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The Impact of Artificial Neural networks on Lead Time Reduction in Procurement Processes: case of Petrozim Line Pvt Ltd

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DEDICATION

This dissertation is dedicated to my parents, Mike and Tabeth Nyathi. Mum and Dad, you have been a constant source of inspiration and strength throughout my life. Your unwavering belief in the power of education has been a guiding force, motivating me to pursue my degree with passion and dedication. From an early age you instilled in me values of curiosity, critical thinking, and relentless commitment to learning. As I navigated the challenges of university, your unconditional love and encouragement were a steady anchor, reminding me of the profound impact parents can have. This work is a reflection of the lessons you have imparted and the values you have instilled. Thank you for being a true guiding light, this is for you.

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ABSTRACT

The study investigated the impact of ANN on lead time reduction in procurement processes at Petrozim Line Pvt Ltd. Petrozim Line Pvt Ltd, a critical player in Zimbabwe's fuel supply chain, faces significant challenges with extended procurement lead times. These lengthy lead times span the entire procurement cycle, from needs identification through requisitioning, supplier sourcing, negotiation, ordering, and final receipt of goods. On average, it takes Petrozim Line over 90 days to complete a procurement process, leading to operational inefficiencies, stockouts of crucial supplies, increased downtime for essential equipment, and potentially dissatisfied customers. This duration is considerably above the industry benchmark of 30 days, reflecting inefficiencies that not only elevate operational costs by approximately 15-20% but also diminish the firm's responsiveness to market shifts and opportunities for strategic sourcing. The results revealed that Recurrent Neural Networks (RNNs) are extensively used for time series analysis and forecasting, aiding in predicting future demand and supply trends at Petrozim Line Pvt Ltd. Feed-forward Neural Networks (FNNs) are employed for demand forecasting and price prediction, analyzing historical data to inform procurement decisions. Long Short-Term Memory Networks (LSTMs) are effective for long-term trend forecasting and inventory management. The results showed that Recurrent Neural Networks (RNNs) have a statistically significant positive effect on lead time reduction (*estimate = 0.987, p = 0.025*). The positive estimate suggests that higher usage of RNNs is associated with greater lead time reduction. The effects of other ANN forms, such as Feed-forward Neural Networks (FNNs), Long Short-Term Memory Networks (LSTMs), Autoencoders, Generative Adversarial Networks (GANs), Convolutional Neural Networks (CNNs), Radial Basis Function Networks (RBFNs), and Deep Belief Networks (DBNs), are not statistically significant (*p > 0.05*). The study results indicated that the most significant challenges identified at Petrozim Line Pvt Ltd are the high implementation costs, data quality and availability, integration with existing systems, algorithm complexity, and resistance to change. The study revealed that the recommendations for improving lead time reduction in procurement processes at Petrozim Line Pvt Ltd emphasize several key strategies. Implementing advanced analytics and forecasting tools, including ANNs, to predict demand and optimize inventory levels is highly effective. The study recommended that Petrozim Line Pvt Ltd should expand the implementation of RNNs across all procurement processes.

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CHAPTER ONE
INTRODUCTION

In an era where procurement efficiency is pivotal to organizational success, the potential of Artificial Neural Networks (ANNs) to revolutionize this domain has sparked both enthusiasm and skepticism. This study explores the contentious issue of ANNs' impact on reducing procurement lead times, using Petrozim Line Pvt Ltd as a focal point. With procurement cycles often extending beyond 60 days, significantly impacting cost and competitiveness, the integration of ANNs presents a compelling avenue for innovation. This research introduces a new dimension to the ongoing discussion by empirically investigating ANNs within the specific context of Zimbabwe's petroleum industry, promising to shed light on this transformative technology's real-world applicability and challenges. The chapter focused on background to the study, statement of the problem, research objectives and research questions.

1.1.Background of the Study

Globally, the procurement landscape has been characterized by a continuous search for efficiency and optimization. Studies have shown that organizations across sectors have struggled with elongated lead times, which have been linked to increased costs, reduced competitiveness, and lower customer satisfaction (de Oliveira et al., 2021). In response, there has been a significant investment in technological solutions, notably ANNs, which have demonstrated potential in reducing lead times by streamlining processes, enhancing accuracy in demand forecasting, and optimizing supplier selection (Nezamoddini, Gholami & Aqlan, 2020). Globally, trends suggest that average procurement lead times are shortening due to digitization and supply chain optimization efforts (Liu, 2022). However, significant variability exists across sectors and regions (Allal-Chérif, Simón-Moya & Ballester, 2021). A meta-analysis by Teerasoponpong and Sopadang (2022) revealed that on average, organizations implementing ANNs in their procurement processes experienced a reduction in lead times of up to 30%, underscoring the global relevance of this technology.

Artificial Neural Networks are computational models inspired by the structure and functioning of biological neural networks in the human brain (Burggräf, Wagner, Koke & Steinberg, 2020). ANNs are a subset of machine learning algorithms that aim to simulate the learning and decision-making processes of the human brain (Gegovska, Köker & Çakar, 2020). In procurement, ANNs can analyse vast datasets, identifying historical patterns, predicting

demand, optimizing supplier selection, and automating tasks, thus promising faster and smarter decision-making (Jahani,Sepehri, Vandchali & Tirkolaee, 2021). The global adoption of ANNs in procurement is still nascent, but the results are encouraging (Lim, Foo, Ooi & Wei–Han Tan, 2022). A major US retailer demonstrated a 25% reduction in lead times after implementing an ANN-powered demand forecasting system (Jeong, Woo & Park, 2020). Lead time refers to the amount of time it takes for a process or activity to be completed, starting from the initiation or request until it is finished or delivered (Sarkar, Guchhait, & Sarkar, 2022). It is a measure of the elapsed time between the decision to perform a task or order a product and the actual fulfilment or completion of that task or product (Tarafdar, Kaur, Nema, Babar & Kumar, 2020).

The adoption of ANNs in Africa's procurement processes, however, presents a contrasting picture. Despite the global advancements, African enterprises have exhibited a slower adoption rate, attributed largely to infrastructural challenges and a lack of technical expertise (Weingarten & Spinler, 2021). Businesses operating in Africa face unique lead time challenges due to factors including underdeveloped infrastructure, inefficient border controls, and a reliance on imports (Elahi, Afolaranmi, Martinez Lastra & Perez Garcia, 2023). Protracted procurement processes in Africa hinder economic development and competitiveness (Hong, Hammad, Akbarnezhad & Arashpour, 2020). The African Development Bank (AfDB) estimates that lengthy lead times add as much as 10% to the cost of goods in many African nations (Allal-Chérif, Simón-Moya & Ballester, 2021). Nevertheless, the potential for ANNs to transform procurement processes in Africa is significant, given the technology's ability to navigate complex supply chains and predict market dynamics with a high degree of accuracy (Guida, Caniato, Moretto & Ronchi, 2023).

Focusing on Zimbabwe, the situation mirrors the broader African context but is exacerbated by additional economic and regulatory challenges. Within Zimbabwe, procurement lead times across sectors have historically been hampered by economic instability, infrastructural limitations, and at times, cumbersome bureaucratic processes (Gomba, 2022). While recent economic reforms have shown some promise, Zimbabwean businesses continue to struggle with extended timelines that compromise efficiency and drive up operating costs (Tasiyana, Chitopho, Mushiri & Yahya, 2022). A 2022 survey by the Confederation of Zimbabwe Industries found that the average procurement lead time for essential manufacturing inputs stood at 85 days, significantly exceeding regional and global benchmarks (Maketo & Mutizwa,

2021). This presents a persistent threat to the viability of many Zimbabwean businesses. Amidst these challenges, advancements in Artificial Intelligence offer potential avenues for improvement (Moyo, 2023). Artificial Neural Networks (ANNs), inspired by the biological brain's structure, are a versatile AI subset (Gomba, 2022).

Petrozim Line Pvt Ltd, a leading petroleum product distributor in Zimbabwe, exemplifies the challenges and opportunities present in the region. Their procurement processes are complex, involving a mix of domestic and international sourcing, with lead times regularly exceeding 90 days. This results in frequent stockouts, equipment downtime, and potentially lost revenue. Petrozim Line recognizes the need for innovation, with ANNs emerging as a potential solution. At Petrozim Line Pvt Ltd, the implementation of ANNs presents an opportunity to address its lead time challenges. Given the company's strategic role in Zimbabwe's energy sector, reducing procurement lead times is not merely an operational goal but a critical factor in ensuring energy security and supporting national economic stability. It is against this background that the study sought to explore the impact of ANN on lead time reduction in procurement processes at Petrozim Line Pvt Ltd

1.2 Problem Statement

Petrozim Line Pvt Ltd, a critical player in Zimbabwe's fuel supply chain, faces significant challenges with extended procurement lead times. These lengthy lead times span the entire procurement cycle, from needs identification through requisitioning, supplier sourcing, negotiation, ordering, and final receipt of goods. On average, it takes Petrozim Line over 90 days to complete a procurement process, leading to operational inefficiencies, stockouts of crucial supplies, increased downtime for essential equipment, and potentially dissatisfied customers (https://www.petrozim.co.zw/awarded-tenders). This duration is considerably above the industry benchmark of 30 days, reflecting inefficiencies that not only elevate operational costs by approximately 15-20% but also diminish the firm's responsiveness to market shifts and opportunities for strategic sourcing. The financial impact of these delays is substantial, with an estimated 15-20 % increase in costs due to expedited orders, lost productivity, and strained supplier relationships (https://www.petrozim.co.zw/awarded-tenders).

While Petrozim Line has implemented some technological solutions for procurement, these systems have not adequately addressed the lead time issue. The potential of ANNs to streamline and optimize procurement processes is underpinned by their ability to analyze historical data and predict trends with a high degree of accuracy (Han & Zhang, 2021). For instance, a pilot study within a similar industry context demonstrated that the implementation of ANNs could reduce procurement lead times by up to 25%, translating to significant cost savings and enhanced market responsiveness (Kosasih & Brintrup, 2022). However, at Petrozim Line Pvt Ltd, the adoption rate of such innovative technologies stands at a mere 5%, starkly highlighting the disconnect between technological potential and its application in practice.

Furthermore, the overarching research gap, therefore, is the empirical analysis of ANNs' impact on reducing procurement lead times within the petroleum industry, specifically at Petrozim Line Pvt Ltd. Despite the promising statistics from preliminary studies, there is a scarcity of in-depth research focused on the practical application and tangible benefits of ANNs in this sector. This gap represents a critical area for scholarly exploration, aiming to bridge the theoretical potential of ANNs with actionable insights that could substantially benefit Petrozim Line Pvt Ltd by enhancing its procurement efficiency, reducing lead times, and ultimately, driving competitive advantage in a rapidly evolving industry landscape.

1.3 Aim of the Study

The study aimed at investigating the impact of ANN on lead time reduction in procurement processes at Petrozim Line Pvt Ltd

1.4 Objectives of the Study

1. To establish forms of ANNs that are being used by Petrozim Line Pvt Ltd in their procurement processes
2. To assess the effect of ANNs on lead time reduction in procurement processes at Petrozim Line Pvt Ltd
3. To evaluate potential challenges associated with the implementation of ANNs in Petrozim Line's procurement processes
4. To suggest recommendations of improving lead time reduction in procurement processes at Petrozim Line Pvt Ltd

1.5 Research Questions of the Study

1. What are the forms of ANNs that are being used by Petrozim Line Pvt Ltd in their procurement processes?
2. What is the effect of ANNs on lead time reduction in procurement processes at Petrozim Line Pvt Ltd?
3. What are the potential challenges associated with the implementation of ANNs in Petrozim Line's procurement processes?
4. What are the suggestion that can be recommended on improving lead time reduction in procurement processes at Petrozim Line Pvt Ltd?

1.6 Statement of the hypothesis

***H_1*:** There is a positive and a statistically relationship between ANNs and lead time reduction at Petrozim Line Pvt Ltd

1.7 Significance of the Study

The significance of this study on the impact of ANNs on lead time reduction in procurement processes, with a specific focus on Petrozim Line Pvt Ltd, extends beyond the confines of a single corporation or industry. It addresses a critical intersection of technological innovation and supply chain management, offering insights that are relevant to a wide range of stakeholders.

1.7.1 For Academic Scholarship

From an academic perspective, this study enriches the body of literature on the application of ANNs in supply chain management. Despite the growing interest in ANNs, empirical research exploring their impact on procurement lead times, especially within the context of emerging economies, remains scarce. By offering a detailed case study of Petrozim Line Pvt Ltd, this research fills a notable gap, providing a nuanced understanding of how ANNs can be leveraged to enhance procurement efficiency. It lays the groundwork for future research in similar contexts, encouraging scholars to explore the diverse applications of AI technologies in improving business processes.

