. This purposive sampling technique:

- a) ensures that the participants are well equipped to provide rich information on supplier selection problems about the fastener industry.
- b) provides sufficient understanding of the matters important to the fastener industry and the Company.

This study accomplishes the goal of data collection in two ways, namely a well-structured interview conducted and a specific selection of participants.

3.4 Data Analysis Techniques

The types of cross-sectional data analytical techniques employed in this study are intended to enable the systematic definition of relationships, themes, and refinements within the qualitative interview data collected. Thematic analysis is adopted to assist in taking a closer look at the supplier selection best practices and issues in the fastener industry. The reason for selecting this approach was because of the ability to map its guidelines to pattern recognition of qualitative data, while at the same time offering the researcher leeway to go back to theory as the data collection proceeds and explores occurrences that may have been foreseen in the patterns under study as highlighted by Braun and Clarke (2006). Braun and Clarke (2006) stipulated that thematic analysis has the following components to make coding and analysis systematic to address the research objectives.

The procedure begins with another form of data acquaintanceship, which entails the reading of transcriptions several times just to be aware of the data contents. Researchers get to point out certain facts, observations, or repetitions to enable them to draw a broad meaning out of the data gleaned. Forecasts or perceptions are left there to be kept for future analysis or findings. Subsequently, data pieces are encoded by identifying the lower portions of the text that might contain the answer to the research question. Codes are attached to those parts of the text where different problems are discussed, such as the criteria for the choice of suppliers, measures to minimize risks, or to implementation of new technologies.

Following that category of codes, categories or themes are then developed to integrate different codes into broader patterns that define the prevalence of the various categories in the data set such as quality assurance, costs, and geopolitical risks amongst others. This carries out the step of clustering similar codes together to develop themes that can capture the data reasonably well. These themes are then refined to integrate what has been learned within the research objectives. These themes were discussed to reconcile and integrate the themes set into a better understanding of the data and the goal of the study. Similar strategies are merged or, if present, secondary strategies are identified; m Similar strategies are merged and second strategies are identified if they exist. In

sequence and consequently, each lead to the development of a definition for the theme and intentional naming that is systematic and congruent with an identified approach to reporting such findings. Last, the themes and their proofs are the analysis that links them to research questions and the extant literature.

Concerning the credibility of the study, triangulation is employed in this study as a data source that gathers data from different industry reports and supplier performance data. This approach strengthens the findings from interviews by getting an outside overview of the analyzed issues, gathered from secondary data sources.

Managers and collectors of qualitative data usually engage in systematic analysis of the data utilizing NVivo or similar software. These tools are used in coding, retrieval as well as visualizing themes thus affording a systematic and commentary approach to the analysis. Thematic analysis is improved using software such as NVivo as it increases the evidence, efficiency, and reliability by proposing a rigorous evaluation of the data.

Eight themes are derived from the data set and the themes are in line with the research objectives highlighted in the study. For example, the theme on evaluation criteria informs a reader about what is considered very important in supplier selection while the theme on technology integration and risk management strategies shows the reader about ways and means that are used in practice. Appropriate themes of the research include cost variation and quality risk as they relate to the fundamental problems of supplier selection, and the identification of the new themes enables evaluation of new trends or unexpended factors in the field of fasteners industry.

The proper procedure for dissecting the data is the thematic analysis technique since the technique is intentionally flexible for the examination of the different qualitative results. This makes the AT&T approach especially valuable for properly managing the many and continuously changing facets of supplier choice in the fastener industry. In this way, it is possible to identify not only the anticipated and novel trends that define supplier selection practices in the fastener industry. The fact that nearly all the procedures are in the form of software proof allows systematic, replicable, and well-documented work to be done.

Ethical practice is not violated, taken right from the analysis of the data collected. Erasure of data during transcribing is done confidentially and only the investigators are allowed to access raw data, thus making the analysis more precise. All participants' identities are concealed throughout data collection analysis, and write-up since data protection is a significant ethical consideration (Bryman & Bell, 2015).

Thus, the approach named thematic analysis can be identified as quite a reliable and comprehensive procedure for the analysis of qualitative data with the assistance of triangulation and some specialized software tools. It is useful to ensure the confidence, coverage, and relevance of the findings to the declared objectives of the research. The following sources of knowledge supply a supplier selection model applicable specifically to the tendencies and issues of the fasteners manufacturing industry.

3.5 Limitations and Ethical Considerations

It is noteworthy that in this research, several limitations have the potential to affect its range, management, and outcome. Firstly, the generalization of the study findings is constrained due to the adoption of qualitative data collected through face-to-face semi-structured interviews. This method yields comprehensive and quantitative information about supplier selection in the fastener industry; nevertheless, it may not be generalized to other industry types or locations. According to Bryman and Bell (2015), qualitative research is characterized by Limited generalizability because qualitative research aims at achieving depth rather than width. Furthermore, the purposive sampling strategy is efficient for engaging people with adequate knowledge and experience to provide informed responses and, at the same time, contributes to the selection bias. This is because all the participants in the study are professionals implying that there is limited representation from young or less experienced employees or those without traditional careers in the VR environment.

A final weakness consists of implementing interviews that rely on respondent self-reports that might be subject to respondent bias or memory distortion. When I read Patton (2002), contributor replies characterizing qualitative research stems from their characteristics and may indeed distort objectivity in the research process. However, time and resource restraints restrict the number of interviews sampled and achieved, thus restricting the scope of data coverage. While striving to achieve thematic saturation,

the sample size could be expanded to achieve more profound insights into supplier selection issues and approaches.

Another major drawback of this analysis is that the highlighting of the fastening industry also has implications for generality. Even though the study is designed to fill certain existing research gaps, the results may not reflect all the supplier selection procedures and issues that may exist in various industries. In addition, due to the dynamics of the global supply chain over the last several years and the development of new technologies, other factors that are not considered in this research may occur.

