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Sustainability and performance of the South African mining industry in supply chain management post Covid-19

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Sustainability and performance of the South African mining industry in supply chain management post Covid-19.

Applied Research Project submitted by

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Declaration

I Marakeng Malebana declare that this is my original accomplishment with the input from my supervisor. The work is being submitted in partial fulfilment of the requirement of the degree of Master of Business Administration at the University of the Witwatersrand Business School, Johannesburg. In addition, this research has not been submitted to any other academic institutions for the award of any degree.

Acknowledgment

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Abstract

The COVID-19 pandemic has significantly impacted global supply chains, disrupted operations, and caused delays across various industries. The mining industry in South Africa was not immune to some of these problems. Gradually, restrictions eased, businesses reopened, and supply chain performance slowly improved. However, the pandemic has highlighted the importance of building resilience in supply chains to prepare for future disruptions. Mining firms in South Africa should re-evaluate their supply chain strategies, looking to diversify suppliers, shorten lead times, and increase transparency to mitigate risks. Moreover, adopting advanced technologies like artificial intelligence, Blockchain, and the Internet of Things should assist firms in managing their supply chains better, improving visibility, and enhancing overall performance.

This study examined the post-COVID-19 supply chain management performance in the mining industry. This was quantitative research, and the population of the study was 319 and 175 respondents across five mining companies in South Africa. The study developed and empirically tested hypotheses to determine the influence of supply chain network design, information systems, organizational structure, and supply chain strategy on supply chain finance and performance.

The research suggests that mining firms in South Africa must radically improve their supply chain design, organization structure, and strategy and deploy information systems such as blockchain, machine learning, AI, and ERP to enhance industry performance. The current supply chain challenges in the industry require building capabilities and sharing resources among firms to alleviate the cost and other problems in logistics. The study contributes to the body of knowledge in supply chain management and offers a proposition to management on how to resolve the bottleneck in industry support to improve industry performance.

Acronyms

AI: Artificial Intelligence

ANOVA: Analysis of Variance

BI: Business Intelligence

ERP: Enterprise Resource Planning

ML: Machine Learning

RBC: Richards Bay Coal Terminal

SCM: Supply Chain Management

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Chapter one: Introduction

1.1 Introduction and background

The mining sector is a core driver of the South African economy and contributes 40% of the country's export earnings (Reserve Bank, 2020) and in the first quarter of 2023, the GDP contribution from the mining sector declined by 3.2% (Statistics SA, 2023). The novel coronavirus created both short-term and long-term consequences for the mining industry in South Africa. Some of these consequences include the decline in productivity in the mining industry, retrenchment of the workforce, poor performance, and bottlenecks in the supply chain (Laing, 2020). The pandemic has a significant impact on the long-term growth potential of South African' mining and its sustainability, given that South Africa is mineral-dependent.

In addition, the just energy transition in emerging markets countries such as South Africa has been impacted by the pandemic, which will impact the mining sector's sustainability in the long run (Arndt et al., 2020). The coronavirus pandemic has created uncertainty in the industry, directly impacting the long-term investment in the mining and other sectors of the South African economy (De Villiers et al., 2020). Furthermore, the onset of the coronavirus caused low demand for minerals and a decline in the prices of these minerals, which had a significant impact on the revenues of South Africa, which relies substantially upon the export of minerals **(**Laing, 2020). Overall, the coronavirus pandemic led to a significant decline in mining activities in South Africa, creating a low productivity problem for the sector's human and financial capital (Chitiga-Mabugu et al., 2021; Jowitt, 2020).

The coronavirus had a substantial impact on the global supply chain, which in turn affected the mining sector in South Africa in terms of high inputs and supply chain constraints, and other business processes (Butt, 2021) The supply chain of the mining industry in South Africa has been severely constrained due to high fuel processes and other operational issues during the lockdown and after that **(**Guan et al., 2020).

The pandemic lockdown impacted several business processes, and the industry in South Africa was not spared. There is a need to build a robust and resilient supply chain to respond to such pandemics in the future to protect this vital part of the South African economy (Xu et al., 2020). The coronavirus pandemic has shown the need for a resilient and robust supply chain in the mining sector in emerging markets such as South Africa **(**Bag et al., 2022). The need to close the gap in the vulnerability of the supply chain remains essential to all stakeholders, given the contributions of the mining sector in South Africa (Free & Hecimovic, 2021; Miroudot, 2020).

This study examines the sustainability and performance of the mining industry supply chain post-coronavirus. The sustainability and performance of the supply chain are essential to sustain economic growth in South Africa (Bhagwan & Evans, 2023). In addition, the global supply chain bottleneck post-COVID-19 has highlighted the importance of the supply chain for businesses and the global economy (Kähkönen et al., 2023).

1.2 Mining sector in emerging markets

Tseng Islam et al. (2019) studied the use of supply chains in the mining sector. They indicated that firms that introduce supply chain management strategies have more chance of seeing marked improvement in their business performance, and more significantly. The applications of research and development (R&D) in the supply chain, the use of technology in the firm's business processes, and the building of core organisational competence have the potential to improve the performance of the firm significantly (Wang et al., 2023).

The opportunities in the mining sector in South Africa continue to be hampered by social and economic factors. New entrants, such as the "*Zama Zama*" or illegal miners, pose a severe risk to the sustainability of the mining sector and its performance (Bester, 2023). The study conducted in Ghana has identified several sustainable supply chain practices that mining companies use to improve their operational and business performance. These include green information technology, strategic partnerships with other mining firms, operations and logistical integration of the value chain, eco-innovative practices, and reverse logistics, to mention but a few (Famiyeh & Kwarteng, 2018). Jawaad & Zafar (2020) investigated the improvement of sustainable development and firm performance using sustainable supply chain concepts. He found that green supply chain practices

significantly impact firm performance, and investment in sustainable supply chain practices mediates the relationship between intraorganizational and firm performance.

Furthermore, in Zimbabwe, several challenges have been identified that hinder the implementation of SCCM in the mining industry, such as institutional gaps in transformation and structural changes, stakeholder resistance, and legal and regulatory bottlenecks (Muchaendepi et al., 2019). The coercive, normative and regulative pressure to implement sustainable supply chain management in the mining industry is related to legal and regulatory requirements, customer and consumer demands, and other relevant stakeholder demands, competitive advantage, climate change activism, and reputational loss due to not running a sustainable supply chain (Prinsloo et al., 2019). Sustainable supply chain management has been sampled in four distinctive categories, i.e., individual/functional supply chain processes, supply chain systems, and networks (Seuring et al., 2022).

In the Ghanaian mining industry, mining firms face coercive, normative, and mimetic pressure to adopt supply chain sustainability practices to alleviate the problem of global warming due to the impact of mining activities (Famiyeh & Kwarteng, 2018). The challenges of mine waste and dumps in South Africa are of serious concern (Manjengwa et al., 2023) and require participation of all stakeholders to solve the problems - the impact of mine waste on the environmental performance of the mining industry.

The post-COVID-19 energy transition is essential to the sustainability and performance of the mining industry in South Africa (Abedian & Tsoanamatsie, 2022), especially in the coal mining sector due to the current power crisis that has increased the need for other sources of sustainable energy. Previous research has examined sustainable supply chain practices in mining sectors in other developing countries such as China, India, and Ghana (Wireko-Gyebi et al., 2022). However, in South Africa, limited studies have debated these issues and how they are used to transform the mining industry and cope with the aftereffects of the pandemic (Arndt et al., 2020). A study that used the survey method to study the coal industry and the supply chain in Indonesia shows that sustainability is essential for the performance of coal mining companies (Elfiswandi & Sanjaya, 2020).

The mining environment is associated with pollution. Old and abandoned mines pose severe challenges to local communities and the government due to the waste and acidic mining water left behind. In South Africa, a fierce debate about a just energy transition and the impact of coal mining on the environment has been at the forefront of these debates (Müller et al., 2021).
Mining firms must implement sustainable supply chain management practices after the pandemic to ensure the sustainability of the industry. Wang and Lou (2021) show the numerous benefits that can be gained from implementing sustainable supply chain practices in developing countries.

Pujawan and Bah (2022) examined how the COVID-19 pandemic disrupted the global supply chain and increased the appetite for supply chain management research to alleviate the global supply chain problem during and after the COVID-19 pandemic.

1.3 Context of the study

Context is critical in research undertaking. This research is situated in the mining sector to examine the performance of the sector post covid19. The study attempts to understand the mining industry's sustainability after the pandemic. In addition, the study examines how strategy, supply chain network design, information systems, and organisational structure can improve the sector's performance after the pandemic.

1.4 Research problem

The pandemic has impacted several businesses globally, including South Africa, and businesses are struggling to remain sustainable due to the high cost of rebuilding from the pandemic (Xu et al., 2023). Limited research has been conducted to understand sustainable supply chains and business performance in the mining sector in South Africa. There is a need to understand the impact of strategy, network design, information system, and organisational structure on sustainable supply chain and business performance in mining after the pandemic. Review of previous research has shown that there is limited application of sustainable supply chain management in the South African mining industry (Bag et al., 2022), and this research attempts to enshrine these practices

in the mining industry supply chain to address some of the challenges in the industry during and after covid19. Past studies should include the use of theory to investigate the impact of sustainable supply chain management and its impact on organisational and financial performance in the mining sector (Zhang et al., 2023). Furthermore, the construction to measure sustainable supply chain management practices, such as environmental, social, and sustainable, is understudied in Sub Sharan Africa.

This study seeks to contribute to five essential research gaps: practical/managerial, knowledge, theoretical, population/ context, and methodological gap (Miles, 2017). More knowledge about the managerial practices and innovations that mining companies have used to recover from the COVID-19 pandemic is needed. Most of the literature reviews on the subject show that context, methodology, and theoretical applications in research from Sub-Sharan Africa require the attention of scholars.

Furthermore, policy makers, managers and practitioners in the mining sector must be aware of the importance of this research field. However, there are still areas for theoretical improvement and there are opportunities to build robust and agile supply chains to respond to future pandemics.

1.5 Research objectives

This study's overarching objective is to examine the role of supply chain management in the mining industry post-COVID-19.

1.6 Research hypotheses

H1: Supply chain network design influences organisational supply chain finance performance.

H2: Supply chain strategy influences organisational supply chain performance.

H3: Supply chain network design impacts supply chain operational performance.

H4: Supply Chain strategy impacts organisational supply chain operational performance.

H5: Information systems influence finance organisational supply chain performance.

H6: Organisational structure influences organisational supply chain finance performance

H7: Information systems influence organisational supply chain operational performance.

H8: Organisational structure influences organisational supply chain performance.

1.7 Justification of the study

The business performance of the mining sector has declined due to the pandemic and disruption in the supply chain and energy crisis. There is a need for the business sector and scholars to offer a scalable solution to these problems of poor performance because of the issues mentioned above. This quantitative research contributes significantly to filling a knowledge, methodological, and empirical gap and proffers insights to managers, policymakers, and academics on how the business can reconfigure its operations to ameliorate the problems created by the pandemic. This research adds literature and policy considerations for academics and policymakers to shed more light on the problem.

1.8 Delimitation of the study

The research was deductive and survey in nature and limits itself to the mining sector in South Africa. The study uses Industry 4.0 and supply chain sustainability to examine how to improve performance in the mining industry in South Africa after COVID-19. Additionally, this cross-sectional study was limited to 5-6 large mining companies in Gauteng and Mpumalanga. The unit of analysis was mining firms, and the respondents were employees working in these mining firms. The study focused on supply chain sustainability and performance after COVID-19. Some comparative datasets were used to provide background information before Covid19.

1.10 Structure of the dissertation

This research was organised into five main chapters: Chapter 1 offers the introduction of the study, Chapter 2 presents a synthesis of the literature on the investigation, Chapter 3 offers the methodology, and Chapter 4 presents the study results. Chapter Five provides discussions of the proposals and, finally, Chapter Six offers the conclusion and recommendations of the study.

Chapter two: Literature review

2.1 Introduction

The overriding aim of this literature review is twofold. First, it examines the empirical work of other scholars that examines the relationship between supply chain sustainability and business performance after Covid19. The impact of the pandemic on businesses in South Africa has been widespread in several sectors, such as manufacturing and mining (Arndt et al., 2020). However, it is necessary to understand how the strategy, information systems, and organisation structure of supply chain sustainability firms significantly impact the organisational performance of mining firms in South Africa after Covid19. Secondly, the literature review attempts to identify the research gaps and endeavours to contribute towards closing the identified research gaps. The main research question was how mining firms use sustainable supply chain management, firm strategy, information systems, and organisational structure to improve their performance after covid19.

The critical assumption of the study is that mining companies will have to significantly change their business practices and processes to remain profitable after the pandemic. The relationship between supply chain sustainability and business performance is critical to ensure the long-term survival of mining firms in South Africa (Mishra et al., 2023). Furthermore, this review is critical to developing the theoretical and conceptual framework that will be used as the anchor of the study.

2.2 Theoretical and conceptual framework

Theories are necessary and can act as a glue to hold the research together. The conceptual framework provides the schema and interpretation of critical theoretical constructs and concepts and how they are used to drive the study to investigate the research problem (Miles, 2017).

The study extends the application of transaction cost theory to develop and implement sustainable supply chain management in the mining sector to support the recovery of the mining industry after Covid19 (Williamson, 1985). The cost of production and massive inflation after COVID-19 have impacted the supply chain and resulted in poor business performance in the sector. The weak institutional environment in emerging markets impacts business costs and profitability (Liedong et al., 2020).

H8: The organisational structure influences the performance of the organisational supply chain.