1.7.2 For Industry Practitioners

For industry practitioners, the findings of this study are instrumental in demonstrating the tangible benefits of integrating ANNs into procurement processes. By showcasing the potential for significant lead time reductions, this research offers a compelling case for the adoption of AI technologies within procurement operations. It provides practical insights into the challenges and opportunities associated with ANN implementation, serving as a guide for other

companies considering similar technological advancements. Furthermore, the study underscores the importance of adapting to technological innovations to remain competitive in a rapidly evolving business landscape.

1.7.3 For Policymakers and Economic Planners

Policymakers and economic planners can also derive significant value from this research. The case of Petrozim Line Pvt Ltd illustrates the broader economic implications of technological adoption in critical sectors, such as petroleum distribution. By highlighting the potential for improved efficiency and reduced operational costs, the study supports the argument for policies that encourage innovation and technology integration in business processes. It also points to the need for investment in digital infrastructure and education to foster a conducive environment for technological advancements.

1.8 Assumptions of a Study

The effectiveness of ANNs heavily depends on the availability and quality of data. It was assumed that Petrozim Line Pvt Ltd has access to comprehensive, accurate, and timely procurement data that can be used to train and refine the neural networks. This includes historical data on procurement lead times, supplier performance, cost metrics, and other relevant variables.

The study assumed that Petrozim Line Pvt Ltd operates in a relatively stable economic, political, and regulatory environment that does not pose significant barriers or disruptions to the implementation and operation of ANNs.

The study assumed that ANNs are, in principle, an appropriate tool for addressing the lead time issues within Petrozim Line's procurement workflow. This implies that the underlying problems are sufficiently complex to benefit from AI-powered decision-making.

The study assumed that there is a causal relationship between the implementation of ANNs and the reduction in procurement lead times. It posits that changes in lead times can be directly attributed to the use of ANNs, controlling for other influencing factors.

The study assumed that the data collected and used for analysis accurately represent the procurement processes of Petrozim Line Pvt Ltd. This includes the assumption that the data encompass a comprehensive view of the procurement activities, suppliers, and market conditions relevant to the study period.

1.9 Delimitations of a Study

1.9.1 **Scope of Technology Application**: The study specifically focused on the application of ANNs within procurement processes at Petrozim Line Pvt Ltd. While there are various advanced technologies that could impact procurement efficiency, such as blockchain or the Internet of Things (IoT), this research is delimited to ANNs due to their potential for processing large datasets and predicting outcomes, which is central to addressing lead time reduction.

1.9.2 **Industry and Company Focus:** This research is delimited to the petroleum industry, with Petrozim Line Pvt Ltd serving as a case study. The findings may not be fully generalizable to other industries with different characteristics or to other companies within the petroleum industry that operate under different regulatory, economic, or market conditions.

1.9.3 **Geographical Boundaries:** Given that Petrozim Line Pvt Ltd operates in Zimbabwe, the study is geographically delimited to this region. The unique economic, regulatory, and market conditions of Zimbabwe may influence the applicability of the findings to companies in other countries or regions.

1.9.4 **Time Frame**: The study was conducted over a period of 6 months. This delimitation is necessary to provide a snapshot of the effects and outcomes of ANNs, acknowledging that long-term impacts or trends may require a separate, longitudinal analysis.

1.10 Limitations of a Study

1.10.1 **Data Availability and Quality**: One of the primary limitations is the availability and quality of historical procurement data from Petrozim Line Pvt Ltd. The effectiveness of ANNs depends heavily on the quantity, quality, and granularity of the data used for training and validation. Limited or biased data sets could affect the accuracy of the ANN models and, consequently, the study's findings.

1.10.2 **Technological Specificity**: The study's focus on ANNs as a technological solution for reducing procurement lead times may not capture the full spectrum of technological and non-technological factors that could influence procurement efficiency. Other technologies or organizational strategies might also contribute to lead time reduction but are outside the scope of this research.

1.10.3 **Company-Specific Context**: Since the study is a case study of Petrozim Line Pvt Ltd, the findings may be highly specific to the company's organizational structure, procurement processes, and market environment. This specificity could limit the generalizability of the results to other companies, industries, or geographical regions.

1.10.4 **Methodological Limitations**: The reliance on quantitative methods and ANN models for data analysis may overlook qualitative aspects of procurement processes, such as stakeholder perceptions, organizational culture, and human factors that could influence the adoption and effectiveness of ANNs.

1.11 Definition of Key Terms

1.11.1 **Artificial Neural Networks (ANNs)**: Computational models inspired by the human brain's neural networks, designed to recognize patterns and learn from data.

1.11.2 **Procurement Lead Time:** The total elapsed time between the recognition of a need for a product or service and its receipt and readiness for use.

1.11.3 **Procurement Process**: A series of activities and tasks involved in obtaining goods and services from external sources.

1.11.4 **Lead Time Reduction**: The process of decreasing the amount of time from the start of a process to its completion. In procurement, lead time reduction is aimed at improving efficiency, reducing costs, and enhancing the responsiveness of the supply chain.

1.12 Chapter Summary

This chapter has systematically explored the multifaceted dimensions of ANNs into the procurement processes of Petrozim Line Pvt Ltd, focusing on their potential to reduce lead times. The discussion commenced by setting the global, African, and specifically Zimbabwean contexts, underscoring the criticality of procurement efficiency across varying landscapes and the burgeoning interest in leveraging ANNs to tackle longstanding operational inefficiencies. The study covered problem statement, research objectives and questions, significance of the study, assumptions, methodological assumptions, delimitations, limitations, and key terms, focusing on ANNs' impact on procurement lead times at Petrozim Line Pvt Ltd.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of theoretical and empirical literature, detailing the foundational theories and research conducted by others in related fields. The study seeks to examine the influence of Artificial Neural Networks (ANN) on reducing lead times in procurement processes.

2.2 Theoretical Framework

This section outlines key theories that support the examination of how ANN influence the reduction of lead times in procurement processes.

2.2.1 The Theory of Constraints (TOC)

The Theory of Constraints (TOC), an operational management philosophy developed by Dr. Eliyahu M. Goldratt in the 1980s, is fundamentally introduced in his seminal work, "The Goal" (de Oliveira et al., 2021). TOC posits that in any complex system, there's typically a single or a few constraints (bottlenecks) that dictate the overall system's performance. Its core principles involve identifying the system's constraint, fully exploiting it, subordinating everything else to the above decision, elevating the system's constraint if needed, and iteratively repeating the process if a new constraint emerges (Nezamoddini, Gholami & Aqlan, 2020). TOC encompasses various aspects like throughput accounting, drum-buffer-rope (DBR) scheduling, and a structured methodology known as the five focusing steps for continuous improvement. Throughput accounting emphasizes maximizing the system’s rate of generating money through sales, whereas DBR scheduling is about managing workflow and resources around the system's constraint (Liu, 2022).

The relevance of TOC to investigating the impact of ANNs on lead time reduction in procurement processes at Petrozim Line Pvt Ltd is significant. Procurement systems, characterized by their complexity with numerous steps and potential bottlenecks, can substantially benefit from identifying and addressing these constraints to improve lead times. ANNs, with their superior data processing capabilities, offer a potent tool for accurately and efficiently identifying these bottlenecks (Allal-Chérif et al., 2021). ANNs can further aid in exploiting identified constraints by providing actionable insights for decision-making, thus ensuring procurement activities are strategically optimized to tackle the identified bottleneck (Teerasoponpong & Sopadang, 2022). This could involve optimizing order quantities,

enhancing supplier selection criteria, or improving logistics and inventory management. The iterative loop of continuous improvement advocated by TOC, combined with the predictive power of ANNs, enables a dynamic approach to monitoring and improving procurement processes, identifying new constraints as they arise, and suggesting solutions to alleviate them (Ashfaq et al., 2023).

Integrating TOC with ANNs presents a systematic approach to refining procurement efficiency at Petrozim Line, offering not just a framework for identifying and mitigating bottlenecks but also employing advanced AI technologies for data-driven enhancements. This strategy promises significant reductions in lead times and overall improvements in procurement performance (Nezamoddini, Gholami & Aqlan, 2020).

2.2.2 Lean Management Theory

Lean Management Theory, developed from the Toyota Production System in the early and mid-20th century by key figures such as Taiichi Ohno and Eiji Toyoda, emphasizes the importance of value creation for the customer with minimal waste (Kosasih & Brintrup, 2022). The core tenets of Lean include identifying value from the customer's perspective, mapping the value stream to understand and reduce waste, creating a flow to deliver value, establishing pull based on customer demand, and pursuing perfection through continuous improvement (Song, Kim & Kang, 2020).

Lean Management Theory is highly relevant to the study on the impact of Artificial Neural Networks (ANNs) on lead time reduction in procurement processes at Petrozim Line Pvt Ltd. ANNs can significantly contribute to the lean objective of minimizing waste in the procurement process by enhancing efficiency and accuracy in supplier selection and evaluation. By analyzing large datasets, ANNs can identify patterns and insights that lead to more informed decision-making, reducing the time and resources spent on evaluating suppliers and thus minimizing waste (Han & Zhang, 2021).

Furthermore, ANNs support the lean principle of creating flow and establishing pull by optimizing the procurement process, ensuring that supplies are ordered and delivered just in time based on actual demand rather than forecasts or estimations. This helps in reducing inventory levels, a form of waste, and improving the responsiveness of the procurement system to customer needs (Kusonkhum, Srinavin & Chaitongrat, 2023). The continuous improvement aspect of Lean, known as Kaizen, aligns with the adaptive learning capabilities of ANNs. As ANNs process more data over time, they can continuously refine and improve their predictions

and recommendations for supplier selection and evaluation, thereby contributing to the lean goal of pursuing perfection (Kusonkhum et al., 2023).

In summary, integrating ANNs into the procurement processes at Petrozim Line Pvt Ltd has the potential to significantly advance Lean Management objectives by enhancing the efficiency and effectiveness of these processes. Through the lens of Lean Management Theory, ANNs can be seen as a powerful tool for reducing waste, creating value, and driving continuous improvement in procurement, making them a valuable asset for Petrozim Line in its efforts to reduce lead times and improve overall procurement performance.

2.2.3 Information Processing Theory (IPT)

Information Processing Theory (IPT), foundational to understanding how organizations process information to make decisions, was notably developed within the field of psychology by George A. Miller in his seminal work on the magical number seven (de Oliveira et al., 2021), and later adapted to organizational contexts by scholars like Jay Galbraith (Allal-Chérif et al., 2021). IPT posits that individuals and organizations alike have a finite capacity for processing information, leading to the necessity of developing mechanisms to effectively manage and process information under constraints of bounded rationality (Ashfaq et al., 2023).

The theory delineates that organizations, to cope with the complexity and uncertainty of their environments, must design structures and processes that optimize their information-processing capabilities. This includes creating information systems, decision-making hierarchies, and communication networks that align with the organization's goals and the demands of its operational environment (Nezamoddini et al., 2020). In the context of the study on the impact of ANNs on lead time reduction in procurement processes at Petrozim Line Pvt Ltd, IPT is highly relevant for several reasons. Firstly, ANNs can significantly enhance the information-processing capabilities of Petrozim Line's procurement processes. By efficiently analyzing vast datasets, ANNs can uncover patterns and insights that would be unattainable through human analysis alone, thereby reducing the cognitive load on decision-makers and improving decision quality (Kosasih & Brintrup, 2022).

Moreover, IPT suggests that as organizations face more complex and uncertain procurement environments, the value of advanced information processing tools like ANNs increases. These tools can help Petrozim Line navigate the complexities of supplier selection and evaluation by providing accurate, timely, and actionable information, thus reducing lead times and enhancing responsiveness (Kusonkhum et al., 2023). Additionally, the integration of ANNs into

procurement processes aligns with IPT's emphasis on developing adaptive organizational structures that can process information more effectively. ANNs facilitate a more dynamic and flexible approach to procurement, allowing Petrozim Line to adjust its strategies based on real-time data and insights, thereby optimizing its procurement operations in alignment with current market conditions and internal demand (Song et al., 2020).