From an ethical viewpoint, the investigation developed and strictly followed the rules that allow for obtaining credible and ethical results and conclusions. According to Bryman and Bell's (2015) ethical considerations, participants offer specific information about the research objectives, aims, and uses of data required for the study. All participants are asked to read and sign consent forms before interviews, so they are also aware of their rights saying that they can withdraw their answers without any reason at any time. To ensure Patients' anonymity, all distinguishing features are masked during transcription, and results are presented in the aggregated form.

Actuality confidentiality is also well considered, storing all recordings and transcripts to make sure no one may gain unauthorized access. These measures conform to Patton's (2002) call for ethical conduct in qualitative research given that the participants' identity must be protected, and the research findings need to be credible. That is why there are no questions that might cause discomfort to a respondent or disclose some important information that can influence the business. However, while restricting the data to businesses, it is more likely to do so with some ethical violations while remaining impartial and more inclined to study the overall practices and trends of the industry.

However, the study is limited by the following drawbacks and still contributes significantly to the understanding of supplier selection in the fastener sector. Such limitations allow the research to remain both transparent and credible while also providing applicable advice to the industry players.

Chapter 4: Empirical Results

4.1 Overview of Findings

Based on the results of the semi-structured interviews, a better understanding of the process of supplier selection in the context of the fastener industry can be achieved. Having identified and discussed theoretical aspects by comparing the views of various experts such as procurement managers and analysts, as well as multiple professionals, several major themes and patterns have been assessed. The evaluation findings provide a comprehensive insight into what supplier selection means, its key components, and most importantly, the strengths of supplier evaluation criteria, the kind of tools that existing methods and tools are efficient, the difficulties that decision-makers face, and ways of minimizing these difficulties.

A notable study result is the supplier evaluation criteria in the fastener industry. Concerning the views of participants, the latter stated that criteria including product quality, cost, delivery reliability, and compliance with internationally accepted standards such as ISO 898, and ASTM is critical in supplier selection. For instance, a procurement manager expressed: “If the supplier can’t give quality, do we have to worry about cost or the delivery dates”. It is a statement that resonates with the industry’s drive to make quality a non-negotiable item as evidenced by the reliance of many products on metal (steel, iron) based parts that must reflect high levels of precision and durability.

Another important finding could be identified in the techniques applied to select the suppliers and assess the performance of the current ones. Both AHP and scoring models seem to be central to the overall MCDM process, and these two methodologies were mentioned by interviewees more often than any others. Such an approach also makes it possible to evaluate several criteria at the same time as compared to the traditional tools that limit the supplier evaluation processes. Concerning what can still be observed in the providers’ participants, it highlighted that although such artifacts as spreadsheets remain utilized, there is more pressure toward the digital performance management and utilization of software tools. These methods were said to have been adopted to achieve better decision-making and to reduce bias in supplier selection.

The results also revealed aspects of the process most respondents found difficult during supplier selection. Some of the risks mentioned by interviewees included geopolitical risks, raw material scarcity, and disruptions occasioned by mega events like the COVID-19 pandemic. For example, one procurement manager said the following: “COVID-19 has shown that we have depended on specific regions for supply, whereas now we’re reconsidering this approach.” Some other participants focused on increasing freight costs and applying tariffs to metal, for example, steel and aluminum which influenced the direct criteria to select the supplier. This underlines the fact that industry must look for other sources of supply and contain scenarios likely to result in disruption of the supply chain.

Another major problem is the failure of the suppliers and manufacturers to meet the necessary certification and accreditation requirements of the industry. Interviewees also observed that most of the suppliers, especially those from the emerging region, fail to meet ISO 898 or ASTM standards. One of the participants had this to say: “Sometimes we are supplied with products that do not meet the specified standard, yet the fortunes of having to send them back or perhaps the cost of correcting them is rather steep.” Thus, the experience mentioned above strengthens the need to implement quality assurance throughout the selection of suppliers and renders increased attention to such technologies as blockchain that can be considered as the solution to maintain the suppliers’ compliance with the signed agreements.

On a positive note, it was found that firms in the fastening industry are taking measures that were innovative in solving the problem of supplier selection. For instance, the solution of initiating blockchain solutions is gaining ground in companies to authenticate the source and quality of raw materials. Certain participants also stressed the need to establish close-knit cooperation with major suppliers to mitigate identified risks and deploy a trust-based context. Another procurement manager shared, “The kind of relationship that is has with a supplier enables one to solve most of the quality issues in a way that they do not affect the production process.” Such insight demonstrates a shift towards supplier development and relationships as a strategic supply chain management concept.

In summary, the results of the study offer a life cycle approach to understanding the makeup and characteristics of the supplier selection process in the fastener industry.

These are basic criteria used by firms that seek suppliers as seen in the data and other issues that arise from disruptions, tariffs, and regulations. The application of theories such as AHP and scoring models, moreover, the incorporation of new technologies that are blockchain, has shown a more organized approach and work plans indicating that the industry is moving more towards data-based well managed, and more transparent decision-making systems. These findings provide a basis for subsequent analysis of criteria and methods for selecting suppliers and presentation of solutions to this problem, discussed in the following sections.

4.2 Supplier Selection Criteria in Fasteners

The decisions relating to suppliers are made based on the carefully defined criteria in this fastener industry to get the best quality and value-for-money products at the right time to meet the actual demand. Through insights gathered from interviews with procurement managers, supply chain analysts, and industry professionals, five key criteria have been identified as critical for supplier selection: quality, cost, delivery performance, conformity to the standards of the international market, and other aspects of supplier dependability. All these criteria are important to influence procurement decisions to keep firms running and fulfil customers' demands.