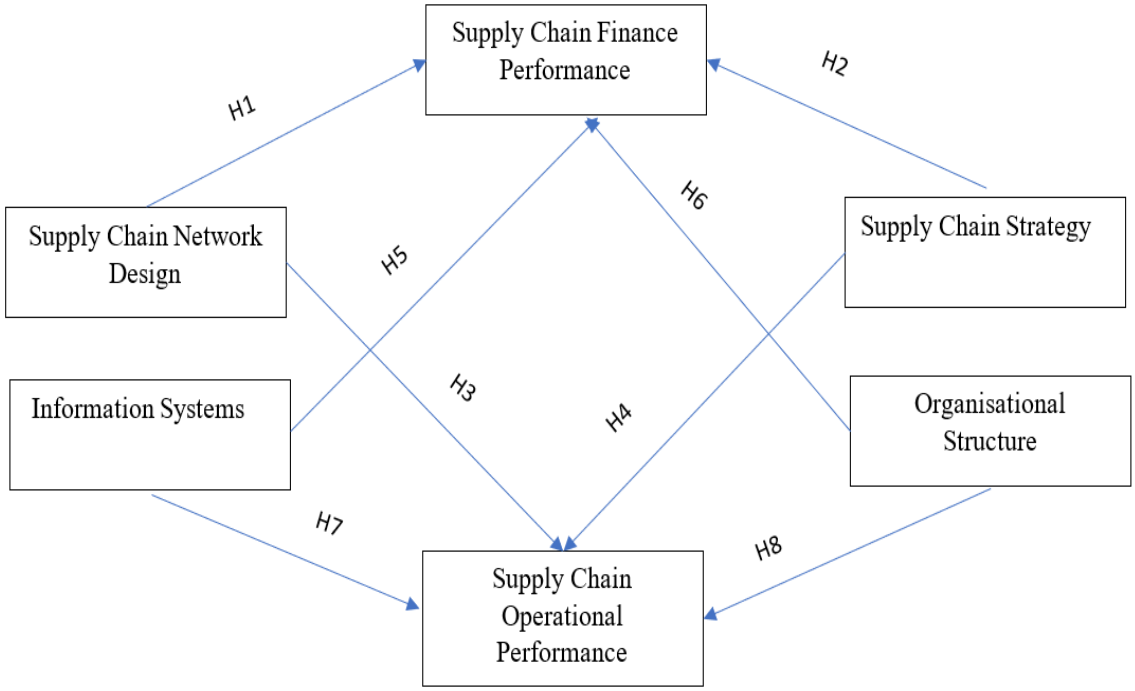


Figure 2.1: Conceptual Framework

Figure 2.1 shows the relationships in the conceptual framework which connects the core measure of supply chain sustainable management and how it impacts business performance. Moreover, the

conceptual relationship is hypotheses developed below. These relationships were tested using multiple regression analysis.

2.3 Transaction cost theory

TCE is *"a general theory of effective management of transaction and trade in relations"* (Ketokivi & Mahoney, 2020: p.1). TCEs are used in supply chain literature to explore how supply chains can be government and how the relationship between partners can be beneficial to each other.

In addition, it was initially developed by Coase (1937) and proliferated by Williamson (1975). The main concepts of TCE include the cost of governance and transaction, the cost of accessing information during argument and "determined by specificity, frequency, limited rationality, opportunistic behaviours and uncertainty, " (Williams, 2010). TCE has been used to assess company performance in international business research in supply chain management.

2.3.1 Key assumptions of Transaction cost economics

Important structures used in TCE include the governance structure, which is a dependent variable, whereas environmental uncertainty, behaviour uncertainty, and asset specificity are independent variables (Grover & Malhotra, 2003). These independent variables contribute to the gaps in the institutional framework of the mining industry. Moreover, the weak institutional impact of transaction cost in the supply chain. North (1990) argues that institutions must develop effective markets in order to lower the control and transaction costs. Institutional changes over time to achieve the highest levels of efficiency levels. Furthermore, the complexity of the supply chain can cause information asymmetries that influence decision making and cooperation with supply chain partners (Michalski et al., 2019).

Furthermore, transaction cost theory is a great tool to explain supply chain efficiency in the mining industry (Ketokivi & Mahoney, 2020). The theory explains why supply chains are structured in the mining sector. The supply chain hierarchy as an analysis unit represents cost opportunism, and reducing the cost of the supply chain can reduce the business's transaction costs, as more than 50% of the company's cost structure comes from the supply side and not the demand (cost structure of the firm).

2.4 Supply chain sustainability and business performance

Previous research in this field has shown the relevancy and relationship between supply chain and supply chain.
business performance in emerging markets (Njualem & Ogundare, 2023; Li et al., 2023). The supply chain is an essential antecedent to business performance and profitability. The importance of the supply chain was more than emphasised during and after COVID-19 when several firms were forced to shut down their entire operations due to bottlenecks in their supply chains (Demirkıran, 2023).

As a result of the pandemic shutdown, most companies' operational performance and productivity were affected. The consequence was poor overall performance across the entire industry value chain and the results showed the impact on the bottom line and firms' profitability. There were lessons to be learnt from the pandemic on firms' operations and profitability. Firms must secure their supply chains and prevent external shocks. Supply chain resilience is critical to support international business operations (Frederico, 2021).

The conceptual framework developed in the following highlights the importance of sustainable supply chain management and how it influences business performance in the mining sector. Business performance is theorised using environment, social and firm performance which also translates to the concept of a triple bottle line, considering people, planet and profits, which is crucial in the mining sector (Que, Wang, Awuah-Offei, Chen, & Yang, 2018; Njualem & Ogundare, 2023).

2.5 Sustainability supply chain management

The mining firms in South Africa must make sure that their supply chains are sustainable, robust, and efficient to provide economies of scale and survive external shocks such as global pandemics while simultaneously serving the customer. The disruption of supply chain activities could be more sustainable due to the long-term impact on firm profitability (Kelling et al., 2021).

The supply chain discipline is nested in logistics, marketing services, strategy, economic and financial information systems, raw materials manufacturing and transformation and logistics (Upadhyay, Laing, Kumar, & Dora, 2021). The mining industry in South Africa depends on its performance in logistics. The movement of coal to Richards Bay is critical.
The sustainability literature in the supply chain encapsulates three core principles or concepts, i.e., social, environmental, and economic performance.

The performance of mining firms is linked to these three concepts and the supply chain is a primary area where the implementation of sustainability can add value and improve business performance (Martins & Pato, 2019). Additionally, Joshi (2022) emphasised the three sustainability issues in the supply chain in the economic dimension to measure waste reduction, recycling, packaging, and reverse logistics. The environmental dimension examines pollution, clean technology, resources, and environmental management. Social indicators include working conditions, human rights, business practices, human development, and GDP. These are very relevant issues for supply chain and mining companies in South Africa.

The finding showed that performance and sustainability of the supply chain is essential, but adopting artificial intelligence protocol needs to be more relevant to the performance of the firms. Operational, economic, environmental, and social factors are essential for sustainable supply chain and impact on firm performance (Jawaad & Zafar, 2020).

The supply chain was first theorised in manufacturing organisations to encapsulate suppliers, manufacturers, distributors, and providers of services involved in upstream and downstream supply chain operations that deal with products, information flow, and financial resources, among others (Mentzer et al., 2001).

Sustainable supply chain management issues have not yet been fully addressed in emerging markets in the mining sector, such as South Africa. Scholars and practitioners must exert effort to improve these gaps and contribute to the dissemination of environmental knowledge and practices in the mining industry.

Njualem & Ogundare (2023) explored the impact of globalisation on supply chain sustainability and determined the relationship between sustainability measurement and application in mining

supply chains. This study is relevant because the South African mining industry is part of global systems, so its supply chains are interconnected.

The finding by Fasan et al., 2021 found that green supply chain practices were able to alleviate some of the problems caused by COVID-19 during and post the pandemic among US firms. The result is significant in South Africa, which is still struggling to recover from the COVID-19 pandemic. Studies in India during the pandemic showed that green practice was an effective instrument in the recovery process of mining companies (Marimuthu et al., 2022). The core problems in Indian mining firms during and after covid19 unemployment are low demand for minerals and disruption in global supply chains. To address these problems, Indian mining companies implement sustainability practices, innovative practices, and health and safety protocols to improve industry performance.

2.6 Supply chain performance and firm strategy

A firm's strategy significantly ensures that the supply chain syncs with other business processes. Mining companies should develop and implement strategies to do this. The performance of the company is directly related to the strategy deployed, and the selection of strategies must be tied to the business and operational capabilities within the company. Some supply chain strategies can significantly impact covid19; for example, firms must develop new strategies to cope with the harsh lockdown implemented globally. Supply chain agility is vital to the success of most companies during the pandemic. Government regulations severely affected mining forms in South Africa during the pandemic and there are several ways to ameliorate these problems.

Supply chain resilience after the pandemic is critical to the success of mining firms in South Africa. The learning lessons from the pandemic have given managers and supply chain professionals some first-hand knowledge on how to avoid future catastrophes in their supply chains to remain commercially profitable (Modgil et al., 2022).

2.7 Information systems & supply chains

The main problem in supply chain management is information asymmetry, and therefore information systems have been considered the lifeblood of supply chains, and mining firms must

be able to share information with different parties in both their downstream and upstream supply chain operations (Daneshvar et al., 2019).

Therefore, mining firms must structure their supply chain operations to avoid information asymmetry. The supply chain must implement big data analytics to ensure that information is processed and readily available across the supply chain to support business processes and functions (Pratt et al., 2022).

The adoption of blockchain technology in the mining sector has benefited the sustainability of supply chains in the industry. Some key benefits included the creation of smart contracts, the enhancement of environmental sustainability, the traceability of mineral products, and the transparency in the mineral value chain to gain legitimacy with buyers and other regulators (Yousefi & Tosarkani, 2022).

In BHP, the introduction of sustainable supply chain practices significantly improved the company's triple bottom line (Treiblmaier, 2019). There is normative, mathematical, and regulatory pressure from stakeholders in the mining industry to respond to environmental challenges and local sustainability issues. Mining firms have responded to these challenges through numerous policies, such as local supplier development programmes in mining that are vital to ensure that legislative and sustainable goals are achieved in the industry (Naveed et al., 2023). However, this policy has not resulted in tangible benefits for the local economy and population due to the fronting of mining firms.

2.8 Big data in the mining industry

According to Jha et al. (2020), decision-making in the mining industry is critical, especially along the supply chain. Decision makers require a considerable set of data analysis skills to significantly improve the decision-making process. The pandemic has shown the value of information for managers and the need for supply chains to be agile; therefore, managers must use sophisticated technologies such as artificial intelligence to model their decision making (Jha et al., 2020).

In addition, Chen et al. (2020) investigated the challenges of extensive data management in the mining industry and noted that the mining industry has several challenges in adopting new technologies to improve performance after the pandemic. The diffusion of technology in the supply

chain is critical to support mining firms in successfully coping with post-pandemic business challenges.

2.9 Organisation structure & supply chain network design

How organisations are structured determines the efficiency and flow of the supply chain and hence the operations capabilities and success (Cowan & Jonard, 2023). The existing literature on the structure of organisations shows that there is a need to optimise the performance of the firms (Helmold, 2023).

In the mining industry, the design of the supply chain network is essential because it significantly determines the structure, cost, and overall organisational performance of the supply chain **(**Farahani et al., 2014). Various decisions must be made along the supply chains, such as logistics, inventory management, and operational capabilities, and location of production facilities, which impacts the organisation's performance. Furthermore, the existing literature shows that the supply chain network is a source of competitive advantages for mining companies and therefore supply chain resilience is critical for mining companies (Li & Zobel, 2020).

2.10 Firm performance & sustainability

Govindan, Muduli et al. 2024 investigated the adoption of green supply chain practices and their impact on mining firms in India. The results showed that adoption contributes significantly to the environmental performance of mining companies in Ghana. The study showed that top management and competitiveness were the main drivers for adopting sustainable supply chain practices. On the contrary, employee pressure was irrelevant to adopting sustainable supply chain practices.

Adomako & Tran (2022) examined the relationship between sustainable environmental strategy, firm competitiveness, and financial performance in the mining industry. Studies found that sustainability in the mining sector is critical, and sustainable environmental practices significantly

improve firm performance. The research also reveals that firm competitiveness mediates the impact of environmental strategy on the financial performance of the mining sector. The research findings presented above are relevant to the South African mining industry.

In a study by Gyan & Jan Bezemer (2022) that examined related diversification, firm-level resources, and firm performance in the context of the Australian extractive industry, the data set showed that diversified firms perform better than their peers in the mining industry.

2.12 Block chains & big data analytics

Deepa et al. (2022) investigated the application of big data analytics and application in several industries. They concluded that there are several benefits to implementing big data and blockchains in supply chains. Vivekananda (2020) studied recent trends and applications in blockchain technology and stated that the technology is an enabler and provides critical support for the industry to solve financial and non-financial problems, especially in emerging markets. Furthermore, Bag et al. (2020) emphasised the importance of big data analytics to promote operational excellence and sustainability in supply chains.

The South African Reserve Bank already uses blockchains, big data analytics, and artificial intelligence to settle some of its daily transactions. This shows the potential of blockchains in other industries, such as the mining sector. It significantly improves supply chain and firm performance in the mining sector in emerging markets in South Africa (Hassani et al., 2024).