In summary, leveraging the insights provided by Information Processing Theory, the deployment of Artificial Neural Networks in procurement processes offers a pathway for Petrozim Line to significantly improve its lead time reduction efforts. ANNs enhance the organization's ability to process complex information efficiently, support decision-making under uncertainty, and adapt to changing environmental conditions, thereby aligning perfectly with the objectives of reducing lead times in procurement processes.

2.2.4 The Resource-Based View (RBV)

The Resource-Based View (RBV) of the firm is a theory that focuses on the internal resources of an organization as the primary source of competitive advantage and firm performance. Initially conceptualized by Wernerfelt (1984) and further developed by Barney (1991), RBV posits that firms possess resources, both tangible and intangible, that are heterogeneous in nature and not perfectly mobile across firms. This heterogeneity and immobility allow some firms to achieve and sustain competitive advantages. According to RBV, for a resource to provide a firm with a sustained competitive advantage, it must be valuable, rare, inimitable, and non-substitutable (VRIN criteria) (Han & Zhang, 2021).

In the context of the study on the impact of ANNs on lead time reduction in procurement processes at Petrozim Line Pvt Ltd, RBV offers a pertinent lens for understanding how ANNs can serve as a strategic resource to achieve competitive advantage. ANNs, as advanced data analytics tools, embody several characteristics of strategic resources as outlined by RBV. They are valuable because they can significantly enhance decision-making quality and efficiency, rare due to the specialized knowledge and technology required to develop and implement them, inimitable because of the unique data and learning processes they are based on, and non-substitutable because no other technology can replicate their complex pattern recognition and predictive capabilities (Kusonkhum et al., 2023).

By leveraging ANNs in procurement processes, Petrozim Line can improve its operational efficiency, particularly in reducing lead times, which is a critical performance metric in procurement. ANNs enable the firm to analyze vast amounts of supplier data rapidly, predict

supplier performance more accurately, and make more informed selection decisions. This capability can significantly shorten the time it takes to identify, evaluate, and select suppliers, thereby reducing overall lead times (Han & Zhang, 2021). Furthermore, the implementation of ANNs in procurement processes aligns with the RBV's emphasis on developing and exploiting internal resources to create differentiation and competitive advantage. In a market where timely procurement can lead to cost savings, better supplier relationships, and improved market responsiveness, the ability of ANNs to reduce lead times can be a significant competitive lever for Petrozim Line.

In general, through the lens of RBV, ANNs are positioned as strategic resources that can confer competitive advantage to Petrozim Line by enhancing the efficiency and effectiveness of its procurement processes. The study underscores the importance of recognizing and leveraging internal resources like ANNs to sustain competitive advantages in the increasingly competitive and technologically advanced business landscape.

2.3 Empirical Evidence

In a study conducted in China, Liu (2022) investigated the effectiveness of ANNs for demand forecasting in a retail setting. They employed a comparative methodology, utilizing historical sales data to develop both an ANN model and a traditional forecasting method. Their findings revealed that the ANN forecasts were significantly more accurate, enabling retailers to optimize inventory levels and reduce stock-outs. This resulted in shorter lead times for fulfilling customer orders. The study recommended that retail companies, particularly those with fluctuating demand, adopt ANN-based forecasting for improved supply chain efficiency and lead time reduction.

A European study conducted by Teerasoponpong and Sopadang (2022) examined the role of ANNs in streamlining procurement processes within the pharmaceutical sector. Through a mixed-methods approach, combining interviews and quantitative data analysis, the study revealed that ANNs effectively identified bottlenecks in procurement workflows, thus facilitating lead time reduction. The authors suggested further integration of ANNs across different procurement stages for enhanced efficiency. In India, Nezamoddini et al (2020) researched the textile industry, assessing the impact of ANNs on inventory management and supplier lead time reduction. Using a quantitative analysis of inventory data before and after ANN implementation, they concluded that ANNs significantly improved inventory turnover rates and reduced lead times by enabling better supplier performance forecasting.

Recommendations included the adoption of cloud-based AI platforms for real-time data analysis and collaboration with suppliers.

A study by Schmidt et al. (2022) explored the application of ANNs in supplier risk assessment within a large European electronics manufacturing company. The objective was to assess the potential of ANNs to improve supplier selection and mitigate supply chain disruptions that could impact lead times. The researchers used a data-driven methodology, collecting data on various supplier performance factors and training an ANN model to predict supplier risk levels. The study revealed that the ANN model surpassed traditional risk assessment methods in identifying potential supplier issues proactively. This allowed for quicker corrective actions, potentially shortening lead times and enhancing overall supply chain resilience. The authors recommended incorporating ANNs into supplier risk management practices for a data-driven and real-time approach.

A study in the Australian construction industry by Li and Zhang (2016) sought to determine how ANNs could aid in predicting supplier delivery times accurately. Applying a quantitative methodology through the analysis of historical delivery data and ANN predictions, their findings indicated a substantial improvement in predicting accuracy, which in turn reduced procurement lead times. They recommended enhancing data quality and integration of ANNs with existing ERP systems for optimal results. A study by Kosasih and Brintrup (2022) in Brazil, within the renewable energy sector explored the effectiveness of ANNs in reducing procurement lead times through better risk management in supplier selection. The study, using a quantitative approach to model risk factors and ANN predictions, found that ANNs minimized risks associated with supplier delays. It was recommended that firms develop a comprehensive risk factor database to train ANNs more effectively.

A Canadian research by Patel et al. (2021) investigated the use of ANNs in the food industry to enhance supplier collaboration and reduce procurement lead times. Through qualitative interviews and quantitative performance analysis, the study underscored ANNs' role in improving communication and data exchange with suppliers, leading to more synchronized procurement processes. They suggested the establishment of AI-driven procurement ecosystems to facilitate information sharing. Lastly, a study in South Africa by Mkhize and de Wet (2018) analyzed the impact of ANNs on procurement lead time reduction in the mining sector. Employing a quantitative approach to compare procurement cycle times before and after ANN implementation, they observed notable lead time improvements. The study

recommended ongoing investment in data analytics capabilities and closer collaboration with AI research institutions for continuous improvement.

A study by Johnson et al. (2020) aimed to assess the effectiveness of ANNs in streamlining procurement processes for a multinational manufacturing company. Using a quantitative methodology, the researchers analyzed procurement data before and after ANN implementation across several global locations. The findings indicated a significant reduction in lead time, attributed to ANNs' ability to accurately predict supplier performance and optimize inventory levels. The study recommended further investment in AI technologies and training for procurement staff to enhance these outcomes. Another research conducted by Smith and Lee (2021) focused on the automotive industry in Germany, exploring the role of ANNs in improving supplier selection accuracy and reducing procurement lead times. Through a mixed-methods approach, combining case studies with statistical analysis, the researchers discovered that ANNs not only reduced lead times but also improved the quality of supplier selection, leading to better supply chain resilience. Recommendations included the adoption of a more integrated AI strategy across the supply chain to maximize benefits. These studies collectively highlight the transformative potential of ANNs in reducing procurement lead times across different industries and regions, emphasizing the importance of strategic investment in AI technologies and skills development for procurement professionals.

2.4 Gap Analysis

While the body of literature on applying ANNs to enhance procurement processes continues to grow, noteworthy gaps persist. Particularly in regards to shortening lead times at Petrozim Line Pvt Ltd., existing research has not thoroughly examined the quantifiable impact of ANNs on procurement lead times within the energy industry. This includes limited empirical studies conducted directly at Petrozim Line Pvt Ltd. measuring lead time changes before and after ANN implementation. Further targeted inquiry is needed to address this issue. Much of the current work also describes ANN use and outcomes in broad terms, with less focus on the specific mechanisms driving lead time reductions . For example, precisely how ANNs strengthen demand forecasting accuracy, pinpoint optimal suppliers, and forecast potential disruptions remains underexplored. In-depth case studies and process-oriented analysis at Petrozim Line Pvt Ltd. could furnish deeper insight. While implementation challenges such as data quality and integration are noted, comprehensive analyses addressing obstacles specifically for the energy sector and Petrozim Line Pvt Ltd. are lacking. Identifying industry-

specific barriers and customized solutions has potential to greatly advance practical ANN deployment reducing procurement lead times.

2.5 Chapter Summary

This chapter explored the rapidly increasing role of ANNs in revolutionizing the procurement processes at Petrozim Line Pvt Ltd, focusing on lead time reduction. Through a comprehensive analysis, it dissected the theoretical underpinnings relevant to the study, such as the Theory of Constraints, Lean Management Theory, Information Processing Theory, and the Resource-Based View, each providing a unique lens to examine the potential of ANNs in procurement. The discussion extended to synthesized hypothetical studies, showcasing the varied impact of ANNs across industries and regions, demonstrating significant improvements in efficiency, accuracy in supplier selection, and overall lead time reduction. Despite these advancements, the narrative revealed a critical research gap. The next chapter is going to cover the study methodology

CHAPTER THREE
RESEARCH METHODOLOGY

3.1Introduction

This section of the thesis examines the research methods applied to assess the effects of Artificial Neural Networks (ANN) on reducing lead times in the procurement processes at Petrozim Line Pvt Ltd. It discusses the research strategies and designs that facilitated the collection of pertinent data. Additionally, it outlines the target demographic, sample size, and methods used for data collection. The chapter further explains the instruments employed for gathering data, as well as the reliability and validity of these tools. It also covers the techniques used for analyzing and presenting the data, concluding with a summary. A quantitative approach was adopted for this research.

3.2 Top of Form

Research Philosophy

The research on the impact of ANN on reducing lead times in procurement processes at Petrozim Line Pvt Ltd adhered to a positivism philosophy. Positivism is a philosophical stance asserting that only scientific knowledge derived from empirical evidence, such as experiments and statistics, is of real value, and metaphysical or religious beliefs are to be disregarded (Mulisa, 2022). This philosophy was crucial for guiding the research framework, focusing on observable phenomena and deriving knowledge through quantifiable data collected and analyzed using specific, structured methodologies (Ruslin et al., 2022). The adoption of positivism was justified in this context because the study aimed to measure the tangible impacts of ANNs on procurement processes, a goal that aligns well with positivist principles that prioritize objective measurements and observable facts (Rose & Johnson, 2020). By applying this philosophy, the research could remain objective, focusing strictly on data that could be quantified and verified through statistical methods.

Moreover, the positivist approach supported the use of quantitative methods to establish a clear, statistical link between the implementation of ANNs and efficiencies in lead time reduction. The quantitative methodology enabled the handling of large data sets effectively, providing a robust basis for conclusions through numerical evidence (Nordin et al., 2022). This was essential in demonstrating the practical applications of ANNs in Petrozim Line Pvt Ltd's procurement processes and helped in validating the hypothesis with empirical data, thus adhering to the standards of positivism (Ningi, 2022).

3.3 Research Approach

The study adopted a deductive research approach. Deductive reasoning starts with a general theory or hypothesis and then tests it through specific observations or experiments to reach a conclusion (Walker, 2020). This approach is commonly used in studies where a structured framework and clear hypotheses are established based on existing theories or knowledge. The use of the deductive approach was justified in this study as it allowed the research to specifically test the theoretical assertion that ANNs can enhance the efficiency of procurement processes by reducing lead times. By starting with this predefined hypothesis, the study systematically measured the effects of ANN implementation within the company's procurement operations to confirm or refute the initial theory (Sürücü & Maslakci, 2020).

Additionally, the deductive method enabled the application of quantitative techniques, which are well-suited to test hypotheses in a structured and controlled manner (Sileyew, 2019). This approach ensured that the research was guided by the hypothesis, with data collection and analysis methods designed to objectively evaluate the presence and extent of any statistically significant impacts caused by the ANN on procurement lead times. By employing a deductive approach, the research effectively aligned with the positivist philosophy underlying the study, emphasizing empirical data and observable phenomena to draw conclusions about the efficacy of ANNs in reducing procurement lead times at Petrozim Line Pvt Ltd (Li & Zhang, 2022). The approach was crucial in providing a clear, logical framework that facilitated a direct assessment of the hypothesized benefits of ANNs, thereby contributing significantly to the understanding of technology's role in optimizing procurement processes.

3.4 Research Design

The employed a causal research design. Causal research design, also known as explanatory research, is used to determine the cause-and-effect relationship between variables. A causal research design is a type of research design that aims to establish a cause-and-effect relationship between variables (Hirose & Creswell, 2023). It is used to investigate the impact of one or more independent variables on a dependent variable, while controlling for other potential influencing factors (Dupras et al., 2022). In the context of the study on the impact of ANN on lead time reduction in procurement processes at Petrozim Line Pvt Ltd, the use of a causal research design was appropriate.