The most important factors were determined to be product quality and feedback, and all of the participants agreed that product quality could not be compromised. Fasteners are relative components applied in the automobile industry, aviation industry, construction industry, and other industries, where product quality safety and mechanical properties of fasteners have a direct relation to the quality of the product. Concerning material properties and quality requirements, the interviewees stressed that suppliers have to adhere to international standards such as ISO 898 concerning mechanical properties and the ASTM standards regarding corrosion properties. A procurement manager said, "If a supplier cannot provide fasteners that meet the necessary quality, then we cut them out from our suppliers' list no matter the price." Standardization of quality, material certification, and implementation of testing standards have now become norms for vendor evaluation, for instance, of the supplied steel, iron, and other metal alloys. Consequently, quality is the dominant characteristic, because failure to deliver high-quality fasteners means returns, warranty costs, and damages to companies' reputations.

The next qualification is the cost where the price is not only the amount of money paid for the product, but also the total cost of the acquisition during its life cycle. Some of the interview participants maintained that while adopting the lowest purchase price might result in overall lower costs in the short-run, it has long-run costly consequences such as costs of rework, delayed production, and/or poor-performing products. Organizations today focus on the fact that costs must be studied in terms of their strategic implications on the management of the supply chain and its supporting costs such as transportation costs, customs duty, and costs to recover the freight charges. The current tariffs placed on steel and aluminum have raised the cost of imported fasteners, forcing firms to change their supply chain. According to one of the procurement analysts, “A cheap supplier sounds great, but you will be receiving your products way later than expected or the quality of the received supplies will be low, and the supposed cost advantage is offset by other costs.” Hence, the business is employing Multiple Criteria Decision Making-MCDM tools in providing the right mix- cost and other aspects such as quality, delivery, and reliability of suppliers.

Delivery performance is another strategic criterion that influences the agile performance of production schedules since many firms depend on just-in-time (JIT) production systems. Firms want to receive supplies on time to enable them to avoid delayed production hence they evaluate supplier lead times and on-time delivery rates. These delivery-related KPIs are monitored by many firms using supplier management solutions that give visibility to delivery status and other operations. The interview study showed that suppliers with delay tendencies can be demoted in supplier scoring systems or excluded from the list of qualified suppliers. In the words of a supply chain manager, “Timing of delivery is very important.” A tiny amount of time lost means that production is stopped for a whole day, which is much more expensive than the fastener itself.” Suppliers today that are most valued are those who can deliver goods on an as-needed basis and bend to the whims of production schedules.

Another precondition for selection is the agreement with international standards and certification. Suppliers of fasteners to companies in the fastener industry need to meet international requirements aimed at guaranteeing the safety and durability of the products. ISO 898 (Mechanical properties of bolts, screws, and studs) & ASTM (Corrosion resistance) are the most spoken compliance issues. This paper revealed that

firms demand CoC and test reports from their suppliers during the supplier evaluation. Suppliers who are unable to show evidence of compliance with certain standards are normally locked out of procurement contracts. The constantly increasing usage of traceability systems based on blockchain technology is now helping to simplify the checking of suppliers' compliance. Some of the participants in the interviews pointed out that through blockchain, firms can attest to the origin and production history of fasteners to meet certification standards. Another procurement manager explained, "We do not allow suppliers who cannot give very detailed data concerning the origin of products, right from the sourcing raw material stage to the time the products are shipped." This eliminates cases of suppliers' failure to meet regulatory standards and customer specifications, hence minimizing cases of product recall.

The last but not the least criterion with a total weight of 25% is supplier reliability, which regards the supplier's performance, activity, and compatibility needed to build long-term partnerships. While supplier reliability is not sufficiently measurable like cost or quality, this attribute is the second most important criterion for supplier selection. Concerning supplier performance measures, interview participants stated that where needed, the reliability of suppliers is evaluated based on performance indicator cards that reflect Supplier SAMs, including quality, timely deliveries, and flexibility in production to demands for change. Firms also assess their management of some risks, some of which include supply chain disruption risks and other demands risks. Supply chain analyst said a lot: "It's like when you do business with a supplier for years and they did a good job, then you will believe them even more during a calamity." Procurement professionals prefer to use a dependable supplier even if the supplier is more expensive than a fly-by-night 'cheaper' supplier during disruptions. Management requires suppliers that can bend both ways and who can provide information without holding any secrecy and parties willing to sort out problems on their own. This has begun forcing many contracting firms to establish supplier development programs in which core suppliers are trained on quality management, delivery competence, and organizational efficiency.

Apart from the findings from the five basic parameters (quality, cost, delivery, compliance, and reliability), the interview participants enumerated several new parameters that are gradually gaining popularity. For instance, companies' suppliers are

now being analyzed by their changed capacities and willingness to embrace sustainable and environmentally sustainable practices, for instance, utilizing recycled raw material or having a lower carbon footprint. This trend is in concordance with general CSR strategies, particularly for multinational corporations experiencing legislative challenges on the environmental footprint. Whereas sustainability as a criterion is not so vital at present that it must be an essential criterion for all firms dealing with other firms or organizations, it is gradually emerging as a criterion that can distinguish a suitable supplier firm from an ineligible one. Another criterion that is emerging is technological capacity where firms seek to partner with suppliers who use blockchain theory to track products or who have production lines that use analytical information.

In summary, supplier selection in the fastener industry is guided by five core criteria: Quality of services, cost, delivery, compliance with regulations, and reliability. All of these criteria have a specific purpose in supplier assessment and in combination define a supplier's score in MCDM models. Quality and conformity with standards are the major issues that firms focus on since fasteners have a direct impact on the safety and reliability of equipment. To enshrine compliance, and checks and balances, companies insist on tracing the origin of the fastener through blockchain solutions and request the supplier to provide a certificate of conformity (CoC) in the wake of ISO 9001 and ASTM. Though many industry requirements are still cost and quality factors, requirements like sustainability and technological readiness are becoming critical factors for industries. Through the systematically streamlined supplier selection process, risks can be minimized, and supply chain solutions may be optimized for sustained industry competitiveness in fasteners.