Bag et al., 2021 identified 13 key industry 4.0 enablers in South Africa which apply to the mining industry as well, such as "government *support, research and development from universities and other academic institutions, corporate governance, legal and regulatory policies, third-party audits, information transparency, vertical integration, horizontal integration, change management, human capital development, standard reference architecture, management commitment improved IT security."*

The cost of transacting in the market with weak institutions is high, and the economic recovery post-pandemic is endangered because of these poor institutional environments, such as state

capture that is prevalent in South Africa and more so in the mining industry, which is core at the centre of energy provision and sustainability in South Africa.

Research on business performance is critical in sub-subsistence markets. Therefore, scholars must attempt to enrich the context of studies and build research opportunities to bring new insights and research to benefit the academic community. Several supply chain innovations have been pioneered during the Covid19 pandemic to ameliorate supply chain disruptions and improve the supply chain and organisational performance of the mining industry (Kabwe, 2023).

2.14 Conclusion

This research provides value to practitioners, managers, stakeholders, and researchers on the role of sustainability practice and how it impacts the supply chain and overall performance of the organisation and mining industry. The literature shows the impact of the pandemic on the mining industry and provides a pathway for mining companies to improve their performance by implementing sustainable supply chain practices. Key concepts reviewed in previous studies include supply chain sustainability, business processes, firm performance, strategy, information systems, and organisational structure.

Chapter three: Research methodology

3.1 Introduction

This section of the work describes the research methodology and discusses issues related to research approaches, design, population, and sampling techniques. This research problem will be investigated using a quantitative research methodology, and the foundation for the approach chosen is supported by a voluminous amount of the data set that will be gathered using the survey to test the relationship in the conceptual model stated above (Story & Tait, 2019; Younas & Porr, 2022).

3.2 Research approaches

Three fundamental research approaches are used in management and international business research, including qualitative research approaches: quantitative research approaches, and mixed methods. Quantitative research approaches view the research from a positivist approach and use the numerical data set to tell the story about the research (Franz, 2023). On the other hand, quantitative research is a building block, and it consists of activities connected to the research project, such as data collection techniques, analysis, and reporting of the research outcome. It tells the participant's stories and experiences.

3.3 Research design

The research design is a logical and coherent strategy to integrate the different research components to support the examination of the problem and provide a comprehensive analytical framework to answer the research question (Coral & Bokelmann, 2017). Various research designs include qualitative, quantitative, or mixed-method research. In quantitative research design, there is a choice of research designs such as experimental, descriptive, correlational, and causal-comparative design (Bloomfield & Fisher, 2019). Therefore, this research is a quantitative research design approached in a plausible direction to investigate the problem. The design choice is causal and correlational, which is robust to examine the relationship between conceptual frameworks developed for this study (Morris, 2023). Correlation research is justified because it can detect measurement errors and the instrument is validated from previous studies.

3.5 Population and sampling

The research population is essential because it provides scholars with the universe required to conduct the study and gather data to make inferences about this population (Asiamah, Mensah, & Oteng-Abayie, 2017; Sukmawati et al, 2023). In quantitative research, the population can also be defined as individuals, dyads, organisations, and groups (Casteel & Bridistudy, 2021).

The study population was carefully selected to ensure that the quality of the research findings match the findings of the research. This study examined the mining industry, and the research population is drawn from employees of mining companies in South Africa, especially those in management. In this study, the population of interest is individuals working in the mining industry, and the rationale for selection was knowledge of the energy sector, its challenges, and possible solutions. Respondents to the random selection sampling approach for the study (Rashid, Rasheed, Amirah, Yusof, Khan, & Agha, 2021).

3.6 Sampling and sampling methods

Several sampling methods are applied in quantitative research, and these are divided into two broad categories, i.e., probability and non-probability sampling (Sukmawati et al, 2023). To sample effectively in probability sampling strategies in international business research, scholars apply simple random; systematic; stratified, and cluster sampling. This research applied simple random sampling strategies.

However, simple random sampling has gained traction with most scholars. Scholars in management research have reiterated that the sampling strategy must be structured, comprehensive, and transparent (Hiebl, 2023). This is important to ensure that the study can be generalised across the population of interest.

In addition, other international business scholars have used nonprobability sampling to study a specific population of interest, and non-probability sampling comprises snowball, purposive, self-selection, and quota sampling (Sukmawati et al, 2023). The nonprobability sampling technique is not popular with international and management scholars primarily because of the need for more generalizability and other biases (Tutz, 2023).

3.7 Research instrumentation

In international and business management research, several research tools are used in quantitative research methodology, such as tools. The research instrument was adapted from the previous studies, which measured the phenomenon in a different context and industry (Dźwigoł, 2019). However, the instrument has the potential to be adapted for current studies. The measurement scales are developed from a literature review and the definition of the terms is clear from the literature review. The research instrument was adapted from Fu et al., 2022). Furthermore, the research questionnaire was pretested in a smaller population group to identify potential problems before being administered to the larger group.

3.8 Data collection method

Several methods of data collection are used by scholars in quantitative research design to collect primary data, such as surveys, observations, experiments, and interviews (Sadan, 2017). Data collected must consider quality to improve the accuracy and validity of data collected. Secondary data collection methods in quantitative research include existing data stored in databases and other published sources.

The data collection methods approach used in this research is the survey using a Likert scale questionnaire developed from constructed as described in the research framework section. The study uses a 7-point Likert scale. The justification for using a questionnaire is the ease of application in cross-sectional data collection (Wallwey & Kajfez, 2023).

3.9 Data analysis methods

The study used a cross-sectional data set collected from a survey, using the Likert scale questionnaire designed from the theoretical and conceptual framework described above. The results were evaluated to determine the suitability of the research instrument and whether the data analysis methods chosen are appropriate, that is, their reliability and validity. Because this research was quantitative in design, the method chosen to analyse and present the dataset was statistical, where the hypotheses are developed a priori to the fieldwork to examine the relationship between the variables in the conceptual framework. The data analysis tool used was SPPS and both descriptive and inferential statisticswere produced to interpret and report the results ofthe study.

3.10 Quality assurance of research

3.10.1 Validity of research

There are three types of validity: content, construct, and criterion. Validity is critical in quantitative research and is defined as the scope to which a variable is measured. Measurement must measure what it is intended to measure and not something else (Heale & Twycross, 2015). The convergent validity measures of the criterion measure how correlated the instrument is when measuring comparable variables. The measurement construct must be reliable, and the research instrument designed to measure the variables must capture all the fundamental concepts of the measurement model (Rahman, 2023).

The construct validity must be assessed, and the construct validity must include homogeneity, convergence, and theoretical evidence. Furthermore, researchers are concerned about external and internal validity, and internal validity examines the internal outcome or the desired change. In contrast, external validity looks at external generalisation (Fuller et al., 2020).

3.10.2 Reliability of research

The reliability of the measurement instrument relates to uniformity in the measurement tool; therefore, research reliability is essential. The three critical reliability attributes include homogeneity, which relates to internal consistency, stability of measure, and equivalence (Cheung et al., 2023). Furthermore, quantitative research is regarded as reliable because of its systematic methods and statistical analysis. Large sample sizes and random sampling techniques further enhance the dependability of the results. Moreover, using standardized data collection tools and procedures promotes consistency and minimizes bias in the data.

Nevertheless, it is essential to acknowledge that no research method is entirely immune to potential errors. It is always crucial to assess any study's limitations and possible biases. In the end, the reliability of quantitative research hinges on the excellence of the research design, data collection methods, and analysis techniques employed (Amjad et al, 2020).

Quantitative research has long been documented as a reliable method of research due to its systematic approach and statistical analysis (Pigott, & Polanin, 2020). The use of large sample sizes and random sampling techniques further strengthen its dependability. Additionally, the use of standardized data collection tools and procedures promotes consistency and minimizes bias in

the data. However, it is important to acknowledge that no research method is entirely immune to potential errors. To ensure the reliability of quantitative research, it is essential to employ excellent research design, data collection methods, and analysis techniques. While quantitative research has its limitations, it remains a valuable tool for researchers in various fields.

3.11 Limitations of the study

Quantitative research has intrinsic limitations, mainly because the problems being investigated are complex. Although three theories (transactions cost theory, institutional theory, and resource-based view) future prominently in the literature, the study applied transaction cost theory as the dominant theoretical lens to examine the problem. There needs to be more consistency in transactions cost theory, which other theories would be most appropriate to address. Furthermore, quantitative research needs to capture real-time events and experiences of the population. Therefore, it is crucial to recognise the strengths of quantitative research while also considering its limitations.

3.12 Considerations

The principles of research ethics in international business research involve crucial issues, such as ethical conduct during research, which was strictly observed during data collection, analysis, and reporting. The research followed the required procedure and process for gaining access to the population. Care was taken to ensure that the information gathered was coded, stored, and processed ethically in accordance with national regulations such as the POPI Act. The research did not cause any harm to the respondents. The researcher obtained consent from respondents before the data was collected. In addition, researchers were transparent in the analysis and reporting of the dataset (Enderle, 2015).

3.13 Conclusions

The research is relevant and essential because of the context under which this research is conducted primarily to understand the post-COVID-19 pandemic recovery strategies for mining firms in South Africa. The power crisis in South Africa also points to severe challenges to economic growth, which further constrain the performance of mining firms. The scholarship seeks to contribute to research in international business and offers theoretical and practical contributions to international business.

Chapter four: Results and interpretation

4.1 Introduction

The purpose of this chapter was to present the empirical results of the study. The study had five constructs: supply chain network design, supply chain finance, information systems, supply chain operational performance, organisation structure, and supply chain strategy. This study focused on the mining industry's attempt to understand its sustainability and supply chain performance post-COVID-19. The data set was collected from five operating mining houses in the Mpumalanga area.

4.2 Descriptive statistics-demographic profile of respondents

The descriptive statistics presented are the survey and dataset collected from 5 mining firms with 175 participants. The dataset collected was used to test the hypothesis discussed in chapter two.

Table 4.1 Descriptive Statistics

	Descriptive	Frequency	Percentage
Gender	Male	106	60.6%
	Female	64	36.6%
	Others	5	2.9%
Education	Matric	8	4.8%
	National Diploma	19	10.9%
	Bachelor's Degree	45	25.7%
	Honours Degree	54	30.8%
	Master's degree	42	24.0%
	Others	7	4.0%
Experience	0-5 Years	4	2.5%
	6-10 Years	22	12.8%
	11-15 Years	80	45.7%
	16-20 Years	52	29.7%
	20+	17	9.7%
Position	Executive Management	17	9.7%
	Senior Management	46	26.3%
	Middle Management	78	44.6%
	Junior Management	34	19.42%
Total		175	

Table 4.1 shows the descriptive statistics of the study. The data set indicates that 60.6% of the respondents were male, 36.6% were female, and 2.9% did not reveal their sex. Regarding qualifications, 4% of the respondents had matriculation, 10.9% had a national diploma, 25.7% had a bachelor's degree, 30.8% had honours, 24% had a master's degree, and 4% had other qualifications.

4.3 Reliability statistics

Table 4.2 Cronbach Alpha

Cronbach's Alpha	N of Items
.935	37

The Cronbach's reliability of .935 shows that there was a high internal consistency among the 37 items in the conceptual model in Figure 4.1. The result also indicates that the latent variable that drive the predictive model has a high internal consistency.

The Cronbach's reliability of .935 shows a high internal consistency among the 37 items in the questionnaire and conceptual model in Figure 4.1. The result also indicates that the latent variable that drives the predictive model has a high internal consistency. The formulated hypothesis was all supported by the dataset because of this high consistency and correlation between variables.

4.4 Multiple regression hypotheses test results

Multiple regression was used to test the hypotheses and offer insights into the hypotheses in the conceptual model. The research hypotheses had supply chain network design, supply chain finance performance, supply chain information systems, organisational structure, and supply chain strategy. The empirical results from the hypothesis are presented in this chapter and the preceding chapter discusses the results from the hypotheses.

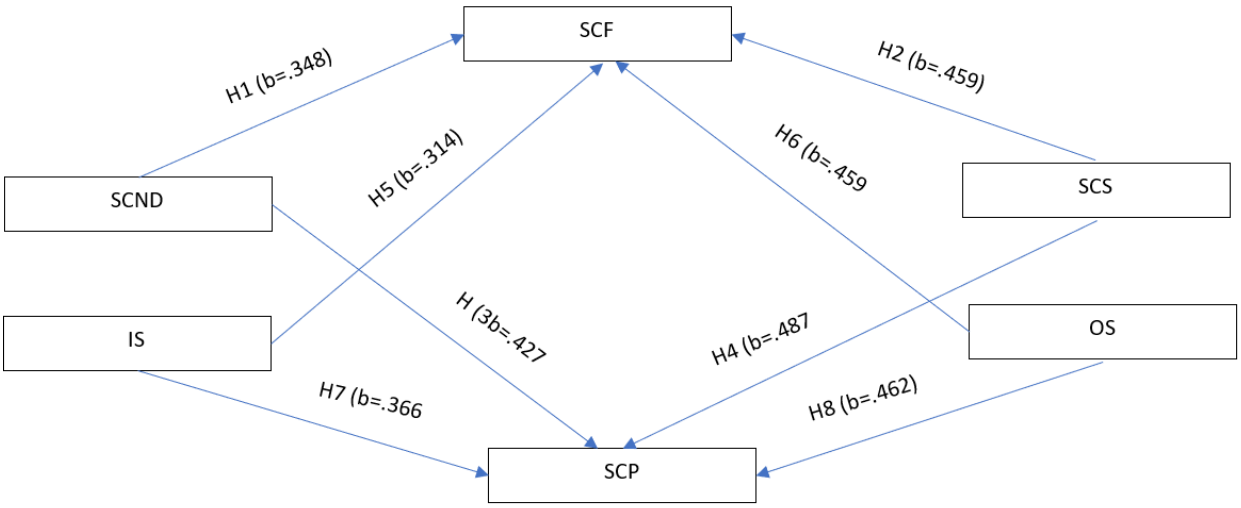


Figure 4.1: Conceptual Model

4.5 Research hypotheses results

H1: Supply chain network design influences organisational supply chain finance performance.