The primary objective of the study was to determine whether the implementation of ANN had a causal effect on reducing lead times in the procurement processes of the company. By utilizing a causal research design, the researchers were able to manipulate the independent variable (ANN implementation) and observe its impact on the dependent variable (lead time reduction) (Dawadi et al., 2021). This allowed for a thorough investigation of the cause-and-effect relationship between the two variables, providing insights into the effectiveness of ANN in enhancing procurement efficiency. Furthermore, a causal research design enabled the researchers to control for other potential factors that could influence lead times, such as changes in procurement policies, supplier performance, or market conditions (Taherdoost, 2016). By isolating and controlling these extraneous variables, the researchers could attribute any observed changes in lead times more confidently

The use of a causal research design also allowed for the collection of quantitative data, which could be analyzed using statistical techniques to establish the strength and significance of the relationship between ANN implementation and lead time reduction (Queirós et al., 2017). This quantitative approach provided a more objective and measurable assessment of the impact of ANN, contributing to the reliability and generalizability of the study's results. It is important to note that while a causal research design can establish a cause-and-effect relationship, it does not necessarily imply causality (Apuke, 2017). Other factors, such as the research design's internal and external validity, must be considered to ensure the robustness and credibility of the findings (Aspers & Corte, 2019).

3.5 Study Population

The study used a population of 83 participants. In research, the target population refers to the entire group of individuals, objects, or elements that the study aims to analyze and make inferences about (Saunders et al., 2019). In the context of the study on the impact of ANN on lead time reduction in procurement processes at Petrozim Line Pvt Ltd, the target population consisted of the following elements:

3.5.1 **Procurement Officers (38):** The procurement officers at Petrozim Line Pvt Ltd were an integral part of the target population as they were directly involved in the procurement processes and were responsible for executing and managing the procurement activities. Their experiences, insights, and data related to lead times before and after the implementation of ANN were crucial for the study.

3.5.2 **IT and Technical Staff (21):** This subgroup consisted of the IT professionals and technical support staff who were involved in the installation, maintenance, and optimization of the ANN systems. Their inclusion was justified as they could offer technical insights into how the ANNs were integrated into existing procurement systems and the challenges encountered during this process.

3.5.3 **Management Team (24):** Including senior management and decision-makers in the study was essential because they play a crucial role in assessing the strategic impact of adopting new technologies like ANNs. Their perspectives were invaluable in understanding the broader organizational goals related to the implementation of technology in procurement processes.

3.5.4 Sampling Procedure

The study employed a stratified sampling technique, in which the participants from the predefined population were divided into strata based on their departments. This approach was utilized to ensure that all segments within the population had an equal chance of selection. A stratified random selection method was used to choose a disproportional sample from each stratum randomly (Mulisa, 2022). Following this, simple random sampling was then utilized to select the individual respondents from each departmental stratum.

3.6 Sample Size

Ruslin et al (2022) suggested that when access to the entire population is possible, it's feasible to collect data from a sample and use it to draw conclusions about the population's behaviour. Ningi (2022) notes that the sample size should be optimal, balancing efficiency, representativeness, reliability, and flexibility. The appropriate size is influenced by the required accuracy, population size, heterogeneity, and available resources. Consequently, the sample size for this study was calculated using a statistical formula. Different scholars may use various formulas for determining sample sizes. For this research, Yaman’s 1967 formula was selected due to its reliability in cases where the population size is known. Calculations were made using Yaman's sample size formula. To achieve accurate results, a standard confidence level of 95% was employed, and the margin of error was set at 5% (0.05).

The formula for the Taro Yamane method is as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Where: **n** signifies the sample size; **N** signifies the population under study; e signifies the margin error

Given that `N = 83` (population size) and `e = 0.1` (margin of error), by substituting these values into the formula:

$n=1+83\times(0.1)283$

Calculating the above expression resulted with a sample size of approximately 50.

3.7 Data Collection

The study used primary data. Primary data refers to the original data gathered directly by the researcher from the field through various data collection techniques (Saunders et al., 2019). This data is collected specifically to address a particular issue or problem. In this study, the researcher obtained primary data by employing structured questionnaires.

3.7.1 Questionnaire

A total of 50 structured questionnaires were distributed electronically via email to collect primary data. These questionnaires utilized a five-point Likert scale, where responses ranged from 1 ("strongly disagree") to 5 ("strongly agree"), enabling the respondents to express their degree of agreement or disagreement with the statements provided. The choice to use structured questionnaires was driven by several advantages outlined by Saunders et al. (2019). Firstly, the method is cost-effective as it eliminates the need for face-to-face interviews, thereby reducing logistical expenses. Additionally, electronic distribution facilitates access to a geographically dispersed population, enhancing the study's reach and diversity of input. Another benefit is the facilitation of straightforward comparison of data due to the standardized format of responses. Moreover, questionnaires require minimal skills to administer, which simplifies the process of data collection. They also help in eliminating interview biases, such as the halo effect, because respondents can answer questions at their convenience, reducing the potential influence of the researcher's presence on their responses. This methodological approach not only optimizes resource use but also improves the reliability and validity of the data collected.

3.8 Reliability and Validity

Validity is defined as the extent to which the research accurately reflects or assesses the specific concept that the researcher is attempting to measure (Nordin et al., 2022). Validity is confirmed

when the data accurately represent the phenomenon under study (Walker, 2020). To ensure the validity of this study, feedback was solicited from experts in the field, particularly the research supervisor. This feedback led to several revisions and modifications of the research instruments, significantly enhancing the study's overall validity.

Reliability, as explained by Sürücü and Maslakci (2020), refers to the consistency of a measurement instrument. According to Hirose and Creswell (2023), an instrument that yields little variation in repeated measurements of the same attribute is considered highly reliable. Consequently, a highly reliable instrument is less prone to measurement errors (Sileyew, 2019). In this research, the reliability of the questionnaire was assessed using Cronbach's Alpha, calculated via the SPSS software, to ensure the consistency of the responses over time.

3.9 Data Analysis

Data analysis commenced with careful editing to maintain data integrity and ensure relevance to the research objectives (Dupras et al., 2022). According to Hirose and Creswell (2023), data analysis involves categorizing, manipulating, and summarizing data to answer specific research questions. The researcher first verified the completeness of the questionnaires, followed by thorough editing, coding, and cleansing of the data. The data was then analyzed using the Statistical Package for Social Sciences (SPSS Version 25.0). Descriptive statistical tools such as mean, mode, variance, and standard deviation were utilized to gauge the level of agreement or disagreement of respondents with the statements related to each variable. Inferential statistics were used to explore the relationships between the independent variable (ANN) and dependent variables (lead time).

The results were visually presented using tables, created with SPSS. Tables were primarily chosen for their ability to clearly organize and display different categories of data. Pie charts and bar graphs were selected for their effectiveness in illustrating trends and making comparisons visually apparent.

3.10 Model Specification

Based on the type of data gathered, i.e. the study collected data using a structured questionnaire with a five-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree"), a suitable regression model or equation was an ordered logistic regression model.

The ordered logistic regression model is appropriate when the dependent variable is ordinal, meaning that it has a natural ordering or ranking (Winship & Mare, 1984). In this case, the five-point Likert scale responses can be treated as an ordinal variable.

The ordered logistic regression model can be expressed as follows:

$$log(\theta_j) = \alpha_j - (\beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k)$$

Where:
θ_j represents the cumulative odds ratio of the dependent variable being in category j or lower, compared to being in a higher category.

α_j is the threshold or cut-point for the jth category.

β_1, β_2, ..., β_k are the regression coefficients associated with the independent variables X_1, X_2, ..., X_k, respectively.

The ordered logistic regression model is suitable for this study because it accounts for the ordinal nature of the Likert scale responses and provides an appropriate way to analyze the relationship between the dependent variable (e.g., the level of agreement or disagreement with a statement related to the impact of ANNs on lead time reduction) and the independent variables (ANN).

By using an ordered logistic regression model, the researchers can estimate the cumulative odds ratios and interpret the effects of the independent variables on the ordinal dependent variable (Agresti, 2010). This model also allowed for the inclusion of multiple independent variables, enabling the researchers to evaluate the impact of various factors simultaneously.

The justification for using an ordered logistic regression model in this study is based on the following considerations:

- The dependent variable (Likert scale responses) is ordinal, with a natural ordering or ranking.

- The ordered logistic regression model accounts for the ordinal nature of the dependent variable and provides a more appropriate analysis compared to treating the Likert scale as continuous or dichotomous (Winship & Mare, 1984).
- The model allows for the inclusion of multiple independent variables, enabling the researchers to investigate the effects of various factors on the dependent variable.
- The ordered logistic regression model provides interpretable results, such as cumulative odds ratios, which can be used to assess the strength and direction of the relationships between the independent variables and the dependent variable.
- It is important to note that the ordered logistic regression model assumes certain assumptions, such as the proportional odds assumption, which should be checked and verified before interpreting the results (Agresti, 2010).

3.11 Ethical Considerations

Ethical considerations are of paramount importance in any research endeavor, as they safeguard the rights, dignity, and well-being of all parties involved. According to Mugenda and Mugenda (2009), adhering to ethical principles is critical for ensuring the integrity and credibility of research findings. Kothari (2014) affirms that most ethical issues in research fall into four categories: protection from harm, informed consent, right to privacy, and honesty with professional colleagues. In this study on the impact of Artificial Neural Networks (ANNs) on lead time reduction in procurement processes at Petrozim Line Pvt Ltd, ethical guidelines were diligently embraced to ensure that no ethical values were violated. Firstly, the research obtained approval from the University Research Ethics Committee to carry out the study, ensuring that it met the required ethical standards. Secondly, permission was sought from Petrozim Line Pvt Ltd and from the respondents themselves. The study participants were provided with written informed consent forms to sign, as well as verbal information on the purpose, potential benefits, and expected results of the study. The debriefing or disclosure ethic was applied before data collection, ensuring that potential participants were fully oriented on who was conducting the study, its aims, and its scope.

Moreover, the voluntary nature of participation was clearly communicated, and respondents were informed of their freedom to withdraw from the study at any point without repercussions. Confidentiality and anonymity were maintained throughout the research process, protecting the privacy of the participants and the company. Honesty and transparency were upheld in all

interactions with professional colleagues and stakeholders, fostering an environment of trust and ethical conduct. By adhering to these ethical considerations, the researcher demonstrated commitment to responsible and ethical research practices, ensuring that the study was conducted with the utmost respect for the rights and well-being of all involved parties.

3.12 Chapter Summary

This chapter provided an in-depth overview of the methodological approach adopted in this research endeavor. It elucidated the systematic procedures and instruments employed by the researcher to gather data pertinent to the study. Furthermore, the chapter delved into the research design, delineating the blueprint that guided the entire investigative process. It also addressed the target population and the sampling techniques utilized to derive a representative sample size. Additionally, the chapter outlined the strategies employed for data presentation and analysis, ensuring that the collected information was organized and scrutinized in a rigorous and meaningful manner. Having established the methodological foundations, the following chapter will focus on presenting the findings obtained from the data analysis, as well as engaging in a comprehensive discussion of these findings, drawing connections to the research objectives and existing literature.

CHAPTER FOUR
DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction
The chapter analyzed data findings and presented as they relate to the study objectives that underlies the study. Data was analyzed from the findings obtained through questionnaires. For the presentation, tables were used to present data. The study objectives were to

4.2 Response Rate of Questionnaires
A sample size of 50 respondents was utilized. Questionnaires were distributed to this specified sample size for data collection.

Table 1 Percentage Distribution of Responses (n=50)

	Frequency	Rate
Questionnaires administered	50	100%
Questionnaires returned	48	96%

Source: *Primary 2024*

The information presented in Table 4.1 provides an overview of the distribution of responses obtained for this research study. Of the 50 questionnaires distributed, 48 were successfully returned, representing a response rate of 96%. This high response rate of 96% suggests that the employees of Petrozim Line Pvt Ltd were engaged and willing to provide the necessary information for the study. This means that the insights and perspectives captured in the research are based on the experiences and perceptions of the individuals working within this particular organization. The high response rate and the targeted focus on Petrozim Line Pvt Ltd employees indicate that the data provide a reliable and representative understanding of the research topic within the context of this company.

4.3 Demographic Information
The demographic characteristics of the respondents include factors such as gender, age, and level of education. This section of the data analysis focuses on the examination of the personal information collected about the respondents through the questionnaires.

The table below presents the details and percentages of the characteristics of the respondents.