4.3 Methods and Tools

The functions and activities involved in supplier selection in the fastener industry provide an important basis for procurement decisions that are as rational, methodical, and striving for the basic objective as possible. The results derived from the analysis of the semi-structured interviews show that firms compare suppliers using both qualitative and quantitative methods. Some of the most typical approaches mentioned are MCDM tools, AHP, scoring models, and the application of digital supplier management tools. These methods seek to minimize conflicting factors like cost, quality, lead time, and supplier's ability to meet international standards.

The most often reported approach was the application of MCDM in which firms can compare multiple criteria of suppliers at once. It provides an opportunity to weigh the suppliers depending on the cost, quality, delivery performance, and adherence to the rules. To paraphrase one procurement manager, they said that “It is imperative that by applying multiple criteria no criterion can take the dominant factor such as cost.” We want a balanced approach.” There was a strong focus that MCDM enables firms to assign weight to each criterion relative to several factors that define the businesses.

Other criteria examined in the study indicated that the Analytic Hierarchy Process (AHP) method was widely accepted in the supplier selection process and warranted its use amongst competing methods where there are multiple decision-makers involved. According to AHP, the decision-making process can be divided into multiple levels where each of the levels contains a criterion or a sub-criterion. Some attendees reported that AHP is often used when determining the supplier of critical fastener elements: there is always a rational method for comparing choices. This method is most effective when there are compromises between cost, quality, and time of delivery as in multinational procurement processes. A supply chain analyst said, “AHP makes one consider tradeoffs, and it helps put an organized structure to a technique that may be viewed as too subjective.”

Supplier selection also involves the use of scoring models which are extensively used in contracting. These models empower organizations to rank suppliers according to a set of parameters that are already predetermined. The performance of each supplier has been evaluated on factors like cost, quality, delivery, and compliance. Importance factors are rated using weights and ‘points’ are given to each supplier to arrive at a total score. The participants noted applicability and comparably low complexity as key strengths of the scoring models. Scoring models on the other hand are easier to comprehend and they are timesaving compared to other tools such as AHP. There is one comment made by one of the participants: “In our team, we like scoring models more as they can be applied easily, especially when working with different suppliers simultaneously.” However, some participants confessed that scoring models work less well in cases of difficult decisions that involve the analysis of dependencies between the criteria.

Some of the trends that were identified are the use of digital business platforms as well as supplier management software solutions. These platforms automate supplier ratings and allow for constant monitoring of supplier performance. Managers and buyers employ IES that indicate delivery performance, scorecard, quality inspection, and supplier compliance data. Technology has made it possible for any procurement manager to have a central point where the evaluation of suppliers' performance can take place using dashboards in digital platforms. A procurement specialist shared with the interviewer the following, "With the development of digital platforms, it is no longer a case of cobbling together manual scorecards." "We receive real-time performance information on the suppliers". An added concern to some firms is the use of blockchain technology in enhancing the traceability of the raw materials through to the steel and metal components used in fasteners.

While the selection process of suppliers relies heavily on quantitative tools, qualitative tools still have a relatively large influence on the process. The use of experience of the procurement managers and supply chain analysts is also common among organizations to judge suppliers' reliability and flexibility. Some of the interviewees said that they always try to speak with lower-level managers and employees of suppliers conducting a semi-structured interview, during which one can assess the supplier's willingness and dedication towards satisfying the buyers. Recommendations from other clients also form part of the quality known as reliability provided by the supplier.

The specific evaluation methods and tools of the fastener industry in supplier selection are characterized by a conceptual mixture of simplicity and strictness as well as innovation and a reduction of complexity. Suppliers are evaluated based on several criteria which include the use of an analytical hierarchy process, scoring models, multiple criteria decision-making tools, and digital supplier management platforms. The combination of blockchain technology and digital platforms analyses in this work indicates a paradigm shift towards evidence-based strategies. Employing these strategies and techniques, businesses strive to ensure that the choices of suppliers are rational, justified, and unambiguous as much as possible where the conditions of the global supply chain procurement process are rather volatile.

4.4 Challenges in Supplier Selection

The process of supplier selection in the context of the fastener industry possesses several stark potential issues that have a direct bearing on overall procurement effectiveness, organizational productivity, and supply chain effectiveness. Interviews with experts in the procurement and supply chain departments showed that some of the emerging hard problems include political risks, unpredictable costs, compromised supply chains, questionable product quality, and compliance of suppliers to global regulatory measures. They not only make supplier selection decisions more complex but also necessitate higher levels of supplier evaluation and risk management techniques to be implemented in companies.

The following is a list of these risks: Geopolitical risk is perhaps among the most significant because it can influence suppliers' accessibility, materials' prices, or delivery times. It is widely known that changes and regulations regarding import/export, trade wars, and tariffs on basic materials including steel and aluminum have a large impact on the choice of suppliers. Respondents observed that additional tariffs placed on steel imports into various markets such as the United States cause higher costs of fasteners, due to the transfer of these new costs by suppliers. A procurement manager put it this way, "The moment tariffs were applied to steel, he noted that many of the suppliers hiked their prices and therefore the organization had to look for other suppliers from other parts of the world which were banned from accessing the product." The exposure of these firms to geopolitical risks has informed their decision for regional supplier diversification to avoid disruptions of supply of raw materials due to trade restrictions.