Table 4.2: Model 1 ANOVA Output

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	115.118	2	57.559	86.022	<.001[b]
	Residual	115.088	172	.669		
	Total	230.206	174			

a. Dependent Variable: Supply chain network design

b. Predictors: (Constant), Supply chain performance, supply chain finance

The dependent variable supply chain finance and supply chain operational performance was regressed on predicting variables supply chain network design. The independent variable supply chain network design significantly predicts supply chain finance performance, F (2, .669) =86.022, p<.001. This shows that the factor under study have a significant impact on supply chain finance performance and supply chain operational performance. Moreover, the R^2=.500 shows that the overall model explains 50.0% of the variance in supply chain network design.

Additionally, coefficients were further assessed to ascertain the influence of each of the factors on the criterion supply chain finance performance. H1 evaluated whether supply chain network design significantly and positively affects supply chain finance performance. The results show that supply chain network work design has a significant and positive impact on supply chain finance performance (B=.348, t=5.508, *p*=,.001). Therefore, H1 is supported by the dataset.

Table: 4.3: Supply chain finance performance

Hypothesis	**Regression Weights**	**Beta Coefficient**	**R^2**	**F**	**t-value**	**P-value**	**Hypothesis supported**
H1	*SCND-SCFPERF*	.348	.500	86.022	5.508	<.001	Yes

Notes: *p<0.05; SCND predicts supply chain finance performance

H2: Supply chain network design impacts supply chain operational performance

H2 assessed whether supply chain network design significantly and positively affects supply chain finance operational performance. The results show that supply chain network work design has a significant and positive impact on supply chain finance performance (B=.459, t=7.262, *p*=<.001). Therefore, H2 is supported by the dataset.

Table: 4.4: Supply chain network design and supply chain performance

Hypothesis	**Regression Weights**	**Beta Coefficient**	**R^2**	**F**	**t-value**	**P-value**	**Hypothesis supported**
H2	*SCND-SCOP*	.459	.500	86.022	7.262	<.001	Yes

Notes: *p<0.05; SCND Predicts Supply Chain Operations Performance

H3: Information systems influence finance organisational supply chain performance.

Table 4.5 Model 2 ANOVA Output

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
2	**Regression**	195.003	2	97.502	152.551	<.001[b]
	Residual	109.932	172	.639		
	Total	304.936	174			

a. Dependent Variable: Supply chain information systems

b. Predictors: (Constant), Supply chain performance, Supply chain finance performance

The dependent variable information systems were regressed on predicting variables of supply chain finance and supply chain operational performance. The independent variable significantly predicts supply chain finance performance and supply chain operational performance, F (2, .639) =152.55, p<.001. This shows that the two factors under study have a significant impact on supply chain network design. Moreover, the R^2=.639 shows that the overall model explains 63.9% of the variance in supply chain information systems.

Additionally, coefficients were further assessed to ascertain the influence of each of the factors on the criterion supply chain finance performance. H3 evaluated whether supply chain information systems significantly and positively affect supply chain finance performance. The results show that supply chain network work design has a significant and positive impact on supply chain finance performance (B=.427, t=7.984, *p*=<.001). Therefore, H3 is supported by the dataset.

Table: 4.6: Supply chain information and supply chain finance

Hypothesis	Regression Weights	Beta Coefficient	R^2	F	t-value	P-value	Hypothesis supported
H3	*SCINFS-SCFP*	.427	.639	152.551	7.945	<.001	Yes

Notes: **p*<0.05; Supply Chain information systems predicts supply chain finance performance

H4: Information systems influence organisational supply chain operational performance.

Furthermore, coefficients were further assessed to ascertain the influence of each of the factors on the criterion supply chain finance performance. H4 evaluated whether information systems significantly and positively affect organisational supply chain operational performance. The results show that supply chain information systems have a significant and positive impact on supply chain organisational performance (B=.489, t=9.099, *p*=, <.001). Therefore, H4 is supported by the dataset.

Table: 4.7: Supply chain information systems and supply organisational performance

Hypothesis	Regression Weights	Beta Coefficient	R^2	F	t-value	P-value	Hypothesis supported
H4	*INFYS-SCPERF*	.487	.639	152.551	9.099	<.001	Yes

Notes: *p<0.05; Information Systems predicts Supply chain organisational performance

H5: Organisational structure influence organisational supply chain finance performance

Table 4.8 Model 3 ANOVA Data Output

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
3	**Regression**	90.741	2	45.370	73.492	<.001[b]
	Residual	106.184	172	.617		
	Total	196.925	174			

a. Dependent Variable: Organisational structure
b. Predictors: (Constant), Supply chain performance, Supply chain financial performance

The dependent variable organisational structure was regressed on predicting variables of supply chain finance and supply chain operational performance. The dependent variable organisational structure significantly predicts supply chain finance, F (2, .617) =73.492, p<.001. This shows that the two factors under study are significantly impacted by organisational structure. Moreover, the R^2=.461 shows that the overall model explains 46.1% of the variance in organisational structure.

The coefficients were further assessed to ascertain the influence of each of the factors on the criterion supply chain finance performance. H5 evaluated whether supply organisational structure significantly and positively affects supply chain finance performance. The results shows that organisational structure has a significant and positive impact on supply chain finance performance (B=.314, t=4.786, *p*=, <.001). Therefore, H5 is supported by the dataset.

Table: 4.9: Organisational structure and supply chain finance performance

Hypothesis	Regression Weights	Beta Coefficient	R^2	F	t-value	P-value	Hypothesis supported
H5	*ORGS-SCF*	.314	.461	73.492	4.786	<.001	Yes

Notes: **p*<0.05; Organisational Structure predicts Supply chain finance performance

H6: Organisational structure influences organisational supply chain performance.

Additionally, coefficients were further assessed to ascertain the influence of organisational structure on organisational supply chain performance. H6 evaluated whether organisational structure significantly and positively affects supply organisational performance. The results shows that organisational structure has a significant and positive impact on supply chain performance (B=.459, t=6.988, *p*=,.001). Therefore, H6 is supported by the dataset.

Table: 4.10: Organisational structure and supply chain performance

Hypothesis	Regression Weights	Beta Coefficient	R^2	F	t-value	P-value	Hypothesis supported
H6	*ORG-SCP*	.459	.461	73.492	6.988	.001	Yes

Notes: **p*<0.05; Organisational structure predicts supply chain performance

H7: Supply chain strategy positively influence organisational supply chain finance performance

Table 4.11 Model 4 ANOVA Data Output

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
4	**Regression**	69.987	2	34.994	95.038	<.001[b]
	Residual	63.332	172	.368		
	Total	133.319	174			

a. Dependent Variable: Supply Chain Strategy
b. Predictors: (Constant), Supply chain performance and supply chain finance performance

The dependent variable supply chain strategy was regressed on predicting variables supply chain finance performance and organisational supply chain operational performance. The dependent variable significantly predicts supply chain finance performance and supply chain organisational performance F (2, .368) =95.038, p<.001. This shows that the two factors under study have a significant impact on supply chain network design. Moreover, the R^2=.525 shows that the overall model explains 52.5% of the variance in supply chain information systems.

Additionally, coefficients were further assessed to ascertain the influence of each of the factors on the criterion supply chain information systems. H7 evaluated whether supply chain information systems significantly and positively affect supply chain finance performance. The results shows that supply chain information systems have a significant and positive impact on supply chain finance performance (B=.366, t=5.936, *p*=,.001). Therefore. H7 is supported by the dataset.

Table: 4.12: Supply chain strategy and supply chain finance performance

Hypothesis	**Regression Weights**	**Beta Coefficient**	**R^2**	**F**	**t-value**	**P-value**	**Hypothesis supported**
H7	*SCSTRAT-SCFP*	.366	.525	95.038	5.936	.001	Yes

Notes: **p*<0.05; Supply chain information systems predict supply chain finance performance.

H8: Supply chain strategy influence organisational supply chain operational performance.

Additionally, coefficients were further assessed to ascertain the influence of each of the factors on the criterion supply chain strategy. H8 evaluated whether supply chain strategy significantly and

positively affects supply chain finance performance. The results shows that supply chain strategy has a significant and positive impact on supply chain organisational performance (B=.462, t=7.498, *p*=,.001). Therefore, H8 is supported by the dataset.

Table: 4.13: Supply chain strategy and supply chain performance

Hypothesis	Regression Weights	Beta Coefficient	R^2	F	t-value	P-value	Hypothesis supported
H8	*SCSTRAT-SCP*	.462	.525	95.038	7.498	.001	Yes

Notes: *p<0.05; Supply chain strategy predicts supply chain performance

Table 4.14: Summary of hypotheses

Hypotheses	Beta Coefficient	R^2	F	*t-value*	*p-value*	Significant
H1	.348	.500	86.022	5.508	<.001	Yes
H2	.459	.500	86.022	7.262	<.001	Yes
H3	.427	.639	152.551	7.495	<.001	Yes
H4	.487	.639	152.551	9.099	<.001	Yes
H5	.314	.679	73.492	4.786	<.001	Yes
H6	.459	.679	73.492	6.988	<.001	Yes
H7	.366	.525	95.038	5.931	<.001	Yes
H8	.462	.525	95.038	7.498	<.001	Yes

Table 4.13 shows that all 8 hypotheses tested were supported. The study used four models to support the conceptual model developed during the literature review. Overall, this result shows that the importance of supply chain network design, information systems, organisational structure, and supply chain strategy to drive performance in its supply chain.

4.8 Conclusion

This chapter proffered both descriptive and inferential statistics to explain the impact of the independent variable; supply chain network design, supply chain information systems, organisational structure, and supply chain strategy regressed on supply chain finance performance, and supply chain organisational performance. Overall, the results from the inferential statistics (multiple regression) tests show that supply chain network design, supply chain information systems, organisational structure, and supply chain strategy have a significant impact on supply chain financial performance and supply chain performance in the South African mining sector post COVID-19. This study explains that for the South African mining sector to improve its performance post COVID-19, it must design its supply chain network, supply chain information systems, organisational structure, and supply chain strategy to solve the current supply chain problems in the sector.

Chapter five: Discussion of results

5.1 Introduction

The aim of this chapter is to interpret and analyse the results from the results of the study. The overall purpose of this study was to examine the relationship between different constructs such as supply chain network design, supply chain information system, organisational structure, and supply chain strategy and how these constructs influence supply chain performance in the mining industry.

5.2 Discussion of research results

5.2.1 Supply chain network design impact of supply chain finance

Supply chain network design influences organisational supply chain finance performance. This hypothesis was confirmed. The inferential statistics from multiple regression support the results and findings in the dataset gathered from the mining firms. The results are related to the research's main proposition and are supported by literature in the field. It's supported by trends and patterns observed by other scholars in supply chain management research. Supply chain network design is concerned with factors such as cost, location, size, distribution network, transportation, and logistics. These actors are imperative to optimise supply chain performance. The key problem in the South African mining industry supply chain is how the supply chain network is designed and some of the bottlenecks. Some of the post-COVID-19 issues have been around port congestions and Transnet's inability to turn around its logistics operations (Sazvar et al, 2021).

In the research model proposed in this supply, the dependent variable supply chain network design showed a significant impact on supply chain finance. There is evidence from the study to opine that the supply chain network does impact supply chain finance performance. Given that cost is an important factor post COVID-19, supply chain decision-makers must focus on where to cut costs to reduce the operations costs and improve their overall supply chain performance (Aldrighetti, et al, 2021). The decision-makers must pay attention to resilience in their supply chain to significantly improve performance. The current operating environment of most mining houses relies heavily on Transnet to move products to the export port in Richards Bay coal terminal (RBCT). However, there are significant delays and backlogs which must be addressed. Therefore,

efficient supply chain network design is a solution to some of the problems at play in the mining sector.

The hypothesis between supply chain network design and supply chain finance performance is that improving supply chain network design can positively impact supply chain finance performance. By optimizing the physical structure of the supply chain, including the locations of suppliers, production facilities, and distribution centers, businesses can reduce costs, increase efficiency, and improve profitability, which can lead to more financial resources to invest in the supply chain (Jia et al, 2020).

Furthermore, a more streamlined supply chain can result in shorter lead times, which can positively impact cash flow. Conversely, supply chain finance can also impact supply chain network design. If a supplier is struggling financially, they may not be able to maintain the same level of service or quality, which might necessitate a change in the supply chain network design. Additionally, the availability of financing options for suppliers can impact their ability to invest in new facilities or technologies, which could also affect the overall structure of the supply chain network (Dekkers et al, 2020).

Overall, the hypothesis suggests that there is a symbiotic relationship between supply chain network design and supply chain finance, with each aspect significantly impacting the other. By optimizing both, businesses can create a more resilient and profitable supply chain. However, further research is needed to fully understand the relationship between supply chain network design and supply chain finance performance and to identify the specific factors that drive this relationship.