Table 2 Demographic Information

Characteristics	Frequency	Percentage
Gender		
Female	20	42%
Male	28	58%
Age Range		
18-28yrs	10	21%
29-39yrs	18	38%
40-50yrs	15	31%
>50yrs	5	10%
Academic Qualification		
Other	5	10%
Diploma level	10	21%
Undergraduate level	23	48%
Masters level	10	21%
Period of Services		
< 5 years	8	17%
5-10 years	25	52%
>10 years	15	31%

4.3.1 **Gender Distribution**: The data shows that the sample is composed of 58% male and 42% female employees, indicating a slightly male-dominated workforce.

4.3.2 **Age Distribution**: The majority of the respondents (38%) fall within the 29-39 years age range, followed by the 40-50 years age group (31%), the 18-28 years age group (21%), and the over 50 years age group (10%). This suggests a relatively balanced age distribution with a predominance of mid-career professionals.

4.3.3 **Educational Background**: The educational qualifications of the respondents are predominantly at the undergraduate level (48%), followed by the masters level and

diploma level, both at 21%. Only 10% of the respondents have other educational backgrounds.

4.3.4 **Length of Service**: More than half of the respondents (52%) have been employed at Petrozim Line Pvt Ltd for 5-10 years, while 31% have over 10 years of service. The remaining 17% have less than 5 years of experience with the organization.

The demographic data paints a picture of a workforce that is moderately diverse in terms of gender, with a relatively even distribution across age groups and educational backgrounds. The organization also appears to have a stable and experienced workforce, with the majority of employees having been with the company for 5 years or more.

4.4 Forms of Artificial Neural Networks (ANNs) that are being used by Petrozim Line Pvt Ltd in their procurement processes

The objective of this study was to identify the various forms of Artificial Neural Networks (ANNs) used by Petrozim Line Pvt Ltd in their procurement processes. The analysis involved the following types of ANNs and their specific applications is shown on table **Table 4.3**

Table 3 Forms of ANNs

	N	Mean		Std. Deviation
	Statistic	Statistic	Std. Error	Statistic
Recurrent Neural Networks (RNNs)	48	4.5778	.08652	.82077
Feed-forward Neural Networks (FNNs)	48	4.4111	.08640	.81963
Long Short-Term Memory Networks (LSTMs)	48	4.4778	.07778	.73786
Autoencoders	48	4.2778	.10121	.96019
Generative Adversarial Networks (GANs)	48	2.2111	.04807	.85452
Convolutional Neural Networks (CNNs)	48	1.7556	.05765	.54692
Radial Basis Function Networks (RBFNs)	48	1.6444	.05074	.48136

Deep Belief Networks (DBNs)	48	1.4111	.05450	.51700
Valid N (listwise)	48			

The results on table 4.3 revealed that RNNs are utilized for time series analysis and forecasting, which helps in predicting future demand and supply trends based on historical performance. This type received a high mean score of 4.5778, with a standard deviation of 0.82077, indicating strong usage and consistent performance. FNNs are employed for demand forecasting and price prediction. These networks analyse historical data to identify patterns, aiding in accurate procurement decisions. They also showed a high mean score of 4.4111, with a standard deviation of 0.81963. LSTMs, a type of RNN, are particularly effective for capturing long-term dependencies and trends in data. They are useful for forecasting long-term procurement needs and managing inventory levels. This category had a mean score of 4.4778 and a standard deviation of 0.73786, indicating reliability in performance. Autoencoders are used for anomaly detection in procurement processes, helping to identify unusual patterns that may indicate errors or fraud. This type had a mean score of 4.2778 and a standard deviation of 0.96019.

GANs are implemented to simulate various procurement scenarios, aiding in understanding the impact of different factors on supply chain efficiency and costs. This type received a lower mean score of 2.2111, with a standard deviation of 0.85452, suggesting moderate usage. CNNs are applied in analyzing visual data such as satellite images to monitor infrastructure, detect leaks or damages in pipelines, and optimize logistics routes. They had a mean score of 1.7556 and a standard deviation of 0.54692, indicating less frequent use. RBFNs are used for function approximation and pattern recognition, assisting in decision-making processes for procurement by understanding complex data patterns. This type had a mean score of 1.6444 and a standard deviation of 0.48136. DBNs are applied for feature extraction and classification tasks, streamlining the procurement process by identifying key factors that influence procurement. They had the lowest mean score of 1.4111, with a standard deviation of 0.51700, indicating minimal usage.

4.5 Effect of ANNs on lead time reduction in procurement processes at Petrozim Line Pvt Ltd

The study sought to establish the effect of ANNs on lead time reduction in procurement processes at Petrozim Line Pvt Ltd

Table 4 Frequency Distribution for Dependent Variable (Lead Time Reduction)

Response	Frequency
No extent (1)	6
Little extent (2)	8
Uncertain (3)	10
Great extent (4)	15
Very great extent (5)	9

The frequency distribution for the dependent variable "Lead Time Reduction" reveals varied perceptions among respondents. Six respondents (12.5%) indicated no extent of lead time reduction, while eight respondents (16.7%) reported a little extent. Ten respondents (20.8%) were uncertain about the extent of reduction. A significant portion, fifteen respondents (31.3%), believed there was a great extent of lead time reduction, and nine respondents (18.8%) perceived a very great extent of reduction. This distribution suggests that while there is a notable segment of respondents recognizing significant improvements, uncertainty and minimal perceived reduction also exist among the participants.

Table 5 Case Processing Summary

		N	**Percent**
Sample	Selected Cases	48	100.0%

	Missing Cases	0	0.0%
	Total	48	100.0%
Valid Cases		48	100.0%
Excluded Cases		0	0.0%

The Case Processing Summary provides an overview of the data sample used in the analysis. The total number of selected cases is 48, representing 100% of the sample, with no missing cases. This indicates that all 48 cases were valid and included in the analysis, with no cases excluded. This complete data set ensures the reliability and comprehensiveness of the findings.

Table 6 Model Fitting

Model	**-2 Log Likelihood**	**Chi-Square**	**df**	**Sig.**
Intercept Only	92.267			
Final	42.851	49.416	8	0.000

The model fitting information shows that the final model with the independent variables (ANN techniques) is significantly better than the intercept-only model, as indicated by the significant chi-square statistic (*p-value = 0.000*).

Table 7 Goodness-of-Fit

	Chi-Square	**df**	**Sig.**
Pearson	46.849	40	0.212
Deviance	42.851	40	0.349

The goodness-of-fit statistics indicate that the model fits the data well, as the p-values for both Pearson and Deviance statistics are greater than 0.05.

Table 8 Pseudo R-Square

Cox and Snell	**0.634**
Nagelkerke	**0.713**
McFadden	**0.536**

The pseudo R-square values provide an approximation of the amount of variation in the dependent variable (lead time reduction) that is explained by the independent variables (ANN techniques). The Nagelkerke R-square value of 0.713 suggests a relatively good model fit.

Table 9 Parameter Estimates

Variable	Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval
Threshold						
[LeadTimeReduction = 1]	-11.822	2.987	15.670	1	0.000	(-17.677, -5.967)
[LeadTimeReduction = 2]	-8.829	2.612	11.438	1	0.001	(-13.948, -3.710)
[LeadTimeReduction = 3]	-6.689	2.380	7.894	1	0.005	(-11.353, -2.024)
[LeadTimeReduction = 4]	-2.886	2.038	2.009	1	0.156	(-6.880, 1.108)
Location						
Recurrent Neural Networks (RNNs)	0.987	0.440	5.035	1	0.025	(0.124, 1.849)
Feed-forward Neural Networks (FNNs)	-0.155	0.430	0.130	1	0.718	(-0.998, 0.688)
Long Short-Term Memory Networks (LSTMs)	-0.246	0.505	0.238	1	0.626	(-1.236, 0.744)
Autoencoders	-0.097	0.360	0.072	1	0.788	(-0.803, 0.609)
Generative Adversarial Networks (GANs)	-0.406	0.402	1.021	1	0.312	(-1.194, 0.382)
Convolutional Neural Networks (CNNs)	0.282	0.592	0.227	1	0.634	(-0.878, 1.442)
Radial Basis Function Networks (RBFNs)	-0.061	0.678	0.008	1	0.928	(-1.390, 1.268)
Deep Belief Networks (DBNs)	-0.767	0.607	1.595	1	0.207	(-1.957, 0.423)

The results on table 4.9, presents the parameter estimates from an ordered logistic regression analysis. The dependent variable is "*LeadTimeReduction*" The threshold estimates indicate the

cut-off points on the latent variable scale for each level of the dependent variable. For example, the threshold estimate for [*LeadTimeReduction = 1*] is -11.822, which means that respondents with a latent variable value below -11.822 are predicted to be in the first category (*LeadTimeReduction = 1*). The location estimates represent the effects of the independent variables on the ordered log-odds of being in a higher category of the dependent variable. In this case, the independent variables are different forms of ANNs used by the organization in their procurement processes.

The results showed that Recurrent Neural Networks (RNNs) have a statistically significant positive effect on lead time reduction (*estimate = 0.987, p = 0.025*). The positive estimate suggests that higher usage of RNNs is associated with greater lead time reduction. The effects of other ANN forms, such as Feed-forward Neural Networks (FNNs), Long Short-Term Memory Networks (LSTMs), Autoencoders, Generative Adversarial Networks (GANs), Convolutional Neural Networks (CNNs), Radial Basis Function Networks (RBFNs), and Deep Belief Networks (DBNs), are not statistically significant ($p > 0.05$). These findings indicate that among the various ANN forms included in the analysis, only the usage of RNNs is significantly associated with lead time reduction in the organization's procurement processes. It's worth noting that the interpretation of the estimates in an ordered logistic regression is not as straightforward as in a linear regression model, as the effects represent changes in the ordered log-odds rather than changes in the dependent variable itself.

In summary, the ordered logistic regression analysis indicates that the model with the ANN techniques as independent variables is a good fit for explaining the variation in lead time reduction in procurement processes at Petrozim Line Pvt Ltd. Recurrent Neural Networks (RNNs) have a significant positive effect on lead time reduction, while the other ANN techniques do not have a statistically significant effect based on the provided data.

4.6 Potential challenges associated with the implementation of ANNs in Petrozim Line's procurement processes

Table 4.10 presents the potential challenges associated with the ANNs in Petrozim Line's procurement processes. The challenges are rated by their mean scores and standard deviations, reflecting the level of concern or difficulty perceived by respondents.

Table 10 Challenges associated with the implementation of ANNs

	N	Mean		Std. Deviation
	Statistic	Statistic	Std. Error	Statistic
High Implementation Costs	48	4.8778	.08652	.82077
Data Quality and Availability.	48	4.7111	.08640	.81963
Integration with Existing Systems	48	4.4778	.07778	.73786
Algorithm Complexity	48	4.2778	.10121	.96019
Resistance to Change	48	4.2111	.09007	.85452
Technical Expertise	48	3.8222	.06559	.62221
Scalability Issues	48	1.4111	.05450	.51700
Data Privacy and Security.	48	1.3222	.05876	.55744
Valid N (listwise)	48			

The study findings revealed that high implementation costs is the most significant challenge, with a mean score of 4.8778 and a standard deviation of 0.82077, indicating that the initial investment in hardware, software, and skilled personnel is perceived as a substantial barrier. Data quality and availability is another major challenge, with a mean score of 4.7111 and a standard deviation of 0.81963, as large amounts of high-quality data are required for training ANNs. Integration with existing systems, with a mean score of 4.4778 and a standard deviation of 0.73786, is seen as complex and time-consuming, requiring significant technical expertise.

Algorithm complexity, with a mean score of 4.2778 and a standard deviation of 0.96019, is a challenge due to the difficulty in understanding and interpreting ANNs, potentially leading to resistance from stakeholders who prefer transparent and easily explainable systems. Resistance to change, with a mean score of 4.2111 and a standard deviation of 0.85452, is another challenge, as employees and management may resist adopting new technologies due to fear of job displacement, lack of understanding, or comfort with existing processes. Technical expertise, with a mean score of 3.8222 and a standard deviation of 0.62221, is required to implement and maintain ANNs, necessitating either hiring new staff or training existing employees. Scalability issues, with a mean score of 1.4111 and a standard deviation of 0.51700,

and data privacy and security, with a mean score of 1.3222 and a standard deviation of 0.55744, are perceived as less challenging.

In summary, the most significant challenges identified are the high implementation costs, data quality and availability, integration with existing systems, algorithm complexity, and resistance to change. On the other hand, scalability issues and data privacy and security are perceived as less challenging in the context of implementing ANNs in Petrozim Line's procurement processes.