Fluctuations in cost are another tough characteristic that makes the selection of suppliers challenging in the fasteners industry. The cost of major inputs, especially steel and iron, has shifted significantly over time due to production supply or demand constraints, geopolitical tensions, and rising production costs. All the interviewees pointed out that fluctuations in the prices of materials adversely affect supplier relations as suppliers seek to change prices or postpone delivery to a time when price volatility is likely to ease. As a carefully chosen example, one participant said such following words, "We had a supplier once delay our shipment for two weeks because they are waiting for the steel price to get cheaper before they can produce more." This shows

how firms are exposed to fluctuations in the cost base of supply chain partners. To overcome this challenge, firms try to agree on fixed price contracts with suppliers or where this is not possible firms may use dynamic pricing policies that include the maximum or the ceiling price to be charged.

Another more often mentioned issue is the disruption of supply chains, which intensified due to the COVID-19 pandemic. Pandemic-induced disruptions such as factory downtime blocked ports, and a slowdown in international transportation routes put a significant amount of delay into their fastener's delivery. Some of the interviewees noted that the delay was made worse by what they referred to as just-in-time (JIT) production systems commonly used by manufacturing firms. For instance, a procurement manager said this: "As we experienced in COVID-19, lead times on fasteners that used to be sourced from overseas stood at 4 weeks were extended to 12 weeks, and this compelled shutdown of production lines." Following this situation, most firms realized that relying on single-source suppliers was disadvantageous, due to constant disruptions and lead time challenges. Many organizations are reviewing supplier strategies and extending suppliers all over the world to be safe from a singular supplier or a specific region.

One of the biggest difficulties in the fastener industry is overcoming issues with quality, particularly in terms of ISO 898 and ASTM. These international standards stipulate mechanical properties, tensile strength, and corrosion resistance of fasteners, and manufacturers of fasteners for use in the automotive, aerospace, and construction sectors it is always preferred to meet these standards. The respondents agreed that one of the challenges that emerge during the supplier selection process is that some suppliers, especially those from lower-cost countries, cannot guarantee that they will provide products of such quality. For instance, a supply chain analyst said, "We once received a batch of fasteners with a tensile strength of less than required, from a supplier who was producing an ISO 898 certificate to the contrary, only to discover the certificates were fake." Such occurrences bring out close identification with fake certifications and quality non-conformity. There must be supplier audits and verification check by firms, before entering new supplier contracts. Managers are also using blockchain traceability systems to ensure manufacturer, provenance, and

certification records for fasteners at every level in the distribution channel such as the provenance of materials used in production.

The last one of the major challenges is regarding the adherence of the suppliers of products to international standards as well as the needed regulatory frameworks. Compliance now extends to cover standards that are within the quality specifications such as ISO 9001 on quality management systems besides the environmental management systems within ISO 14001. Sources suggested that numerous suppliers, especially from cheap origins, have difficulties fulfilling these certifications' expectations, and as such, there are some cases where suppliers present falsified documents to gain access to procurement contracts. Of the participants, one example regarding an actual case was given where their company let go of a supplier because the supplier provided fake certificates to the company. This issue raises the question of sound supplier verification procedures and third-party certification audits. Because of this, many firms are adopting blockchain technology to make supplier certification more traceable and authenticate them. To provide complete transparency in the supply chain, the companies want to reduce dishonest activities and guarantee genuine fasteners supply.

A wide variety and complexity of issues is characteristic of supplier selection in the context of the fastener industry. From the geopolitical risks and cost fluctuations to quality compliance and supply chain disruption each of the issues impacts the procurement decisions and lastly the general operational performance. Managerial and risk management frameworks have to be established in which important and efficient principles are implemented among which are multiple sourcing, blockchain supply chain traceability, and supply chain diversification. By identifying many of these challenges, firms are better placed to undertake supplier decision-making and selection more effectively and accurately to minimize disruptions, delays, and non-compliance within the fastener industry.

4.5 Solutions and Case Studies

The fastener industry is threatened by many risks in supplier selection, though firms are managing to work around some of these problems by using solutions that can help augment supplier assessment, reduce risks, and foster continued business. The best

solutions through interviews with the procurement managers and supply chain analysts include Most procurement managers and analysts reported that the suitable solutions include; In this way, with the help of the listed strategies, firms attempt to create more stable and high-quality relationships with their partners based on more open and less sensitive to disruption or poor quality of supplies.

One of the most important solutions is the application of blockchain to establish a correct paper trail. They can be put on a blockchain that allows tracing of the origin, manufacture, and certification of fasteners in the supply chain. It offers a safer platform where documentation of data associated with products' characteristics, conformity to ISO 898 and ASTM standards as well as CoC can be documented and authenticated. Another procurement manager said, "With blockchain, we can check on every process of supply and confirm that no fake certificate was issued." Such information remains sharable while the physical identifiers for batch numbers and production details immutably reside in a blockchain ledger, thus minimizing the dangers of fake certifications, poor-quality fasteners, and unreported quality inconsistencies. This method also simplifies responding to product recalls and increases the speed at which business identifies the causes of defective products.

The other recommended approach is the multi-sourcing technique that eliminates dependence on one or a specific geographical location supplier. In the COVID-19 pandemic, there was a disruption of supply chains through lockdown and port duration since the reliance of the companies was on single-source suppliers. Hence, firms are managing redundancy with new suppliers because of regional area interruptions or geopolitical incidents. With a large range of suppliers at its disposal from different geographical locations, a firm can minimize risks and guarantee the availability of raw material. The procurement specialist said, "We lost dependence on a single supplier for the life-endangering fasteners." Rather, we get it from European, Asian, and North American suppliers." The use of multiple suppliers raises procurement costs because more suppliers mean more paperwork; however, it has a great impact on the supply chain's reliability.

Another similar solution is pre-qualification audits and supplier certification checks. Before entering contracts, firms perform 'make-or-buy' on-site inspections or demand suppliers' documentation of compliance with ISO 9001, ISO 14001, and ISO 898. It

also guarantees that only the suppliers who can produce the required amount consistently and those whose quality control measures are standard will be allowed in the allowed suppliers list. Further companies also demand from their suppliers a CoC for each batch of containers delivered as they must fulfill high requirements regarding their mechanical strength and resistance against corrosion. One of the supply chain managers interviewed commented: “Pre-qualification audits are no longer optional backchecks.” This process minimizes on potential delays in costs arising from quality failures or nonconforming suppliers which has a considerable implication on the organization's supply chain by maintaining a list of acceptable suppliers.