5.2.2 Supply chain network design impacts supply chain operational performance

The impact of supply chain network design on supply chain operational performance was found to be significant. This is supported by literature for example the epidemic of COVID-19 has had a significant impact on supply chain management performance across various industries, causing disruptions in global supply chains (Frederico, et al, 2023). The pandemic has highlighted the need for businesses to reassess their supply chain management practices and adopt new strategies to mitigate the impact of future disruptions. The key challenge for businesses has been managing the demand and supply chain. The pandemic has caused a sudden and unexpected shift in consumer

behaviour, resulting in changes in demand patterns, which has made it difficult for businesses to manage their inventories effectively (Eger et al, 2021).

Some of the immediate restrictions on travel and transportation have limited the movement of goods, causing delays in the delivery of products. To mitigate these challenges, businesses had to adopt various strategies such as implementing digital platforms to manage the supply chain, diversifying their supplier base, improving inventory management, and increasing flexibility in their supply chain operations (Pujawan, & Bah, 2022).

These strategies have helped businesses to improve their supply chain management performance post-COVID-19. Another key factor that has impacted supply chain management performance is the disruption to global trade. The pandemic not only led to the closure of borders and restrictions on international travel, but it has also impacted the movement of goods across borders. But it's also resulted in national supply chain constraints. This has resulted in delays in the delivery of products and increased transportation costs. To resolve or mitigate these challenges, businesses have started exploring new markets and diversifying their supplier base to reduce their dependence on a single region (Schaupp, 2023).

The mining industry must explore alternative modes of transportation to sea for export purposes to reduce the reliance on rail. Overall, the study shows that the COVID-19 pandemic has highlighted the need for mining firms to adopt a more agile and flexible approach to supply chain management. By adopting new strategies and improving their supply chain management practices, businesses can better manage future disruptions and improve their overall performance. The supply chain network design significantly and positively affects supply chain finance operational performance. This result is supported by evidence in the literature which shows that supply chain network work design has a significant and positive impact on supply chain operational performance (Tirkolaee et al, 2023).

5.2.3 Information systems influence finance organisational supply chain performance.

The dependent variable information systems were regressed on predicting variables supply chain finance and supply chain operational performance. The independent variable significantly predicts supply chain finance performance and supply chain operational performance. Information systems such as ERP and blockchains support supply chain performance (Dong et al, 2023).

Other studies have shown that supply chain information systems significantly and positively affect supply chain finance performance (Choi, 2020). The results shows that supply chain network work design has a significant and positive impact on supply chain finance performance.

5.2.4 Information systems and supply chain operational performance.

Furthermore, coefficients were further assessed to ascertain the influence of each of the factors on the criterion supply chain finance performance. Supply chain information systems significantly and positively affect organisational supply chain operational performance. The results shows that supply chain information systems have a significant and positive impact on supply chain organisational performance.

5.2.5 Supply chain strategy and organisational supply chain finance performance.

Supply chain strategy and performance are crucial aspects of any business that deals with the mining, manufacturing, and distribution of goods. A well-designed supply chain strategy can help a company streamline its operations, reduce costs, and improve the overall quality of its products. On the other hand, poor supply chain performance can lead to delays, stock shortages, and higher costs, ultimately impacting the company's profitability. Therefore, it is essential for businesses to continuously monitor and optimize their supply chain strategy to maintain high levels of performance and stay competitive in the market.

Supply chain strategy is important and has an impact on supply chain finance performance and organisational supply chain operational performance and supports the need to manage risk (Munir et al, 2020). The independent variable significantly predicts supply chain finance performance and supply chain organisational performance.

Supply chain information systems significantly and positively affect supply chain finance performance. These results confirm the finding from the literature which shows that supply chain information systems have a significant and positive impact on supply chain finance performance (Wang, & Hu, 2020).

5.2.6 Supply chain strategy and organisational supply chain operational performance.

Supply chain strategy significantly and positively affects supply chain finance performance. The results shows that supply chain strategy has a significant and positive impact on supply chain organisational performance.

A well-designed supply chain strategy is critical to achieving organisational success in today's business landscape. The literature suggests that companies prioritising their supply chain strategy tend to have a competitive edge, reducing costs, improving product quality, and increasing customer satisfaction. A long-term perspective is critical to a successful supply chain strategy. By building solid relationships with suppliers, investing in technology, and developing efficient distribution channels, organisations can improve their performance and stay ahead of the competition. Moreover, collaboration within the supply chain is crucial. When organisations prioritise collaboration, they can build trust with suppliers, share knowledge and resources, and work together towards meeting customer demands. This can improve product quality, reduce lead times, and increase customer satisfaction. To achieve and maintain high-performance levels, businesses must continuously monitor and optimise their supply chain strategies. Those who invest in their supply chains and adopt a long-term perspective tend to perform better and remain competitive. Therefore, businesses must prioritise their supply chain strategy to achieve organisational success.

5.2.7 Organisational structure and supply chain finance performance

Several organisational structure influence each of the factors on the criterion of supply chain finance performance. supply organisational structure significantly and positively affects supply chain finance performance. The results show that organisational structure has a significant and positive impact on supply chain finance performance (Elliot et al, 2020).

Organisational structure is a crucial determinant of supply chain performance. According to the literature, companies with a flat and flexible Organisational structure tend to perform better regarding supply chain efficiency and effectiveness. A flat structure allows for faster decision-making and facilitates communication among different levels of the organisation, which is critical for effective supply chain management. Moreover, the literature suggests that a decentralized Organisational structure can improve supply chain performance by empowering employees and

allowing them to make decisions independently. This can lead to faster response times, improved customer service, and reduced lead times.

On the other hand, a centralised structure may hinder supply chain performance by slowing down decision-making and reducing flexibility. Another critical factor influencing supply chain performance is aligning organisational structure with supply chain strategy. The literature suggests that companies that align their organisational structure with their supply chain strategy tend to perform better than those that do not. For example, a company that prioritises collaboration within the supply chain may benefit from a decentralised structure that allows for more autonomy and decision-making power among employees (Dominguez et al, 2022). The literature indicates that the organisational structure plays a critical role in supply chain performance. Firms prioritising a flat and flexible structure and aligning it with their supply chain strategy tend to perform better in efficiency, effectiveness, and customer satisfaction (Bier et al, 2020).

5.2.8 Organisational structure and organisational supply chain performance.

Organisational structure significantly and positively affects supply organisational performance. The empirical results are supported by findings from literature that organisational structure has a significant and positive impact on supply chain performance (Skipworth et al, 2015). Strategic alignment of organisational structure impact on performance.

The importance of organizational structure and its impact on supply chain performance must be considered. Companies that prioritize the design of their organizational structure with their supply chain in mind can significantly improve their competitiveness and profitability. The literature has identified various types of organizational structures, each with pros and cons regarding supply chain performance. However, a well-designed structure can enhance supply chain performance by improving delivery time, inventory levels, and customer satisfaction.

In addition, the literature indicates that various factors, such as information sharing, collaboration, and risk management, can impact supply chain performance. Mining firms must share information with their suppliers and customers to reduce lead times and improve forecasting accuracy. Collaboration between different functions and stakeholders in the supply chain can reduce costs and improve quality.

Furthermore, effective risk management can mitigate the impact of supply chain disruptions, such as natural disasters or geopolitical events. Mining houses must recognize the importance of organizational structure and supply chain performance to succeed in today's business environment. The mining industry can improve its supply chain's responsiveness, flexibility, and resilience by implementing a well-designed structure and focusing on factors that impact performance. The literature provides a wealth of knowledge on this topic, and companies that take advantage of it can gain a competitive advantage and drive long-term success (Knudsen et al, 2021).

The organizational structure can have a significant impact on supply chain operational performance. The organizational structure refers to how a business is organized, including how activities are divided and coordinated across different functions of the supply chain. Here are some ways in which organizational structure can impact supply chain operational performance (Rasool et al, 2022).

5.3 Supply chain network design and supply chain performance

There is a significant amount of literature available on supply chain performance, which is a critical aspect of supply chain management. Many studies have been conducted to explore the various factors that impact supply chain performance and how businesses can improve their performance by implementing effective strategies. One of the most common factors that impact supply chain performance is supply chain integration.

Studies have found that businesses that prioritize supply chain integration tend to perform better than those that do not. Supply chain integration involves coordinating and sharing information across different functions of the supply chain, such as procurement, production, and logistics, to improve overall efficiency and effectiveness. Other factors that impact supply chain performance include supply chain agility, collaboration, and risk management.

Supply chain agility involves the ability to adapt quickly to changes in the market, such as sudden shifts in demand or supply chain disruptions. Collaboration involves working closely with suppliers and other partners to improve coordination and communication, while risk management involves identifying and mitigating potential risks in the supply chain (Ahmadi-Gh et al 2024). There are numerous strategies that mining firms can deploy to improve supply chain performance, such as lean supply chain management, just-in-time (JIT) inventory management, and total quality

management (TQM). These strategies aim to improve efficiency, reduce costs, and enhance overall performance. In sum, the literature suggests that there are various factors that impact supply chain performance, and businesses should prioritize effective supply chain management strategies to improve their performance and remain competitive in the market.

5.4 Supply chain information systems and supply chain finance performance

Supply chain information systems and supply chain finance are two critical aspects of supply chain management. Supply chain information systems refer to the use of technology to manage and share information across different functions of the supply chain, while supply chain finance involves managing the financial aspects of the supply chain, such as payment terms, financing options, and risk management (Kamble & Gunasekaran, 2020).

Supply chain information systems can play a significant role in improving supply chain finance. In providing real-time data and visibility into the supply chain, businesses can make more informed financial decisions, such as optimizing payment terms and managing inventory levels to reduce carrying costs. Supply chain information systems can also help businesses identify potential risks and opportunities in the supply chain, allowing them to make proactive financial decisions. On the other hand, supply chain finance can also impact supply chain information systems (Han et al, 2020).

For instance, businesses that offer financing options to suppliers may be able to incentivize them to adopt more advanced information systems, such as electronic data interchange (EDI) or radio frequency identification (RFID) technology. These systems can improve supply chain visibility and coordination, allowing for more efficient and effective supply chain management (Smith et al, 2020).

In a nutshell, the relationship between supply chain information systems and supply chain finance is symbiotic, with each aspect significantly impacting the other. Mining firms must leverage technology to improve supply chain information systems and manage the financial aspects of the supply chain effectively, so businesses can create a more resilient and profitable supply chain (Karatas et al, 2021).

5.5 Supply chain information systems and supply chain management

There is a significant amount of literature available on supply chain information systems, which are critical to effective supply chain management. Supply chain information systems refer to the use of technology to manage and share information across different functions of the supply chain, such as procurement, production, and logistics (Mehrjerdi et al, 2021).

One of the most common types of supply chain information systems is enterprise resource planning (ERP) software. ERP systems integrate information from various functions of the supply chain into a single system, providing real-time data and visibility into the supply chain. Other types of supply chain information systems include electronic data interchange (EDI), radio frequency identification (RFID) technology, and supply chain analytics (Unhelkar et al, 2022).

Several studies have been conducted on the use of supply chain information systems and their impact on supply chain performance (Gao et al, 2020; Ditkaew, et al, 2020). Many of these studies have found that businesses that leverage technology to improve their supply chain information systems tend to perform better than those that do not. For example, businesses that use ERP systems tend to have more efficient supply chains, reduced inventory costs, and improved customer service. Other studies have examined the impact of specific types of supply chain information systems.

For example, RFID technology can help businesses track inventory levels and improve supply chain visibility, while supply chain analytics can help businesses identify potential risks and opportunities in the supply chain. The literature suggests that supply chain information systems are critical to effective supply chain management (Gu & He, 2024). When Mining entities leverage technology to improve supply chain information systems, mining firms can enhance supply chain visibility, coordination, and efficiency, leading to improved performance and a competitive advantage in the market. The exportation of minerals to international markets can be simplified.

5.6 Supply chain information and supply chain finance

Supply chain information systems can have a significant impact on supply chain finance. By providing real-time data and visibility into the supply chain, information systems can help businesses make more informed financial decisions, such as optimizing payment terms and managing inventory levels to reduce carrying costs (Wang et al, 2020).

There are several ways in which supply chain information systems can impact supply chain finance in the mining sector. Firstly, the firms must improve financial decision-making. Given, supply chain information systems provide businesses with real-time data on inventory levels, production schedules, and delivery times, allowing them to make more informed financial decisions. For example, businesses can use this data to optimize payment terms and negotiate better financing options with suppliers (Choi, 2020).

Secondly, there is a need to reduce inventory costs: technology is an enabler in assisting mining firms provide visibility into inventory levels, and supply chain information systems can help businesses reduce inventory carrying costs. This can free up capital that can be used to invest in other areas of the supply chain (Dehshiri et al, 2024). Thirdly, mining firms must improve cash flow (). Supply chain information systems can help businesses improve cash flow by reducing lead times and streamlining the supply chain. This can help businesses get paid faster and reduce the need for short-term financing. Fourthly, risk management and supply chain information systems can help businesses identify potential risks in the supply chain, allowing them to take proactive steps to mitigate those risks. This can reduce the likelihood of supply chain disruptions and financial losses (Sánchez-Flores, et al, 2020).

The results support the finding in the literature suggesting that supply chain information systems can have a significant impact on supply chain finance. Technology adoption can improve supply chain information systems, thereby assisting mining to make more informed financial decisions, reduce costs, and improve cash flow, leading to a more resilient, sustainable, and profitable supply chain (Inman et al, 2024).

Supply Chain Information Systems and Supply Chain Performance.

Supply chain information systems can have a significant impact on supply chain performance. The provision of real-time data and visibility into the supply chain, and information systems can help businesses make more informed decisions, optimize processes, and improve overall efficiency (Rath et al, 2024).