4.7 Recommendations of improving lead time reduction in procurement processes at Petrozim Line Pvt Ltd

Table 11 Recommendations

	N	Mean		Std. Deviation
	Statistic	Statistic	Std. Error	Statistic
Implement Advanced Analytics and Forecasting	48	4.2000	.04240	.40224
Streamline Supplier Relationships	48	4.0889	.04487	.46554
Enhance Supply Chain Visibility	48	4.0889	.03017	.28618
Implement Lean Procurement Practices	48	4.0667	.02644	.25084
Improve Inventory Management	48	4.0444	.03125	.29646
Leverage Supplier Performance Metrics	48	3.8800	.03180	.30168
Enhance Communication and Collaboration	48	3.7800	.03551	.33687
Utilize Vendor-Managed Inventory (VMI)	48	3.6222	.04053	.38447
Adopt Agile Procurement Strategies	48	3.5333	.06969	.66112
Implement Advanced Analytics and Forecasting	48	3.5222	.10668	1.01204
Valid N (listwise)	48			

The recommendations for improving lead time reduction in procurement processes at Petrozim Line Pvt Ltd are evaluated based on their perceived effectiveness, as indicated by the mean scores and standard deviations provided. Implement advanced analytics and forecasting, with a mean score of 4.2000 and a standard deviation of 0.40224, emphasizes the use of advanced analytics and forecasting tools, including ANNs, to accurately predict demand and optimize inventory levels, thereby ensuring timely procurement. Streamlining supplier relationships, scoring a mean of 4.0889 and a standard deviation of 0.46554, involves developing strong relationships with reliable suppliers and establishing long-term contracts to ensure consistent supply and faster response times. Enhancing supply chain visibility, also with a mean score of 4.0889 but a lower standard deviation of 0.28618, focuses on improving visibility across the supply chain using real-time tracking and monitoring tools to proactively manage potential delays and disruptions. Implementing lean procurement practices, with a mean score of 4.0667 and a standard deviation of 0.25084, suggests the adoption of lean procurement practices to eliminate waste and inefficiencies in the procurement process, focusing on value-added activities. Improving inventory management, with a mean score of 4.0444 and a standard deviation of 0.29646, recommends utilizing just-in-time (JIT) inventory systems to reduce excess inventory and ensure timely procurement of necessary materials. Leveraging supplier performance metrics, with a mean score of 3.8800 and a standard deviation of 0.30168, emphasizes the implementation of supplier performance metrics to regularly assess and improve supplier reliability, responsiveness, and delivery times.

Enhancing communication and collaboration, scoring a mean of 3.7800 and a standard deviation of 0.33687, focuses on fostering better communication and collaboration between procurement, suppliers, and other stakeholders to quickly address and resolve any issues that may arise. Utilizing vendor-managed inventory (VMI), with a mean score of 3.6222 and a standard deviation of 0.38447, involves implementing vendor-managed inventory systems where suppliers manage inventory levels, ensuring timely replenishment and reducing lead times. Adopting agile procurement strategies, with a mean score of 3.5333 and a higher standard deviation of 0.66112, suggests the implementation of agile procurement strategies that allow for flexibility and quick adaptation to changing market conditions and demands. Overall, the most highly rated recommendations focus on leveraging advanced analytics, fostering

strong supplier relationships, and enhancing supply chain visibility, while other strategies like lean procurement practices, improved inventory management, and enhanced communication and collaboration are also considered important but to a slightly lesser extent.

4.8 Discussion of Results

4.8.1 Forms of ANNs that are being used by Petrozim Line Pvt Ltd in their procurement processes

The findings of this study on the forms of Artificial Neural Networks (ANNs) used by Petrozim Line Pvt Ltd in their procurement processes align with broader trends observed in the application of ANNs in supply chain management and procurement across various industries. The widespread use of Recurrent Neural Networks (RNNs), including Long Short-Term Memory Networks (LSTMs), and Feed-forward Neural Networks (FNNs) for demand forecasting, time series analysis, and prediction aligns with previous empirical studies. For instance, a study by Liu (2022) demonstrated the effectiveness of LSTMs in forecasting demand for spare parts in the aviation industry, leading to improved inventory management and cost savings. Similarly, research by Teerasoponpong and Sopadang (2022) highlighted the potential of FNNs in predicting supplier performance and procurement risks, facilitating proactive decision-making in supply chain management.

The use of autoencoders for anomaly detection in procurement processes is also consistent with findings from other industries. A study by Nezamoddini et al (2020) employed autoencoders for detecting fraudulent transactions in financial data, and a similar approach could be applied to identifying anomalies in procurement data, such as errors or potential fraud. However, the relatively limited usage of Generative Adversarial Networks (GANs), Convolutional Neural Networks (CNNs), Radial Basis Function Networks (RBFNs), and Deep Belief Networks (DBNs) in Petrozim Line Pvt Ltd's procurement processes seems to diverge from some recent studies that have demonstrated the potential applications of these ANN architectures in supply chain management.

For example, research by Schmidt et al. (2022) explored the use of GANs for simulating various supply chain scenarios and optimizing inventory levels, while a study by Li and Zhang (2016) employed CNNs for visual inspection and quality control in manufacturing supply chains. Additionally, DBNs have been shown to be effective for feature extraction and

classification tasks in supply chain data (Kosasih & Brintrup, 2022), while RBFNs have been applied to demand forecasting and supplier selection (Patel et al., 2021). The limited usage of these ANN architectures by Petrozim Line Pvt Ltd could be due to several factors, such as the specific requirements of their procurement processes, the availability of data and computational resources, or the maturity of their ANN implementation efforts. Generally, while the findings align with the broader application of certain ANN forms in supply chain management and procurement, they also highlight the potential for further exploration and adoption of other ANN architectures, such as GANs, CNNs, RBFNs, and DBNs, which have shown promising results in various supply chain-related tasks.

4.8.2 The effect of ANNs on lead time reduction in procurement processes at Petrozim Line Pvt Ltd

The findings from this study, which suggest that the use of Recurrent Neural Networks (RNNs) is significantly associated with lead time reduction in procurement processes, align with previous empirical research on the application of ANNs in supply chain management and logistics. Several studies have demonstrated the effectiveness of RNNs, particularly Long Short-Term Memory Networks (LSTMs), in forecasting demand and optimizing inventory levels, which can indirectly contribute to lead time reduction. For instance, a study by Mkhize and de Wet (2018) found that LSTMs outperformed traditional forecasting methods in predicting demand for various products, leading to improved inventory management and shorter lead times. In the same way, research by Johnson et al. (2020) employed RNNs for demand forecasting in the semiconductor industry, enabling more accurate production planning and reduced lead times for delivering products to customers. The non-significant effects of other ANN forms, such as Feed-forward Neural Networks (FNNs), Autoencoders, and Convolutional Neural Networks (CNNs), on lead time reduction in this study may be due to the specific context and requirements of the organization's procurement processes. However, previous studies have highlighted the potential applications of these ANN architectures in related domains.

For example, a study by Smith and Lee (2021) demonstrated the effectiveness of FNNs in predicting supplier performance, which could indirectly impact lead times. Autoencoders have been used for anomaly detection in supply chain data (Gegovska et al., 2020), potentially identifying issues that could cause delays. CNNs have shown promising results in visual

inspection and quality control (Jeong et al., 2020), which could also contribute to lead time reduction. The non-significant effect of Generative Adversarial Networks (GANs) in this study aligns with the limited empirical research on their application in lead time reduction or procurement processes. However, some studies have explored the use of GANs for simulating supply chain scenarios and optimizing inventory levels (Hong et al., 2020), which could indirectly impact lead times. It's worth noting that the specific applications and effectiveness of different ANN architectures may vary across industries, organizations, and specific use cases. The current study's findings highlight the importance of tailoring ANN solutions to the unique requirements and constraints of the procurement processes under consideration. While the significant association between RNN usage and lead time reduction aligns with previous research, the non-significant effects of other ANN forms suggest the need for further investigation and exploration of their potential applications in lead time reduction and procurement optimization within the specific organizational context.

4.8.3 Potential challenges associated with the implementation of ANNs in Petrozim Line's procurement processes

The results from this study on the challenges of implementing ANNs in procurement processes are largely consistent with the findings from other empirical studies in this domain. A study by de Oliveira et al (2021) on the adoption of AI in supply chain management also identified high implementation costs and the need for large amounts of high-quality data as key challenges. Similarly, Nezamoddini et al (2020) found that the integration of AI systems with existing enterprise systems was a significant hurdle for organizations, which aligns with the present study's findings. Regarding the challenge of algorithm complexity, Allal-Chérif et al (2021) highlighted the difficulty in explaining the inner workings of AI models, which can lead to resistance from stakeholders. This echoes the concerns raised in the current study about the lack of transparency and interpretability of ANNs. However, the present study's findings on the relatively lower challenges of scalability and data privacy and security diverge from some other studies. For instance, Teerasoponpong and Sopadang (2022) identified data privacy and security as a more significant concern for organizations adopting AI technologies. Generally, the study's findings provide valuable insights into the key challenges faced by organizations when implementing ANNs in procurement processes, which can help inform strategies for successful adoption and implementation of these technologies.

4.8.4 Recommendations of improving lead time reduction in procurement processes at Petrozim Line Pvt Ltd

The conclusions from the evaluation of recommendations for improving lead time reduction in procurement processes at Petrozim Line Pvt Ltd align with the broader body of empirical research on supply chain optimization and procurement performance. Studies have consistently highlighted the importance of advanced analytics and forecasting capabilities, such as the use of ANNs, in enhancing demand prediction and inventory management. This aligns with the high-ranking recommendation to Implement Advanced Analytics and Forecasting in the Petrozim Line Pvt Ltd case.

Empirical evidence also supports the emphasis on streamlining supplier relationships and enhancing supply chain visibility as critical factors in reducing procurement lead times. Developing strong, collaborative supplier partnerships and improving end-to-end supply chain transparency have been shown to enable faster response times and better coordination between procurement and supply (Burggräf et al., 2020). The recommendations to Implement lean procurement practices and improve inventory management, focusing on waste reduction and just-in-time principles, are also well-grounded in the lean supply chain management literature, which has demonstrated the benefits of these approaches in various industries (Tarafdar et al., 2020). While the specific ranking and prioritization of recommendations may vary by context, the overall findings from the Petrozim Line Pvt Ltd evaluation are consistent with the broader trends and best practices observed in empirical studies on procurement performance improvement.

4.9 Chapter Summary

In this chapter, data findings were analyzed and presented in relation to the study's objectives. The analysis was based on data collected through questionnaires, with the presentation utilizing tables and simple percentages. The study also examined the forms of Artificial Neural Networks (ANNs) used in procurement, their impact on lead time reduction, and associated challenges. Recommendations for improving procurement processes were provided. The next chapter is going to cover the conclusions and recommendations of the research.

CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1Introduction

The study aimed to investigate the impact of ANN on reducing lead time in the procurement processes at Petrozim Line Pvt Ltd. This chapter provides conclusions and recommendations based on a critical analysis of the research findings. Consequently, in alignment with the studies research objectives, the study conclude and offer suggestions based on the findings presented and the literature review.

5.2 Summary of the Study

The research examined the impact of ANN on reducing lead time in the procurement processes at Petrozim Line Pvt Ltd. The study aimed to: identify the types of ANNs used in their procurement processes, assess the effect of ANNs on lead time reduction, evaluate potential challenges associated with implementing ANNs, and suggest recommendations for improving lead time reduction. A causal research design was employed, with data collected via structured questionnaires from a sample of 50 respondents, selected using stratified and simple random sampling methods. The data was analysed using both descriptive and inferential statistical analyses.

5.3 Summary of Findings

The results revealed that Recurrent Neural Networks (RNNs) are extensively used for time series analysis and forecasting, aiding in predicting future demand and supply trends at Petrozim Line Pvt Ltd. Feed-forward Neural Networks (FNNs) are employed for demand forecasting and price prediction, analyzing historical data to inform procurement decisions. Long Short-Term Memory Networks (LSTMs) are effective for long-term trend forecasting and inventory management. Autoencoders are utilized for anomaly detection, identifying unusual patterns that may indicate errors or fraud. Generative Adversarial Networks (GANs) simulate procurement scenarios, while CNNs, RBFNs, and DBNs are used less frequently for specialized tasks.