Another solution of the program is supplier development where the main aim is to assist suppliers through special training to meet outstanding international standards of production. Instead of market penetration or supplier diversification, companies cooperate with the existing suppliers in the refinement of their models, in the introduction of new quality control measures, or in enhancing production performance. Some of the actions may include training interventions, process improvement methods, and appraisal checks. A procurement manager expressed it this way: “It is far cheaper and more efficient to enhance the efficiency of a current supplier rather than engage in a continuous hunt for others”. Supplier development programs yield improved relationships with suppliers, quicker problem-solving, and higher conformity with firm-specific quality and delivery expectations. This is because firms who have long-term relationships with their suppliers lower operational risks as well as enhance supplier credibility.

Finally, firms are using digital supplier management platforms that enable one to monitor the performance of the supplier in real time. These platforms monitor and record service performance data such as on-time delivery, defective rates, and suppliers' responses. Extension of such KPIs includes the use of management dashboards and automated notification on key suppliers' performance to enable procurement managers to promptly respond to indications of delays or non-conformities. A supply chain analyst was quoted saying, “With real-time information, we can tell that a supplier is either lagging or not meeting the required quota and change supplier. The different digital applications increase supplier responsibility while assisting firms in making improved decisions. These platforms also consist of supplier scorecards that are

efficient in the constant appraisal of supplier performance and impact on subsequent supplier choices on selection.

Therefore, the best approaches for resolving issues related to supplier selection in the fastener industry include the implementation of blockchain for traceability, umbrella sourcing, pre-qualification checks, supplier improvement initiatives, and supplier management technology. These strategies make it possible for firms to have better ways of managing the suppliers, hence the quality of the certificated products, in addition, the strategies help in avoiding fraudulent certifications, making the supply chain more secure. These solutions can help firms avoid delays, increase compliance, and enhance the supplier relationship which results in disrupting the supply chain less.

Chapter 5: Discussion of Results

The presentation of results helps to coordinate the connection between the objective analysis of the empirical data and theoretical constructs and to reveal their theoretical and practical consequences for the development of research and application fields. Thus, the analysis shows a clear connection with the findings of prior research as well as the contribution of novel ideas that enrich theoretical innovations. Consequently, the study shows how supplier selection criteria, evaluation techniques, and risk management strategies are essential in the fastener business; and provides inherent practices for managing supplier relationships. This chapter offers a discussion of the connection of theory with fact, a discussion of the implications for the industry practitioners, as well as additional contributions to the knowledge of supplier selection in the fastener industry.

The connection between theory and data is transparent when defining the supplier selection criteria. Theoretical literature highlights five primary criteria for supplier selection: quality, cost, delivery, compliance, and reliability inferred by Carter (1996) and Saaty (1996). During the empirical study, all these criteria were commonly confirmed by the participants while highlighting the importance of enhancing operational efficiency and guaranteeing the continuation of production and product safety. The various papers under review point to ISO 898 and ASTM standards as key tools in quality assurance especially in fasteners that require tensile strength and from corrosion. There was supporting evidence with the procurement managers for the CoC

to uphold the above standards. These aspects of alignment go a long way in substantiating the assertion that selecting supplier frameworks, especially those used in industries that are keen on their regulatory standards, should pay a lot of attention to quality assurances and certifications. Moreover, the practical application of the employment of blockchain for traceability takes the theoretical idea of supplier compliance to the real world and provides the firms with the opportunity to implement traceability of the raw material origin along with the possibility of a more independent and verifiable supplier certification. As summarized, the literature supports both Abeyratne and Monfared's (2016) suggestion of utilizing blockchain for traceability and the current study identifies its applicability to supplier assessment in the fastener industry.

As far as the supplier evaluation methods are concerned, there is ample empirical evidence to show that AHP and MCDM models are being used by firms as described in the literature (Saaty 1996; Das et al. 2000). These models offer a mechanical approach to supplier evaluation against the predefined weighted factors thus offering firms the best value between the costs, quality delivery, and compliance. Specifically, a literature review revealed that the AHP and the other MCDM models are most often used when determining the suppliers ... in a mass selection scenario. Some of the participants said it is most helpful where there are choices to be made that pit one against the other, such as between a low-cost supplier with a long lead time and a high-cost one with a short lead time. This shows that the theoretical concepts of MCDM are implemented in actual situational problems in supplier selection. However, the empirical evidence also highlights an emerging trend: such as the heightened supplier partnership scorecards in real time. Unlike the conventional AHP and MCDM, which are the basic on/off theoretical decision-making tools, the firms are today moving towards incorporating active real-time performance measuring systems. These platforms supply procurement managers with constant feedback about on-time delivery frequencies, defect frequencies, and response rates that are often omitted in the theoretical models. This shift appears to indicate that digital transformation and data analytics are leading to a new mode of supplier evaluation – one defined by ongoing rather than episodic scrutiny.

Many of the findings highlighted in the study's empirical data hold important implications for practice particularly for procurement managers and supply chain decision-makers. One idea underpinning them is portfolio diversification in supply chains. The overall results point out that the use of multiple strategic suppliers is a key strategy that can greatly increase supply chain robustness. It became very evident during the COVID-19 pandemic outbreak when firms that sourced from only one supplier had raw material and components procurement disrupted by closed ports, slowed transportation, and factory closures. This practical realization highlights the credit of extending supplier sources across multiple regions to reconstitute reliance on a specific region. Companies are now looking forward to obtaining regional supplier diversification as they want to have different suppliers for every important part of the fastener. In other words, many-tier supply networks help manage risks associated with geopolitical conflicts, climate catastrophes, as well as rising costs. This form is in line with the theoretical explanations given by Govindan and Hasanagic (2018) relating to diversification as one of the important strategies of risk management. However, where the above conceptual literature calls for diversification in the broadest of terms, the data brought to the table explains the specificity of that insight by pointing to the fact that firms now keep at least three suppliers per critical component in multiple geographic locations.