The mining firms should use some of these approaches and techniques to ensure supply chain information systems can impact supply chain performance:

Firstly, there is a need to improve supply chain visibility. The supply chain information systems are vital because they provide businesses with real-time data on inventory levels, production

schedules, and delivery times, allowing them to make more informed decisions and manage the supply chain more effectively (Hasan et al, 2024).

Secondly, there is a need for streamlined processes, and through supply chain information systems can help businesses streamline processes, reduce lead times, and improve overall efficiency. For example, businesses can use information systems to automate procurement processes, reduce manual data entry, and optimize production schedules (Samaranayake et al, 2024).

Thirdly, mining firms must enhance collaboration: A centralized platform for information sharing, and supply chain information systems can help businesses improve collaboration with suppliers and partners. This can help improve communication and coordination across the supply chain, leading to better performance and risk management (Geldenhuys & Flynn, 2024).

Fourthly there is a need for better risk management and supply chain information systems can help businesses identify potential risks in the supply chain, allowing them to take proactive steps to mitigate those risks (Amoah & Eweje, 2024). This can reduce the likelihood of supply chain disruptions and financial losses. The results from the hypothesis tie well with literature which suggests that supply chain information systems can have a significant impact on supply chain performance. It's important to leverage technology such as blockchains, AI, and Machine Learning to improve supply chain information systems, businesses can improve supply chain visibility, streamline processes, enhance collaboration, and manage risks more effectively, leading to a more efficient and effective supply chain.

5.5 Supply chain organizational structure and supply chain finance

The organizational structure can have a significant impact on supply chain finance performance. The organizational structure refers to how a business is organized, including how activities are divided and coordinated across different functions of the supply chain. Organisation structure can either be centralised or decentralization (Adana et al, 2024).

Moreover, the degree of centralization or decentralization in the organizational structure can impact supply chain finance performance. A more centralized structure can lead to more efficient financial decision-making, as decisions are made by a smaller group of people with specialized knowledge (Orlanyuk-Malitskaya et al, 2024). However, a more decentralized structure can lead to more flexibility and adaptability, which can be important in a rapidly changing market depending on the industry.

The second organisation structure adopted by the mining industry is the silos vs. collaboration setting and the degree to which different functions of the supply chain are siloed or collaborate can impact supply chain finance performance (Li & Zhao, 2024). Silos can lead to a lack of coordination and communication, which can result in inefficiencies and higher costs. Collaboration, on the other hand, can lead to better information sharing and more effective decision-making, which can improve financial performance (Pereira et al, 2021).

The other structure to utilise is standardization vs. customization: This is more processes related and procedures are standardized or customized across different functions of the supply chain can impact supply chain finance performance. The standardization can lead to more efficient and cost-effective processes but may not be appropriate in all situations. Customization in mining logistics can lead to higher costs but may be necessary to meet specific customer needs or requirements (Vlachos & Polichronidou, 2024).

Lastly, the outsourcing vs. insourcing approach is a key organisational structural design. The degree to which different functions of the supply chain are outsourced or insourced can impact supply chain finance performance (Barata et al, 2024). In mining, outsourcing can lead to lower costs but may also result in a loss of control over the supply chain. This approach can be more effective and significantly reduce costs. Insourcing can provide more control but may be more expensive. The literature suggests that the organizational structure can have a significant impact on supply chain finance performance. By designing an appropriate organizational structure that balances efficiency, flexibility, and control, businesses can create a more resilient and profitable supply chain. Most logistics in the mining industry are outsourced to third-party logistics.

5.7 Supply chain strategy and supply chain performance

The supply chain strategy can have a significant impact on supply chain performance. Supply chain strategy refers to the overall approach that a business takes to manage its supply chain, including decisions related to sourcing, production, logistics, and customer service. There are several approaches to supply chain strategy in the literature that can impact supply chain performance (Ofélia de Queiroz et al, 2024).

Mining firms may pursue a cost reduction strategy in their supply chain strategy that focuses on cost reduction can impact supply chain performance. The optimization of the supply chain to

reduce costs, businesses can improve their bottom line. Cost reduction strategies may include optimizing inventory levels, streamlining transportation and logistics, and increasing supplier collaboration, among other things (Statsenko et al, 2024).

Moreover, customer service is imperative. A supply chain strategy that focuses on customer service can impact supply chain performance. Improving customer service, mining houses can increase customer satisfaction, reduce returns, and increase performance. Customer service strategies may include faster delivery times, more reliable service, and better communication with customers (Yaiprasert, & Hidayanto, 2024).

In addition, the flexibility strategy can be perused and a supply chain strategy that focuses on flexibility can impact supply chain performance. In the quest for a flexible supply chain, mining firms can adapt quickly to changes in customer demand, supply chain disruptions, and other unexpected events. Flexibility strategies may include using agile production techniques, having multiple suppliers, and using advanced logistics technologies (Ranjan, & Foropon, 2021).

In addition, quality is a very important aspect, and a supply chain strategy that focuses on quality can impact supply chain performance. Product quality is a critical, and coal and other minerals of high quality, mining firms exporting to international markets can reduce returns, increase customer satisfaction, and improve their reputation. The quality strategies may include using advanced quality control techniques, working closely with suppliers to ensure quality standards are met, and using data analytics to identify quality issues (Saffar et al, 2020).

Literature suggests that the supply chain strategy can have a significant impact on supply chain performance. The designing and implementing an effective supply chain strategy that balances cost, customer service, flexibility, and quality, businesses can create a more efficient and effective supply chain (Sánchez-Flores et al, 2020).

5.8 Challenges in the mining industry post covid19

The mining industry is known for its complex and challenging supply chain operations due to the often-remote locations of mining sites, the need for specialized equipment and materials, and the unpredictability of demand and supply. However, with effective supply chain management, mining companies can optimize their operations, reduce costs, and improve their overall performance. Here are some key factors that impact supply chain performance in the mining industry:

The issue of supplier management and sustainability is critical. The mining companies rely heavily on suppliers for critical equipment and materials needed for mining activities. In the mining industry, effective supplier management is critical to ensure the timely delivery of supplies, reduce lead times, and manage costs. Mining companies in South Africa need to establish strong relationships with their suppliers, monitor supplier performance, and collaborate with suppliers to identify opportunities for improvement (Asif et al, 2020).

In addition, there have been logistical problems in the mining sector, especially the traffic to the export port in Durban. The mining firms need to manage the movement of materials and equipment from suppliers to mining sites and from mining sites to processing facilities. Moreover, effective logistics management can improve supply chain efficiency, reduce transportation costs, and improve delivery times. Mining companies need to optimize transportation routes, use advanced logistics technologies, and establish effective communication and coordination across the supply chain (Cezne, & Garcia, 2024).

Besides, inventory management. The mining firms need to manage inventory levels to ensure that they have the necessary materials and equipment when they are needed while avoiding excess inventory carrying costs. Efficient inventory management can improve supply chain efficiency, reduce costs, and improve cash flow. Mining companies need to use advanced inventory management techniques, such as just-in-time inventory management, to optimize inventory levels and reduce waste (Becerra, et al, 2021).

Furthermore, risk management. The mining industry is subject to a range of risks, including supply chain disruptions, equipment breakdowns, and unexpected changes in demand. There is a need for effective risk management can help mining companies mitigate these risks and ensure that their operations remain stable and profitable (Sharma et al, 2022). Mining companies need to identify potential risks, establish contingency plans, and use advanced risk management techniques, such as predictive analytics, to anticipate and mitigate potential risks.

Effective supply chain management is critical for the success of mining companies. In focusing on supplier management, logistics, inventory management, and risk management, mining companies can optimize their operations, reduce costs, and improve their overall performance (Gałaś et al, 2021).

Chapter six: Conclusion and recommendation

6.1 Introduction

In South Africa, the mining industry is very complex and there have been several challenges post COVID-19. The challenging supply chain operations is often due to the remote locations where the sites are located. This often requires specialized equipment and materials, and the unpredictability of demand and supply. The aim of this study was to study how mining firms can design their supply chain networks to alleviate these challenges and improve their performance.

6.2 Summary of findings

Supply chain network design in the mining industry involves optimizing the physical structure of the supply chain to ensure that materials and equipment are transported in the most efficient and effective manner possible. Here are some key factors that impact supply chain network design in the mining industry:

The supply chain network design must consider the location of mining sites and configure it to its logistics and warehouse facilities. The location of mining sites is a critical factor in supply chain network design. Mining companies need to consider the proximity of mining sites to transportation hubs, processing facilities, and suppliers when designing their supply chain network.

The transportation and logistics network are critical and the transportation of materials and equipment is a critical component of the mining supply chain. The mining firm companies need to consider the most efficient transportation methods, such as trucks, trains, and ships, to transport materials and equipment between mining sites, processing facilities, and suppliers.

The warehousing location and facilities must support how mining firms operate. The mining companies need to consider the most efficient warehousing solutions for storing and transporting materials and equipment. Moreover, this may involve using temporary storage facilities or establishing long-term storage facilities near mining sites or transportation hubs.

The mining industry must undertake to rationalise supplier management: Mining companies need to establish strong relationships with their suppliers and manage their suppliers effectively to

ensure that they have access to the necessary materials and equipment when they are needed. This may involve establishing long-term contracts with suppliers, monitoring supplier performance, and collaborating with suppliers to identify opportunities for improvement.

The mining industry is subject to a range of risks, including supply chain disruptions, equipment breakdowns, and unexpected changes in demand. Effective risk management is critical to ensure that mining operations remain stable and profitable. Mining companies need to identify potential risks, establish contingency plans, and use advanced risk management techniques, such as predictive analytics, to anticipate and mitigate potential risks. Overall, effective supply chain network design is critical for the success of mining companies. By optimizing the physical structure of the supply chain and managing suppliers and risks effectively, mining companies can improve supply chain efficiency, reduce costs, and improve overall performance.

6.4 Key recommendations

The South African mining industry faces various challenges in its supply chain operations. The improvement of supply chain sustainability and transition to renewable energy continues to dominate the debate. However, several issues besides renewable energy impact the mining supply chains.

Transportation and logistics are critical components of the mining supply chain, and the remote locations of mining sites in South Africa can make transportation particularly challenging. Mining must configure transport and logistics to support its operations. Specialized transportation modes are essential, and the lead time must be improved to ensure goods arrive at the port of departure on time. There is a high transport cost.

The infrastructure is vital, and the infrastructure in South Africa, particularly in rural areas where many mining sites are located, needs to be improved for the mining industry's needs. There is a need to improve this infrastructure decay, which will ensure sustainability in the mining value chain.

The health and safety measures in the mining firms must be improved. Health, safety, and the environment are critical concerns in the mining industry, and supply chain operations can present safety challenges. There have been several HSE challenges, and the transportation of materials and equipment over long distances can be hazardous. The use of heavy machinery in mining operations

can be dangerous for workers which at times results in major safety incidents due to several issues such as bypassing safety rules and complacency.

In addition, there is a need for political and regulatory changes to address the challenges in the industry. The mining industry in South Africa is subject to various political and regulatory challenges, which can impact supply chain operations. For example, changes in government policies or regulations can impact the availability of permits or licenses needed for mining operations, leading to delays or disruptions in supply chain operations.

Furthermore, environmental issues remain a serious concern. The mining industry in South Africa has been subject to increasing scrutiny from regulators and the public due to environmental concerns. Moreover, mining firms must manage their supply chain operations to minimize their environmental impact and promote sustainability. The issues of global warming and the transition to sustainable energy remain a crucial concern for many stakeholders.

Lastly, the labour relations challenges in the sector remain a ticking time bomb. The issues of strikes and inadequate remuneration have dogged the industry. There are labour disputes and strikes. These disputes can impact supply chain operations, leading to delays and disruptions in the supply of materials and equipment. The South African mining industry faces various supply chain challenges, including transportation, infrastructure, safety, political and regulatory challenges, environmental concerns, and labour relations. By addressing these challenges effectively, mining companies can optimize their operations, reduce costs, and improve their overall performance.

6.5 Implication for the study and future studies

The study's implications are critical to advancing research and improving practices in supply chain management in the mining industry. The findings should enjoin researchers to confirm or refute existing theories, develop new hypotheses, or explore alternative research methodologies such as mixed methods and qualitative research to address the dearth in quantitative research used in this study.

Additionally, the implications can provide valuable insights for practitioners and policymakers to make informed decisions based on the evidence about the current state of the mining supply chain management in South Africa. Overlooking the implications of a study can delay progress and limit

our understanding of the subject matter. Therefore, it is crucial to consider the implications of a study to amplify its impact.

The mining industry, a linchpin of the South African economy, is in need of your expertise. This research proposal advocates for a deep dive into the potential of artificial intelligence and machine learning techniques to revolutionize decision-making in the supply chain. Operational efficiency is not just a goal, but a necessity to improve production costs and enhance the profitability of mining firms. Studies using big datasets to support decision-making can be the catalyst for this much-needed change.

6.6 Limitations of the study

The quantitative study explored quantitative variables. However, they are often criticized for their limitations. The fundamental limitation is that they tend to oversimplify complex phenomena by reducing them to numerical data. This approach may need to capture the richness and complexity of human experience. Moreover, this quantitative research relied on preconceived categories and measures, which may not accurately reflect individuals' diverse perspectives and experiences.

The second limitation of this study is that quantitative research needed to provide a complete understanding of the context in which phenomena occur, as it often focusses on isolated variables rather than the interplay between multiple factors. Finally, this quantitative study may have needed help with issues related to sample size, generalizability, and reliability of data collection methods, which can limit the validity and usefulness of the findings. However, despite these limitations, this quantitative research was a valuable tool to generate and test hypotheses, and the confirmation of the theory was evidence that the design was appropriate for the study.