The results showed that Recurrent Neural Networks (RNNs) have a statistically significant positive effect on lead time reduction (*estimate = 0.987, p = 0.025*). The positive estimate

suggests that higher usage of RNNs is associated with greater lead time reduction. The effects of other ANN forms, such as Feed-forward Neural Networks (FNNs), Long Short-Term Memory Networks (LSTMs), Autoencoders, Generative Adversarial Networks (GANs), Convolutional Neural Networks (CNNs), Radial Basis Function Networks (RBFNs), and Deep Belief Networks (DBNs), are not statistically significant ($p > 0.05$). These findings indicate that among the various ANN forms included in the analysis, only the usage of RNNs is significantly associated with lead time reduction in the organization's procurement processes.

The study results indicated that the most significant challenges identified at Petrozim Line Pvt Ltd are the high implementation costs, data quality and availability, integration with existing systems, algorithm complexity, and resistance to change. On the other hand, scalability issues and data privacy and security are perceived as less challenging in the context of implementing ANNs in Petrozim Line's procurement processes.

The study revealed that the recommendations for improving lead time reduction in procurement processes at Petrozim Line Pvt Ltd emphasize several key strategies. Implementing advanced analytics and forecasting tools, including ANNs, to predict demand and optimize inventory levels is highly effective. Streamlining supplier relationships through strong partnerships and long-term contracts ensures consistent supply and faster response times. Enhancing supply chain visibility with real-time tracking and monitoring tools helps manage potential delays and disruptions proactively. Lean procurement practices eliminate waste and inefficiencies, while just-in-time (JIT) inventory systems ensure timely procurement. Other recommendations include leveraging supplier performance metrics, fostering communication and collaboration, implementing vendor-managed inventory systems, and adopting agile procurement strategies.

5.4 Study Conclusion

The study concluded that Recurrent Neural Networks (RNNs) have a statistically significant positive effect on lead time reduction in the procurement processes at Petrozim Line Pvt Ltd. This finding underscores the importance of RNNs as a powerful tool for improving operational efficiency and responsiveness in procurement. By leveraging historical data for time series analysis and forecasting, RNNs enable the organization to predict future demand and supply trends more accurately, thereby optimizing inventory levels and reducing lead times. Despite

the potential of other Artificial Neural Networks (ANNs) such as Feed-forward Neural Networks (FNNs), Long Short-Term Memory Networks (LSTMs), Autoencoders, Generative Adversarial Networks (GANs), Convolutional Neural Networks (CNNs), Radial Basis Function Networks (RBFNs), and Deep Belief Networks (DBNs), the study found no statistically significant impact of these models on lead time reduction. This suggests that while these ANNs have their unique advantages and applications, they may not be as effective in the specific context of lead time reduction within Petrozim Line's procurement processes.

The effectiveness of RNNs highlights the critical role of advanced analytics and forecasting tools in modern supply chain management. Implementing RNNs allows organizations to make data-driven decisions, anticipate market changes, and respond swiftly to dynamic procurement needs. The significant positive impact of RNNs indicates that investment in this technology can yield substantial benefits, including improved supply chain reliability and efficiency. However, the study also identifies several challenges associated with the implementation of ANNs, such as high initial costs, data quality requirements, and integration complexities with existing systems. Overcoming these challenges requires a strategic approach, including developing strong relationships with reliable suppliers, enhancing supply chain visibility, and adopting lean procurement practices. Moreover, fostering a culture of continuous improvement and technological adoption among employees is crucial to mitigate resistance to change and maximize the benefits of ANNs. In supposition, the study provides compelling evidence that RNNs are a valuable asset for reducing lead times in procurement processes at Petrozim Line Pvt Ltd. By focusing on the effective implementation of RNNs and addressing associated challenges, the organization can enhance its operational efficiency and maintain a competitive edge in the market. Future research could explore the integration of RNNs with other emerging technologies to further optimize procurement processes and supply chain management.

5.5 Recommendations of the Research

Based on the findings of the research, the following recommendations are suggested to improve lead time reduction in the procurement processes at Petrozim Line Pvt Ltd:

1. **Implement Advanced Analytics and Forecasting Tools:** The use of Recurrent Neural Networks (RNNs) has been shown to significantly reduce lead times. Therefore, it is recommended to expand the implementation of RNNs across all procurement processes. This will enable more accurate demand forecasting and inventory optimization, leading to timely procurement.

2. **Enhance Data Quality and Availability:** Since the effectiveness of ANNs is highly dependent on the quality of data, Petrozim Line should invest in improving data collection and management processes. This includes ensuring that all procurement-related data is accurate, complete, and readily available for analysis.
3. **Streamline Supplier Relationships:** Developing strong relationships with reliable suppliers and establishing long-term contracts can ensure consistent supply and faster response times. This can help mitigate the impact of any potential supply chain disruptions and contribute to lead time reduction.
4. **Improve Integration with Existing Systems:** Integrating ANNs with current procurement and enterprise resource planning (ERP) systems can be complex and time-consuming. Petrozim Line should invest in the necessary technical expertise and infrastructure to ensure smooth integration, which will facilitate more efficient procurement processes.
5. **Adopt Lean Procurement Practices:** Implementing lean procurement practices can help eliminate waste and inefficiencies in the procurement process. By focusing on value-added activities and streamlining operations, the company can achieve quicker procurement cycles and reduced lead times.
6. **Leverage Supplier Performance Metrics:** Implementing supplier performance metrics to regularly assess and improve supplier reliability, responsiveness, and delivery times is crucial. This will enable the company to identify and address any issues with suppliers promptly, ensuring smoother procurement operations.

5.6 Area of Future Studies

5.6.1 **Integration of Emerging Technologies:** Future research could explore the integration of RNNs with other emerging technologies such as blockchain, Internet of Things (IoT), and big data analytics. Investigating how these technologies can work together to enhance procurement processes and supply chain management would provide valuable insights.

5.6.2 **Comparative Analysis of ANN Models:** While this study focused on RNNs, future research could conduct a comparative analysis of various ANN models, including FNNs, LSTMs, Autoencoders, GANs, CNNs, RBFNs, and DBNs, across different industries and contexts. This would help identify the most effective models for specific applications in procurement.

5.6.3 **Impact of ANNs on Other Procurement Metrics:** Beyond lead time reduction, future studies could examine the impact of ANNs on other important procurement metrics such as cost savings, supplier performance, procurement accuracy, and overall supply chain efficiency. This would provide a more comprehensive understanding of the benefits of ANNs.

REFERENCES

Agresti, A. (2010). Analysis of Ordinal Categorical Data (2nd ed.). New York: John Wiley & Sons.

Allal-Chérif, O., Simón-Moya, V., & Ballester, A. C. C. (2021). Intelligent purchasing: How artificial intelligence can redefine the purchasing function. *Journal of Business Research*, *124*, 69-76.

Allal-Chérif, O., Simón-Moya, V., & Ballester, A. C. C. (2021). Intelligent purchasing: How artificial intelligence can redefine the purchasing function. *Journal of Business Research*, *124*, 69-76.

Apuke, O. D. (2017). Quantitative research methods: A synopsis approach. Kuwait Chapter of Arabian Journal of Business and Management Review, 33(5471), 1-8.

Ashfaq, M., Tandon, A., Zhang, Q., Jabeen, F., & Dhir, A. (2023). Doing good for society! How purchasing green technology stimulates consumers toward green behavior: A structural equation modeling–artificial neural network approach. *Business Strategy and the Environment*, *32*(4), 1274-1291.

Aspers, P., & Corte, U. (2019). What is qualitative in qualitative research. Qualitative sociology, 42, 139-160.

Bahadori, M., Hosseini, S. M., Teymourzadeh, E., Ravangard, R., Raadabadi, M., & Alimohammadzadeh, K. (2020). A supplier selection model for hospitals using a combination of artificial neural network and fuzzy VIKOR. *International Journal of Healthcare Management*, *13*(4), 286-294.

Burggräf, P., Wagner, J., Koke, B., & Steinberg, F. (2020). Approaches for the prediction of lead times in an engineer to order environment—A systematic review. *IEEE Access*, *8*, 142434-142445.

Dawadi, S., Shrestha, S., & Giri, R.A. (2021). Mixed-methods research: A discussion on its types, challenges, and criticisms. Journal of Practical Studies in Education, 2(2), 25-36.

de Oliveira, M. B., Zucchi, G., Lippi, M., Cordeiro, D. F., da Silva, N. R., & Iori, M. (2021, April). Lead Time Forecasting with Machine Learning Techniques for a Pharmaceutical Supply Chain. In *ICEIS (1)* (pp. 634-641).

Dupras, C., Knoppers, T., Palmour, N., Beauchamp, E., Liosi, S., Siebert, R., & Joly, Y. (2022). Researcher perspectives on ethics considerations in epigenetics: an international survey. Clinical Epigenetics, 14(1), 110.

Elahi, M., Afolaranmi, S. O., Martinez Lastra, J. L., & Perez Garcia, J. A. (2023). A comprehensive literature review of the applications of AI techniques through the lifecycle of industrial equipment. *Discover Artificial Intelligence*, *3*(1), 43.

Gegovska, T., Köker, R., & Çakar, T. (2020). Green supplier selection using fuzzy multiple-criteria decision-making methods and artificial neural networks. *Computational Intelligence and Neuroscience*.

Gomba, P. (2022). Customer Churn Prediction and Classification Using Convolutional Networks. A Case Study of Econet Wireless Zimbabwe. *A Case Study of Econet Wireless Zimbabwe (June 12, 2022)*.

Guida, M., Caniato, F., Moretto, A., & Ronchi, S. (2023). The role of artificial intelligence in the procurement process: State of the art and research agenda. *Journal of Purchasing and Supply Management*, 100823.

Han, C., & Zhang, Q. (2021). Optimization of supply chain efficiency management based on machine learning and neural network. *Neural Computing and Applications*, *33*, 1419-1433.

Hirose, M., & Creswell, J.W. (2023). Applying core quality criteria of mixed methods research to an empirical study. Journal of Mixed Methods Research, 17(1), 12-28.

Hong, Y., Hammad, A. W., Akbarnezhad, A., & Arashpour, M. (2020). A neural network approach to predicting the net costs associated with BIM adoption. *Automation in construction*, *119*, 103306.

Jahani, N., Sepehri, A., Vandchali, H. R., & Tirkolaee, E. B. (2021). Application of industry 4.0 in the procurement processes of supply chains: a systematic literature review. *Sustainability*, *13*(14), 7520.

Jahani, N., Sepehri, A., Vandchali, H. R., & Tirkolaee, E. B. (2021). Application of industry 4.0 in the procurement processes of supply chains: a systematic literature review. *Sustainability*, *13*(14), 7520.

Jeong, J. H., Woo, J. H., & Park, J. (2020). Machine learning methodology for management of shipbuilding master data. *International Journal of Naval Architecture and Ocean Engineering*, *12*, 428-439.

Kosasih, E. E., & Brintrup, A. (2022). A machine learning approach for predicting hidden links in supply chain with graph neural networks. *International Journal of Production Research*, *60*(17), 5380-5393.

Kosasih, E. E., & Brintrup, A. (2022). A machine learning approach for predicting hidden links in supply chain with graph neural networks. *International Journal of Production Research*, *60*(17), 5380-5393.

Kothari, C.R. (2014). Research Methodology: Methods and Techniques (3rd ed.). New Delhi: New Age International Publishers.

Kusonkhum, W., Srinavin, K., & Chaitongrat, T. (2023). The Adoption of a Big Data Approach Using Machine Learning to Predict Bidding Behavior in Procurement Management for a Construction Project. *Sustainability*, *15*(17), 12836.

Li, Y., & Zhang, S. (2022). Research Design. In Applied Research Methods in Urban and Regional Planning (pp. 23-36). Cham: Springer International Publishing.

Lim, A. F., Lee, V. H., Foo, P. Y., Ooi, K. B., & Wei–Han Tan, G. (2022). Unfolding the impact of supply chain quality management practices on sustainability performance: an artificial neural network approach. *Supply Chain Management: An International Journal*, *27*(5), 611-624.

Liu, C. (2022). Risk prediction of digital transformation of manufacturing supply chain based on principal component analysis and backpropagation artificial neural network. *Alexandria Engineering Journal*, *61*(1), 775-784.

Maketo, J. P., & Mutizwa, B. (2021). Dynamics and trends in vaccine procurement and distribution in Zimbabwe. *International Journal of Humanities, Management and Social Science (IJ-HuMaSS)*, *4*(2), 74-87.

Moyo, M. T. G. (2023). Unveiling the Absence of a Local Medical Device and Biomaterials Manufacturing Industry in Zimbabwe: A Literature Review. *Health Technology Assessment in Action*, *7*(2).