Another significant implication is that current and future integration activities will require improved supplier compliance verification systems. Manufacturers in the fastener industry have set pre-qualification audits and third-party certifications as requirements in supplier selection criteria. Theoretical literature considers compliance with ISO 9001, ISO 14001, and ISO 898 as factors that determine supplier selection (Cooper & Ellram, 1993; Finnegan, 2001). The study also shows that, in practice, firms perform even better than by theory because they apply blockchain traceability systems to thwart fake certifications and forged CoCs. This eliminates instances whereby fraudulent certificates are uploaded by suppliers because blockchain provides only a unique record of various supplier certifications thus any incidence of non-compliance can be followed. Some of the benefits realized by firms that have embraced the use of blockchain in their compliance frameworks include faster verifications, fraudulent suppliers' risks are as well minimized, and; enhanced supply chain visibility.

Also, it provides valuable findings concerning supplier development practices. These empirical results extend the literature on supplier development (Krause, 1997) by identifying how the firms practically implement supplier development to enhance quality, delivery, and compliance. For example, managers of procurement roles described how they offered technical training, production, and process improvement help for vital suppliers. Through supplier development, firms eliminate the long and expensive search for a new supplier and develop long-term supplier relations. This approach is of particular importance in the context of the fasteners as quality and tested adhesion to the regulatory requirements are crucial. Firms therefore engage in the development of long-term relationships to enhance the quality of suppliers' performance hence minimizing the risks of the supply chain.

This study brings many interesting ideas to the current literature because of the focus on monitoring performance in real-time and utilizing the blockchain system. Whereas supplier selection research investigates various methods, including AHP and MCDM as guides to the selection process, experience-based results identify dynamic and continuous supplier performance evaluation by utilizing digitalized supplier management platforms. Companies currently employ real-time scorecards related to suppliers' dependability, scrappage levels, or delivery timelines. Such real-time features enable the procurement teams to detect likely troublemakers as they prevent them from causing interference. In addition, unlike the works written in previous literature where blockchain is described as a means for generic supply chain tracking (Abeyratne & Monfared, 2016), the research evidence shows the direct use of the system in supplier assurance of compliance for fasteners. Another problem known from the literature but effectively solved by blockchain is to ensure that supplier certifications for ISO 898 compliance are independent and immutable.

As shown in this chapter, the empirical results relate to theory to offer an elaborate comprehension of supplier selection in the fastener industry. The study enhances the literature on supplier selection criteria, AHP, supplier development, and risk management findings, and brings novelty to the discussion of blockchain and real-time supplier monitoring systems. The results, therefore, affirm that multi-sourcing and supplier diversification are efficient and effective ways of managing risk. Hypotheses derived from the literature supporting the model were validated, and further ideas

concerning the application of blockchain technology to compliance management and real-time tracking systems were discussed as extensions of the existing theories.

Chapter 6: Conclusion

The final section of this research work offers the summary of results and discussion of the practical implications of the study, limitations of the study as well as laid down the suggestion for future research. The primary goal of the chapter is to tie together the major findings of the study highlighting the theoretical and practical implications of the research and in the same process mark out areas for future investigation. The findings of this study on supplier selection in the fastener industry extend the knowledge base towards how firms can improve superior supplier appraisal procedures, to minimize the risks and improve the supply chain overall.

The findings pointed out that the process of the selection of suppliers in the fastener industry in the context of multiple criteria including quality, cost, delivery, compliance, and reliability. Research findings provided a perfect ride in undergoing the criticism test criterion regarding ISO 898 and ASTM standards while suggesting compliance with these standards as the key means to guarantee product quality and security. The notion emerged that companies are valuable to those suppliers that can offer certificates of conformity (CoC). The study also identified how blockchain technology is increasingly being used for traceability as well as certification verification helping firms mitigate cases of fake certificates. Blockchain helps encrypt and maintain the justified trust in the supplier data and our information which makes it act as a compliance assurance that boosts the strength of the supplier evaluation.

The second significant empirical result regards the techniques utilized in supplier selection. The research insisted and determined that organizational entities use the Analytic Hierarchy Process (AHP) and Multi-Criteria Decision-Making (MCDM) models extensively to assess the vital suppliers and rank them. Whereas AHP and MCDM are applied for solving one-time decision-making problems, firms are gradually implementing dynamic supplier monitoring platforms. These platforms give current figures on supplier's performance indicators, for example, delivery frequency, quality, and reliability. The transition from static models to real-time tracking could be

attributed to this growing trend in the digitized supply chain, a system that allows firms to make procurement decisions in real-time, based on real-time data.

Another interesting idea found in this study that can be called theoretical is multi-sourcing. The hypothesis was supported by empirical evidence that firms are diversifying their supply sources to minimize risks such as lack of supply, fluctuating prices, and geographical conflicts. Multi-sourcing procurement strategies were more applicable during the COVID-19 outbreak since organizations that sourced their products from multiple suppliers faced minimal disruptions. Companies are now able to ensure that they have sources of supply for at least three different geographic regions about key components so that the effect of any one region can be easily handled. This strategy increases revenue and profit security in that the business continues to operate during unstable market conditions. By the formation of relationships with many suppliers, firms also enhance their negotiation power and decrease vulnerability to contracts from any individual supplier.