To address the limitations of quantitative studies, it is recommended that future scholars consider incorporating qualitative methods into their research designs. The use of qualitative methods, such as interviews, focus groups, and observation, can provide a more in-depth understanding of participants' perspectives, experiences, and context. Subsequent studies must combine quantitative and qualitative methods for scholars to gain a more comprehensive understanding of the phenomena under study regarding supply chain and performance in the study.

Additionally, researchers should strive to use measures sensitive to participants' diverse experiences and perspectives and ensure that their sample sizes are adequate and representative of

the population of interest. Finally, researchers should be transparent about their methods and limitations and acknowledge the limitations of their findings. With the implementation of these recommendations, researchers can improve the quality and usefulness of their studies.

5.7 Conclusion

The research examined the sustainability and performance of the mining supply chain industry in South Africa after Covid19. The analysis of the data gathered in this study shows that efficient supply chain management is a vital factor in attaining business success. The study reveals that businesses with well-organized supply chains reported higher customer satisfaction, increased revenue, and improved profitability than those with less effective supply chains. Additionally, the study emphasizes the significance of technology investment and training to optimize supply chain processes and minimize inefficiencies. In the mining industry, there is a competitive business landscape and firms must prioritise supply chain management to remain competitive.

6. References

Abedian., I., & Soanamatsie, N. (2022). Energy Transition for Post-COVID-19 South Africa. *The Future of the South African Political Economy Post-COVID 19,* 10(2), 211-234).

Adana, S., Manuj, I., Herburger, M., Cevikparmak, S., Celik, H., & Uvet, H. (2024). Linking decentralization in decision-making to resilience outcomes: a supply chain orientation perspective. *The International Journal of Logistics Management*, *35*(1), 256-280.

Adomako, S., & Tran, M. D. (2022). Sustainable environmental strategy, firm competitiveness, and financial performance: Evidence from the mining industry. *Resources Policy*, 2(75), 102515.

Ahmadi-Gh, Z., & Bello-Pintado, A. (2024). Sustainability isomorphism in buyer–supplier relationships: The impact of supply chain leadership. *Business Strategy and the Environment*, 7(21), 356-381,

Ali, H., & Shoaib., M. (2023). A comprehensive literature review on green supply chain management: recent advances and potential research directions. *International Journal of Supply and Operations Management*, *10*(1), 57-75.

Amoah, P., & Eweje, G. (2024). Examining the social sustainability strategies of multinational mining companies in a developing country. *Social Responsibility Journal*, *20*(3), 568-584.

Arndt, C., Davies, R., Gabriel, S., Harris, L., Makrelov, K., Modise, B., & Anderson, L. (2020). Impact of Covid-19 on the South African economy. *Southern Africa-Towards Inclusive Economic Development Working Paper*, 20 (*111),* 201-215.

Asiamah, N., Mensah, H., & Oteng-Abayie, E. F. (2017). General, target, and accessible population: Demystifying the concepts for effective sampling. *The qualitative report*, *22*(6), 1607-1621.

Asif, M. S., Lau, H., Nakandala, D., Fan, Y., & Hurriyet, H. (2020). Adoption of green supply chain management practices through collaboration approach in developing countries–From literature review to conceptual framework. *Journal of Cleaner Production*, 12 (276), 124191.

Asmussen, C. B., & Møller, C. (2020). Enabling supply chain analytics for enterprise information systems: a topic modelling literature review and future research agenda. *Enterprise Information Systems*, 14(5), 563-610.

Bag, S., Rahman, M. S., Srivastava, G., Chan, H. L., & Bryde, D. J. (2022). The role of big data and predictive analytics in developing a resilient supply chain network in the South African mining industry against extreme weather events. *International Journal of Production Economics*, 6(251), 108541.

Barata, F., Ricardianto, P., Haq, L., Octaviani, R., Ariohadi, M., Sitorus, P., & Endri, E. (2024). Safety risk and operational efficiency on logistic service providers' sustainable coal supply chain management. *Uncertain Supply Chain Management*, 12(1), 461-470.

Battesini, M., ten Caten, C. S., & de Jesus Pacheco, D. A. (2021). Key factors for operational performance in manufacturing systems: Conceptual model, systematic literature review and implications. *Journal of Manufacturing Systems*, 12(60), 265-282.

Becerra, P., Mula., J., & Sanchis, R. (2021). Green supply chain quantitative models for sustainable inventory management: A review. *Journal of Cleaner Production*, 8(*328)*, 129544.

Besa, B., Kabwe, J., Masinja, J., & Banda, W. (2023). Socio-economic impact of mine closure and development of exit strategy for rural mining areas in Zambia: A case study of Kalumbila District. *International Symposium on Mine Planning & Equipment Selection*, 20(46), 411-421.

Bester, V. (2023). Towards a sustainable artisanal gold mining sector in South Africa: Proposed developmental initiatives. *Journal of Rural Studies*, 8(*97)*, 375-384.

Bhagwan, N., & Evans, M. (2023). A review of industry 4.0 technologies used in the production of energy in China, Germany, and South Africa. *Renewable and Sustainable Energy Reviews*, 21(*173)*, 113075.

Bier, T., Lange, A., & Glock, C. H. (2020). Methods for mitigating disruptions in complex supply chain structures: a systematic literature review. *International Journal of Production Research*, *58*(6), 1835-1856.

Bloomfield, J., & Fisher, M. J. (2019). Quantitative research design. *Journal of the Australasian Rehabilitation Nurses Association*, *22*(2), 27-30.

Butt, S. A., Barraza, F., Devito, K., Frost, L., Javed, M. B., Noernberg, T., & Shotyk, W. (2024). Spatio-temporal variations in dissolved trace elements in peat bog porewaters impacted by dust inputs from open-pit mining activities in the Athabasca bituminous sands (ABS) region. *Environmental Pollution*, 12(23), 123470.

Cezne, E., & Garcia, A. S. (2024). The rise and fall of Brazilian extractivism in Africa: Taking stock of Vale's mining operations on the continent (2004–2022). *The Extractive Industries and Society*, 6(17), 101400.

Chakuu, S., Masi, D., & Godsell, J. (2019). Exploring the relationship between mechanisms, actors and instruments in supply chain finance: A systematic literature review. *International Journal of Production Economics*, 8(216), 35-53.

Chehbi-Gamoura, S., Derrouiche, R., Damand, D., & Barth, M. (2020). Insights from big Data Analytics in supply chain management: an all-inclusive literature review using the SCOR model. *Production Planning & Control*, *31*(5), 355-382.

Chen, J., Qi, A., & Dawande, M. (2020). Supplier centrality and auditing priority in socially responsible supply chains. *Manufacturing & Service Operations Management*, *22*(6), 1199-1214.

Chen., Y. (2023). How blockchain adoption affects supply chain sustainability in the fashion industry: a systematic review and case studies. *International Transactions in Operational Research*, 5(40), 3321-3345.

Chitiga-Mabugu, M., Henseler, M., Mabugu, R., & Maisonnave, H. (2021). Economic and distributional impact of COVID-19: Evidence from macro-micro modelling of the South African economy. *South African Journal of Economics*, *89*(1), 82-94.

Chitiga-Mabugu, M., Henseler, M., Mabugu, R., & Maisonnave, H. (2021). Economic and distributional impact of COVID-19: Evidence from macro-micro modelling of the South African economy. *South African Journal of Economics*, *89*(1), 82-94.

Choi., T. M. (2020). Supply chain financing using blockchain: Impacts on supply chains selling fashionable products. *Annals of Operations Research*, 20(5),1-23.

Coral, C., & Bokelmann, W. (2017). The role of analytical frameworks for systemic research design, explained in the analysis of drivers and dynamics of historic land-use changes. *Systems*, *5*(1), 20.

Cowan, R., & Jonard, N. (2023). Modular organization and informal structure: Modularity, performance, and the alignment of organizational networks. *Industrial and Corporate Change*, *32*(1), 181-207.

Csiki, O., Demeter, K., & Losonci, D. (2023). How to improve firm performance? –The role of production capabilities and routines. *International Journal of Operations & Production Management*, 27(6), 1234-1243.

Daneshvar-Kakhki, M., & Gargeya, V. B. (2019). Information systems for supply chain management: a systematic literature analysis. *International Journal of Production Research, 57*(15), 5318-5339.

de Camargo Fiorini, P., & Jabbour, C. J. C. (2017). Information systems and sustainable supply chain management towards a more sustainable society: Where we are and where we are going. *International Journal of Information Management*, *37*(4), 241-249.

De Villiers, C., Cerbone, D., & Van Zijl, W. (2020). The South African government's response to COVID-19. *Journal of Public Budgeting, Accounting & Financial Management*, 32(5), 797-811.

Deepa, N., Pham, Q. V., Nguyen, D. C., Bhattacharya, S., Prabadevi, B., Gadekallu., T. R., & Pathirana., P. N. (2022). A survey on blockchain for big data: approaches, opportunities, and future directions. *Future Generation Computer Systems*, 31(7), 215-247.

Dehshiri, S. J. H., & Amiri, M. (2024). Evaluation of blockchain implementation solutions in the sustainable supply chain: A novel hybrid decision approach based on Z-numbers. *Expert Systems with Applications*, 10(*235)*, 121-123.

Dekkers, R., de Boer, R., Gelsomino, L. M., de Goeij, C., Steeman, M., Zhou, Q., & Souter, V. (2020). Evaluating theoretical conceptualisations for supply chain and finance integration: a Scottish focus group. *International Journal of Production Economics*, 8(220), 107-451.

Demirkıran, Y. (2023). COVID-19 Pandemic-Related Supply Chain Disruptions and Impacts on the Global Economy: In Managing Inflation and Supply Chain Disruptions in the Global Economy. *IGI Global*, 23(5), 199-219).

Dikgwatlhe, P., & Mulenga, F. (2023). Perceptions of local communities regarding the impacts of mining on employment and economic activities in South Africa. *Resources Policy*, 7(*80)*, 103-138.

Ditkaew, K., Pitchayatheeranart, L., & Jermsittipasert, K. (2020). The causal structural relationships between accounting information system quality, supply chain management capability, and sustainable competitive advantages of maize. *International Journal of Supply Chain Management*, *9*(1), 144.

Dixon, J. M., Adams, P. D., & Sheard, N. (2021). The impacts of COVID-19 containment on the Australian economy and its agricultural and mining industries. *Australian Journal of Agricultural and Resource Economics*, *65*(4), 776-801.

Dominguez, R., Cannella, S., Ponte, B., & Framinan, J. M. (2022). Information sharing in decentralised supply chains with partial collaboration. *Flexible services and manufacturing journal*, *34*(2), 263-292.

Dong, L., Qiu, Y., & Xu, F. (2023). Blockchain-enabled deep-tier supply chain finance. *Manufacturing & Service Operations Management*, *25*(6), 2021-2037.

Durmaz, Y. G., & Bilgen, B. (2020). Multi-objective optimization of sustainable biomass supply chain network design. *Applied Energy*, 8(*272)*, 115259.

Dźwigoł, H. (2019). Research methods and techniques in new management trends: research results. *Virtual Economics*, *2*(1), 31-48.

Eden, L., & Nielsen, B. B. (2020). Research methods in international business: The challenge of complexity. *Journal of International Business Studies*, 6(*51)*, 1609-1620.

El Baz, J., Cherrafi, A., Benabdellah, A. C., Zekhnini, K., Beka Be Nguema, J. N., & Derrouiche, R. (2023). Environmental Supply Chain Risk Management for Industry 4.0: A Data Mining Framework and Research Agenda. *Systems*, 11(1), 46.

Elfiswandi, E., Sanjaya, S., Pratiwi, N., Yulia, Y., & Ramadhan, M. F. (2020). Macroeconomic factors, energy consumption and firms' performance on stock return of mining and energy sector: Evidence from Indonesia. *International Journal of Energy Economics and Policy*, 10(6), 229-234.

Elliot, V. H., De Goeij, C., Gelsomino, L. M., & Woxenius, J. (2020). Supply chain finance is not for everyone. *International Journal of Physical Distribution & Logistics Management*, 50(10), 775-807.

Enderle, G. (2015). Exploring and conceptualizing international business ethics. *Journal of Business Ethics*, 127(9), 723-735.

Famiyeh, S., & Kwarteng, A. (2018). Implementation of environmental management practices in the Ghanaian mining and manufacturing supply chains. *International Journal of Productivity and Performance Management*, *67*(7), 1091-1112.

Farahani, R. Z., Rezapour, S., Drezner, T., & Fallah, S. (2014). Competitive supply chain network design: An overview of classifications, models, solution techniques and applications. *Omega*, *45*, 92-118.

Fasan, M., Soerger Zaro, E., Soerger Zaro, C., Porco, B., & Tiscini, R. (2021). An empirical analysis: Did green supply chain management alleviate the effects of COVID-19? *Business Strategy and the Environment*, *30*(5), 2702-2712.

Frederico, G. F., Kumar, V., Garza-Reyes, J. A., Kumar, A., & Agrawal, R. (2021). Impact of technologies and their interoperability on performance: future pathways for supply chain resilience post-COVID-19. *The International Journal of Logistics Management*, 23(4), 63-92.

Free, C, & Hecimovic, A. (2021). Global supply chains after COVID-19: the end of the road for neoliberal globalisation? *Accounting, Auditing & Accountability Journal*, *34*(1), 58-84.

Fu, Q., Abdul Rahman, A. A., Jiang, H., Abbas, J., & Comite, U. (2022). Sustainable supply chain and business performance: The impact of strategy, network design, information systems, and organizational structure. *Sustainability*, *14*(3), 1080.