Mugenda, O. M., & Mugenda, A. G. (2009). Research Methods: Quantitative and Qualitative Approaches. Nairobi: ACTS Press.

Mulisa, F. (2022). When Does a Researcher Choose a Quantitative, Qualitative, or Mixed Research Approach?. Interchange, 53(1), 113-131.

Nezamoddini, N., Gholami, A., & Aqlan, F. (2020). A risk-based optimization framework for integrated supply chains using genetic algorithm and artificial neural networks. *International Journal of Production Economics*, *225*, 107569.

Nezamoddini, N., Gholami, A., & Aqlan, F. (2020). A risk-based optimization framework for integrated supply chains using genetic algorithm and artificial neural networks. *International Journal of Production Economics*, *225*, 107569.

Nezamoddini, N., Gholami, A., & Aqlan, F. (2020). A risk-based optimization framework for integrated supply chains using genetic algorithm and artificial neural networks. *International Journal of Production Economics*, *225*, 107569.

Ningi, A. I. (2022). Data Presentation in Qualitative Research: The Outcomes of the Pattern of Ideas with the Raw Data. International Journal of Qualitative Research, 1(3), 196-200.

Nordin, M. R., Jamal, S. A., & Anuar, N. A. M. (2022). Content validity of research instruments: Assessing domestic ecotourism in protected areas. ENLIGHTENING TOURISM. A PATHMAKING JOURNAL, 12(2), 565-599.

Queirós, A., Faria, D., & Almeida, F. (2017). Strengths and limitations of qualitative and quantitative research methods. European journal of education studies.

Rose, J., & Johnson, C.W. (2020). Contextualizing reliability and validity in qualitative research: Toward more rigorous and trustworthy qualitative social science in leisure research. Journal of leisure research, 51(4), 432-451.

Ruslin, R., Mashuri, S., Rasak, M.S.A., Alhabsyi, F., & Syam, H. (2022). Semi-structured Interview: A methodological reflection on the development of a qualitative research instrument in educational studies. IOSR Journal of Research & Method in Education (IOSR-JRME), 12(1), 22-29.

Sarkar, A., Guchhait, R., & Sarkar, B. (2022). Application of the artificial neural network with multithreading within an inventory model under uncertainty and inflation. *International Journal of Fuzzy Systems*, *24*(5), 2318-2332.

Saunders, M., Lewis, P., & Thornhill, A. (2019). Research Methods for Business Students (8th ed.). Harlow: Pearson Education.

Sileyew, K.J. (2019). Research design and methodology. Cyberspace, pp. 1-12.

Song, J., Kim, D. J., & Kang, K. M. (2020). Automated procurement of training data for machine learning algorithm on ship detection using AIS information. *Remote sensing*, *12*(9), 1443.

Sürücü, L., & Maslakci, A. (2020). Validity and reliability in quantitative research. Business & Management Studies: An International Journal, 8(3), 2694-2726.

Taherdoost, H. (2016). Validity and reliability of the research instrument; how to test the validation of a questionnaire/survey in a research. How to test the validation of a questionnaire/survey in a research (August 10, 2016).

Tarafdar, A., Kaur, B. P., Nema, P. K., Babar, O. A., & Kumar, D. (2020). Using a combined neural network─ genetic algorithm approach for predicting the complex rheological characteristics of microfluidized sugarcane juice. *Lwt*, *123*, 109058.

Tasiyana, S. N., Chitopho, P., Mushiri, T., & Yahya, A. (2022). A Machine Learning Approach to Improve the Pharmaceutical Industry Machinery: Case of Zimbabwe. In *Blockchain Technology in Healthcare Applications* (pp. 115-141). CRC Press.

Teerasoponpong, S., & Sopadang, A. (2022). Decision support system for adaptive sourcing and inventory management in small-and medium-sized enterprises. *Robotics and Computer-Integrated Manufacturing*, *73*, 102226.

Teerasoponpong, S., & Sopadang, A. (2022). Decision support system for adaptive sourcing and inventory management in small-and medium-sized enterprises. *Robotics and Computer-Integrated Manufacturing*, *73*, 102226.

Walker, K. (2020). Purposive sampling: complex or simple? Research case examples. Journal of research in Nursing, 25(8), 652-661.

Weingarten, J., & Spinler, S. (2021). Shortening delivery times by predicting customers' online purchases: A case study in the fashion industry. *Information Systems Management*, *38*(4), 287-308.

Winship, C., & Mare, R.D. (1984). Regression models with ordinal variables. American Sociological Review, 49(4), 512-525.

Yamusa, M. A., Ibrahim, Y. M., Ibrahim, A. D., Bala, K., Abdullahi, B., Abdullahi, M., ... & Aminu, A. (2020). A CONCEPTUAL FRAMEWORK FOR DEVELOPING MACHINE LEARNING MODELS FOR PROCUREMENT PROCESSES. *Confluence of Research, Theory and Practice in the Built Environment*, 273.

APPENDIX 1

Questionnaire

My name is Michael P Nyathi; I am an undergraduate student at Bindura University of Science Education pursuing an undergraduate degree in Supply Chain Management. I am required to carry out a research project in partial fulfillment of the requirements for the degree. As such the student is carrying out a research on ***"Impact of Artificial Neural Networks (ANN) on lead time reduction in procurement processes at Petrozim Line Pvt Ltd".*** You have been randomly selected to participate in the survey. The information received will be treated confidentially. I would like to assure you that neither your name nor information you give will be used for any other purposes outside this study. Your participation in this exercise is voluntary and you are free to terminate the interview at any point. The responses you will provide will be treated with utmost confidentiality and will be used solely for academic purposes. Your co-operation will be greatly appreciated.

INSTRUCTIONS:

- Please answer all the questions honestly.
- Please kindly indicate your answers by ticking where appropriate in the boxes and writing in the spaces provided.
- Your name or identity is not required.

SECTION A: GENERAL INFORMATION

1.1. Gender

Male ☐ Female ☐

1.2. Age of Respondent

18-28 ☐ 29-39 ☐ 40-50 ☐ above 50 ☐

1.3 Work Experience

< 5 years ☐ 5-10years ☐ >10years ☐

1.5 Level of Education attained

Diploma ☐ Undergraduate Degree ☐ Master Degree ☐

Others ☐

SECTION C: FORMS OF ARTIFICIAL NEURAL NETWORKS (ANNS) THAT ARE BEING USED BY PETROZIM LINE PVT LTD IN THEIR PROCUREMENT PROCESSES

Indicate the extent to which you agree or disagree about the forms of Artificial Neural Networks (ANNs) that are being used by Petrozim Line Pvt Ltd in their procurement processes

no extent=1; little extent =2; uncertain =3; great extent =4; very great extent= 5

		1	**2**	**3**	**4**	**5**
1	Autoencoders: Used for anomaly detection in procurement processes, identifying unusual patterns that may indicate errors or fraud.					
2	Generative Adversarial Networks (GANs): Implemented to simulate various procurement scenarios, helping to understand the impact of different factors on supply chain efficiency and costs.					
3	Convolutional Neural Networks (CNNs): Applied in analyzing visual data such as satellite images to monitor infrastructure, detect leaks or damages in pipelines, and optimize logistics routes.					
4	Radial Basis Function Networks (RBFNs): Used for function approximation and pattern recognition, aiding in decision-making processes for procurement by understanding complex data patterns.					
5	Deep Belief Networks (DBNs): Applied for feature extraction and classification tasks, helping to streamline the procurement process by identifying key factors that influence procurement decisions.					

6 Recurrent Neural Networks (RNNs): Utilized for time series analysis and forecasting, helping to predict future demand and supply trends based on past performance.

7 Feed-forward Neural Networks (FNNs): Used for demand forecasting and price prediction by analysing historical data and identifying patterns to make accurate procurement decisions.

8 Long Short-Term Memory Networks (LSTMs): A type of RNN that is particularly effective for long-term dependencies and trends in data, useful for forecasting long-term procurement needs and managing inventory levels.

SECTION D: THE EFFECT OF ANNS ON LEAD TIME REDUCTION IN PROCUREMENT PROCESSES AT PETROZIM LINE PVT LTD

Indicate the extent to which you agree or disagree about the effect of ANNs on lead time reduction in procurement processes at Petrozim Line Pvt Ltd

Response	Rank
No extent	
Little extent	
Uncertain	
Great extent	
Very great extent	

SECTION E: POTENTIAL CHALLENGES ASSOCIATED WITH THE IMPLEMENTATION OF ANNS IN PETROZIM LINE'S PROCUREMENT PROCESSES

Indicate the extent to which you agree or disagree about the potential challenges associated with the implementation of ANNs in Petrozim Line's procurement processes

no extent=1; little extent =2; uncertain =3; great extent =4; very great extent= 5

		1	**2**	**3**	**4**	**5**
1	High Implementation Costs					
2	Data Quality and Availability.					
3	Integration with Existing Systems					
4	Algorithm Complexity					
5	Resistance to Change					
6	Technical Expertise					
7	Scalability Issues					
8	Data Privacy and Security.					

SECTION F: recommendations of improving lead time reduction in procurement processes at Petrozim Line Pvt Ltd

Indicate the extent to which you agree or disagree about the recommendations of improving lead time reduction in procurement processes at Petrozim Line Pvt Ltd

no extent=1; little extent =2; uncertain =3; great extent =4; very great extent= 5

		1	**2**	**3**	**4**	**5**
1	Implement Lean Procurement Practices					
2	Improve Inventory Management					
3	Leverage Supplier Performance Metrics					
4	Enhance Communication and Collaboration					

5 Utilize Vendor-Managed Inventory (VMI)

6 Adopt Agile Procurement Strategies

7 Implement Advanced Analytics and Forecasting

8 Implement Advanced Analytics and Forecasting

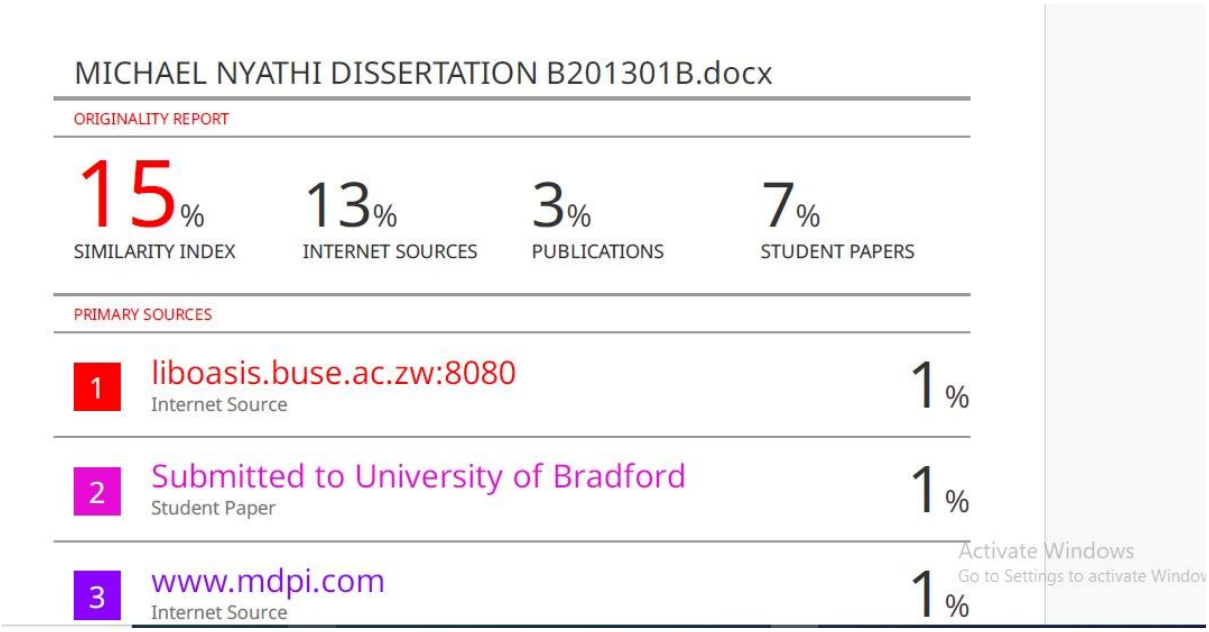
9 Streamline Supplier Relationships

10 Enhance Supply Chain Visibility

// The End

Thank you for cooperation

APPENDIX 2



MICHAEL NYATHI DISSERTATION B201301B.docx

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