The findings also shed more light on the importance of supplier development programs. Unlike previous studies that found that most firms use supplier evaluation to identify potential supplier substitutes, this research established that firms are increasingly engaging in supplier development as the optimal strategy. Currently, various companies are providing technical assistance, new process consultancy, and consulting services of quality control to address the compliance requirements and organizational effectiveness of suppliers. Instead of dropping suppliers and finding new ones when there is a problem with performance, firms look for ways through which supplier relationships will be improved to cover for the long-term future. In addition, it eliminates other operational risks such as placing orders with the wrong supplier; thus enhancing the bonding between buyers and suppliers for mutual growth.

The implications of these findings are for practice. For companies in the fastener industry, the use of change enabler technology platforms is not a luxury. Supplier compliance verification through a technology wizard known as blockchain has become inevitable for firms that need to have improved traceability and reduced risks that are correlated with fake CoCs. The failure to adopt such tools in corporate organizations puts them at risk of having higher compliance risks, costs, and even product recall. Furthermore, there are real-time supplier monitoring platforms that can give firms key

performance insight on the suppliers once again giving the firms a competitive advantage by pointing out areas of concern and where interventions are required. This makes the procurement teams more responsive while also always keeping the suppliers fully accountable.

The movement from simple and fixed-point evaluation systems to dynamic and real-time or near real-time supplier evaluation systems therefore forms a new epoch in supplier evaluation approaches. Earlier, supplier selection was a one-time event, and firms, to make decisions adopted AHP and MCDM models at certain time points. However, the use of real-time dashboards reverses this perspective. Today procurement teams are always on the lookout for how their suppliers are performing so they can act on the matter immediately it happens. This shift in practice demands that companies give more credence to supplier performance metrics as well as live data feeds. Organizations that conduct their operations this way get more agility and operational flexibility and can minimize risks and keep abreast with unexpected changes.

Another implication of the study for practice is multi-sourcing as a risk management measure. Companies must understand the significance of the issue of diversification of suppliers, especially against the background of the crisis that began with the COVID-19 virus. Single-sourcing suppliers affected some firms more critically, while others that adopted multiple suppliers proved to have a strong supply chain. Company-wise, it can decentralize supplier networks across different geographical locations to avoid the impact of natural disasters, political instabilities, and capability delays. Locating at least three active suppliers for the critical parts supply chain managers should ensure operational supply continuity if disruption impacts specific suppliers.

Furthermore, supplier development programs provide another intervention avenue that is easier for firms to implement than engaging in supplier switching yet has benefits as discussed above enhancing the suppliers' performance. The current study reveals that through cooperation with key suppliers, the firms can secure improved levels of compliance, enhance the quality of products supplied, and effectively manage supply chain problems. Therefore, supplier development activities should fit within overall supplier relationship management (SRM) processes which guarantee that appropriate relations with key suppliers are maintained and that these suppliers are given adequate attention to enable them to meet the necessary company requirements. They ensure that

supplier allegiance is achieved, and at the same time, a more robust supply chain network that is capable of handling shocks is fostered.

Limitations of the Study

Nonetheless, the following limitations should be noted regarding this study's recommendations. However, the study is limited to procurement managers and specialists in the industry with an interest in fasteners. As with any research, the results are most applicable to the specific industry in question and may not necessarily translate well to industries such as automotive or electronics. Thus, it will be advisable to extend the range of participants in further research and conduct cross-industry studies.

Secondly, the study utilizes qualitative data collection and analysis method. Qualitative data therefore gives more detailed information on the supplier selection practices of the organization, but it is limited by the participant's bias and subjectivity. The significant value of quantifiable outcomes could have been grossly measured and quantified in future studies to enhance generalization. Emendation for future research is the use of both qualitative and quantitative methods to attempt to offer a panoramic view of supplier selection and evaluation.

Finally, one of the primary emphases of the study is on blockchain and real-time dashboards, but few points are being made about the challenges related to adoption. Challenges that may affect the firms include cost, growth, and skills to manage blockchain systems and digital supplier monitoring tools. Further research could be done on how the above challenges are addressed during the strategic process especially in SMEs since they face a lot of financial and technical challenges.

Propositions for Further Research

Further studies should be carried out to determine the use of AI and ML in supplier selection. These technologies can help identify supplier risks, and alert one concerning risks from the suppliers' end or general slowness in supplier performance. Although this paper focused on the role of blockchain and real-time tracking, AI-based prognostic models could assist firms in decreasing operational hazards and supply chain reliability.

Second, there should be a long-term evaluation of supplier performance as a viable research suggestion. This approach would provide a richer source of understanding of the dynamics of supplier development programs on performance and compliance. Also, further studies need to be conducted on how firms can overcome the challenges of blockchain implementation including cost, training, and regulation. Such research studies that concentrate on eradicating these hurdles would be insightful to the firms to improve the compliance and traceability of the supply chains.

Concluding Remarks

In filling this gap, this study offers a useful contribution to the theoretical understanding of supplier selection, while simultaneously providing a real-life case application of the theories discussed. It brings our attention to the aspects of supplier selection criteria, ways of establishing verification compliance, how to dynamically track supplier performance, and how to develop suppliers to create strong, effective, and transparent supply chain networks. The research presents its novelties, like blockchain for certification traceability and real-time monitoring of suppliers, which cannot be explained through current theoretical concepts. Through multi-sourcing, a firm is able to get more options on supply in its supply chain, and through supplier development, the long-term relationship with suppliers is enhanced. Despite the limitations of this study, the implications for practice are clear: industry players need to adopt digital strategies, decision-making sourcing strategies, and real-time supply chain visibility as key requirements of the current globalization. This paper suggests the following areas for future research: AI, predictive analytics, and the challenges of slower adoption of the blockchain in supplier selection. By such measures, organizations can cultivate long-term, reliable, and responsive SC that are less prone to risk factors that are inevitable in a dynamic world economy.

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