Gałaś, A., Kot-Niewiadomska, A., Czerw, H., Simić, V., Tost, M., Wårell, L., & Gałaś, S. (2021). Impact of Covid-19 on the mining sector and raw materials security in selected European countries. *Resources*, *10*(5), 39.

Gao, Q., Guo, S., Liu, X., Manogaran, G., Chilamkurti, N., & Kadry, S. (2020). Simulation analysis of supply chain risk management system based on IoT information platform. *Enterprise Information Systems*, 14(9-10), 1354-1378.

Geldenhuys, K., & Flynn, B. H. (2024). International Syndicates & Illegal mining in South Africa. *Servamus Community-based Safety and Security Magazine*, 117(1), 10-15.

Gelsomino, L. M., Mangiaracina, R., Perego, A., & Tumino, A. (2016). Supply chain finance: a literature review. *International Journal of Physical Distribution & Logistics Management*, 17(3), 334-342.

Golan, M. S., Jernegan, L. H., & Linkov, I. (2020). Trends and applications of resilience analytics in supply chain modeling: systematic literature review in the context of the COVID-19 pandemic. *Environment Systems and Decisions*, 40(2), 222-243.

Govindan, K., Jain, P., Singh, R. K., & Mishra, R. (2024). Blockchain technology as a strategic weapon to bring procurement 4.0 truly alive: Literature review and future research agenda. *Transportation Research Part E: Logistics and Transportation Review*, 181(6), 103-352.

Grover, V., & Malhotra, M. K. (2003). Transaction cost framework in operations and supply chain management research: theory and measurement. *Journal of Operations management*, 21(4), 457-473.

Gu, F, & He, M. (2024). A Study of Supply Chain Relationship Change and RFID IT Adoption-Based on a Share Listed Company. *Finance Research Letters*, 34(5)105-120.

Guan, D., Wang, D., Hallegatte, S., Davis, S. J., Huo, J., Li, S, & Gong, P. (2020). Global supply-chain effects of COVID-19 control measures. *Nature human behaviour*, 4(6), 577-587.

Gyan, K. A, & Jan-Bezemer, P. (2022). Related diversification, firm level resources, and firm performance in the context of Australian extractive industry. *Journal of Corporate Accounting & Finance*, 33(2), 142-153.

Han, Y., Chong, W. K., & Li, D. (2020). A systematic literature review of the capabilities and performance metrics of supply chain resilience. *International Journal of Production Research*, 58(15), 4541-4566.

Hasan, R., Kamal, M. M., Daowd, A., Eldabi, T., Koliousis, I., & Papadopoulos, T. (2024). Critical analysis of the impact of big data analytics on supply chain operations. *Production Planning & Control*, 35(1), 46-70.

Helmold, M. (2023). Quality Management (QM). In *Virtual and Innovative Quality Management Across the Value Chain: Industry Insights, Case Studies and Best Practices* (pp. 1-13). Cham: Springer International Publishing, 1(2), 15-27.

Helmold, M. (2023). Quality Management (QM). In *Virtual and Innovative Quality Management Across the Value Chain: Industry Insights, Case Studies, and Best Practices*. Cham: Springer International Publishing, 2(4), 1-13.

Helo, P., & Shamsuzzoha, A. H. M. (2020). Real-time supply chain—A blockchain architecture for project deliveries. *Robotics and Computer-Integrated Manufacturing*, 63(56), 101-909.

Hmouda, A. M., Orzes, G., & Sauer, P. C. (2024). Sustainable supply chain management in energy production: A literature review. *Renewable and Sustainable Energy Reviews*, 191(28), 114-185.

Hobbs, J. E. (1996). A transaction cost approach to supply chain management. *Supply Chain Management: An International Journal*, 1(2), 15-27.

Inman, R. A., Green, K. W, & Roberts, M. D. (2024). A COVID replication and extension of firms' resilience to supply chain disruptions. *Supply Chain Management: An International Journal*, 7(2), 53-72.

Ivanov, D. (2010). An adaptive framework for aligning (re) planning decisions on supply chain strategy, design, tactics, and operations. *International journal of production research*, 48(13), 3999-4017.

Jawaad, M., & Zafar, S. (2020). Improving sustainable development and firm performance in emerging economies by implementing green supply chain activities. *Sustainable Development*, 28(1), 25-38.

Jha, A. K., Agi, M. A, & Ngai, E. W. (2020). A note on big data analytics capability development in supply chain. *Decision Support Systems, 138(25)*, 113-382.

Jia, F., Blome, C., Sun, H., Yang, Y., & Zhi, B. (2020). Towards an integrated conceptual framework of supply chain finance: An information processing perspective. *International Journal of Production Economics*, 219(34), 18-30.

Jia, F., Zhang, T., & Chen, L. (2020). Sustainable supply chain Finance: Towards a research agenda. *Journal of cleaner production*, 243(9), 118-680.

Joshi, S. (2022). A review on sustainable supply chain network design: Dimensions, paradigms, concepts, framework and future directions. *Sustainable Operations and Computers*, 1(2), 15-27.

Jowitt, S. M. (2020). COVID-19 and the global mining industry. *SEG discovery*, 48(122), 33-41.

Kähkönen, A. K., Evangelista, P., Hallikas, J., Immonen, M., & Lintukangas, K. (2023). COVID-19 as a trigger for dynamic capability development and supply chain resilience improvement. *International Journal of Production Research*, 61(8), 2696-2715.

Kalaiarasan, R., Olhager, J., Agrawal, T. K., & Wiktorsson, M. (2022). The ABCDE of supply chain visibility: A systematic literature review and framework. *International Journal of Production Economics*, 4(2), 108-464.

Kamble, S. S., & Gunasekaran, A. (2020). Big data-driven supply chain performance measurement system: a review and framework for implementation. *International journal of production research*, 58(1), 65-86.

Karatas, C., & Gultekin, M. (2021, June). EDI Based Secure Desing Pattern For Logistic and Supply Chain. In *2021 9th International Symposium on Digital Forensics and Security*, 1(2), 1-5.

Kelling, N. K., Sauer, P. C., Gold, S., & Seuring, S. (2021). The role of institutional uncertainty for social sustainability of companies and supply chains. *Journal of Business Ethics*, 173(8), 813-833.

Ketokivi, M., & Mahoney, J. T. (2020). Transaction cost economics as a theory of supply chain efficiency. *Production and Operations Management*, 29(4), 1011-1031.

Khanuja, A., & Jain, R. K. (2023). The conceptual framework on integrated flexibility: an evolution to data-driven supply chain management. *The TQM Journal*, 35(1), 131-152.

Knudsen, E. S., Lien, L. B., Timmermans, B., Belik, I, & Pandey, S. (2021). Stability in turbulent times? The effect of digitalization on the sustainability of competitive advantage. *Journal of Business Research*, 12(8), 360-369.

Kotzab, H., Bäumler, I, & Gerken, P. (2023). The big picture on supply chain integration–insights from a bibliometric analysis. *Supply Chain Management: An International Journal*, 28(1), 25-54.

Kumar, M., Raut, R. D., Gunasekaran, A., Venkateshwarlu, M., & Choubey, V. K. (2023). Developing Supply Chain Capabilities Through Digitalization and Viability for Controlling the Ripple Effect. *IEEE Transactions on Engineering Management*, 13(2), 153-271.

Laing, T. (2020). The economic impact of the Coronavirus 2019 (Covid-2019): Implications for the mining industry. *The extractive industries and society*, 7(2), 580-582.

Le Billon, P., Lujala, P., Singh, D., Culbert, V., & Kristoffersen, B. (2021). Fossil fuels, climate change, and the COVID-19 crisis: pathways for a just and green post-pandemic recovery. *Climate Policy*, 21(10), 1347-1356.

Lee, Y. (2023). When does a supplier tolerate resellers' opportunistic behaviors? Transaction benefit and cost perspectives. *Journal of Business & Industrial Marketing*, 38(5), 1101-1115.

Li, P., & Zhao, X. (2024). The impact of digital transformation on corporate supply chain management: Evidence from listed companies. *Finance Research Letters*, 60(4), 104890.

Li, Y., & Zobel, C. W. (2020). Exploring supply chain network resilience in the presence of the ripple effect. *International Journal of Production Economics*, 228(3), 107693.

Li, Y., Pinto, M. C. B., & Kumar, D. T. (2023). Analyzing sustainability indicator for Chinese mining sector. *Resources Policy*, 80(5), 103-275.

Liang, Y. H. (2015). Performance measurement of interorganizational information systems in the supply chain. *International Journal of Production Research*, *53*(18), 5484-5499.

Liedong, T. A., Peprah, A. A., Amartey, A. O., & Rajwani, T. (2020). Institutional voids and firms' resource commitment in emerging markets: A review and future research agenda. *Journal of International Management*, *26*(3), 100-756.

Lone, S. A., & Ahmad, A. (2020). COVID-19 pandemic–an African perspective. *Emerging microbes & infections*, 9(1), 1300-1308.

Manjengwa, E. R., Dorfling, C., & Tadie, M. (2023). Development of a conceptual framework to evaluate factors that affect drivers for stakeholder engagement in mine waste management. *Resources Policy*, 81(12), 103-280.

Martins, C. L., & Pato, M. V. (2019). Supply chain sustainability: A tertiary literature review. *Journal of cleaner production*, 225(43), 995-1016.

Mehrjerdi, Y. Z., & Shafiee, M. (2021). A resilient and sustainable closed-loop supply chain using multiple sourcing and information sharing strategies. *Journal of Cleaner Production*, 28(9), 125-141.

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D, & Zacharia, Z. G. (2001). Defining supply chain management. *Journal of Business logistics*, 22(2), 1-25.

Michalski, M., Montes, J. L., & Narasimhan, R. (2019). Relational asymmetry, trust, and innovation in supply chain management: a non-linear approach. *The International Journal of Logistics Management*, 30(1), 303-328.

Miles, D. A. (2017, August). A taxonomy of research gaps: Identifying and defining the seven research gaps. In *Doctoral student workshop: finding research gaps-research methods and strategies, Dallas, Texas*, 1-15.

Mishra, M., Ghosh, S. K., & Sarkar, B. (2022). Maintaining energy efficiencies and reducing carbon emissions under a sustainable supply chain management. *AIMS Environ. Sci*, 12*(9)*, 603-635.

Modgil, S., Singh, R. K., & Hannibal, C. (2022). Artificial intelligence for supply chain resilience: learning from Covid-19. *The International Journal of Logistics Management*, 33(4), 1246-1268.

Morris, S. B. (2023). Meta-analysis in organizational research: A guide to methodological options. *Annual Review of Organizational Psychology and Organizational Behavior*, 10(6), 225-259.

Muchaendepi, W., Mbowa, C., Kanyepe, J., & Mutingi, M. (2019). Challenges faced by the mining sector in implementing sustainable supply chain management in Zimbabwe. *Procedia Manufacturing*, 33(4), 493-500.

Müller, F., & Claar, S. (2021). Auctioning a 'just energy transition'? South Africa's renewable energy procurement programme and its implications for transition strategies. *Review of African Political Economy*, 48(169), 333-351.

Munir, M., Jajja, M. S. S., Chatha, K. A., & Farooq, S. (2020). Supply chain risk management and operational performance: The enabling role of supply chain integration. *International Journal of Production Economics*, 22(7), 107-667.

Njualem, L. A, & Ogundare, O. (2023). A sustainability model for globalized mining supply chain. *International Journal of Supply and Operations Management*, 10(1), 105-116.

North, D. C, & Institutions, I. C. (1990). *Economic performance* (Vol. 3). Cambridge: Cambridge University Press.

Ntabe, E. N., LeBel, L., Munson, A. D, & Santa-Eulalia, L. A. (2015). A systematic literature review of the supply chain operations reference (SCOR) model application with special attention to environmental issues. *International Journal of Production Economics*, 16(9), 310-332.

Ochara, N. M. (2016). What is Your Research Problem? Discovering a Research (Able) Problem and Topic. *Discovering a Research (Able) Problem and Topic (January 26, 2016)*.

Ofélia de Queiroz, F. A., Morte, I. B. B., Borges, C. L., Morgado, C. R., & de Medeiros, J. L. (2024). Beyond clean and affordable transition pathways: A review of issues and strategies to sustainable energy supply. *International Journal of Electrical Power & Energy Systems*, 15(5), 109-544.

Orlanyuk-Malitskaya, L., Plakhova, T., Sakulyeva, T., & Glazkova, I. (2024). The impact of globalisation processes on supply chain management. *Innovative Infrastructure Solutions*, *9*(2), 35-42.

Park, A., & Li, H. (2021). The effect of blockchain technology on supply chain sustainability performances. *Sustainability*, 13(4), 17-26.

Pereira, J., Braga, V., Correia, A., & Salamzadeh, A. (2021). Unboxing organisational complexity: how does it affect business performance during the COVID-19 pandemic? *Journal of Entrepreneurship and Public Policy*, 10(3), 424-444.

Perez-Franco, R., Phadnis, S., Caplice, C, & Sheffi, Y. (2016). Rethinking supply chain strategy as a conceptual system. *International Journal of Production Economics*, 18(2), 384-396.

Perkmann, M., Salandra, R., Tartari, V., McKelvey, M., & Hughes, A. (2021). Academic engagement: A review of the literature 2011-2019. *Research policy*, 50(1), 104-114.

Piprani, A. Z., Jaafar, N. I., Ali, S. M., Mubarik, M. S., & Shahbaz, M. (2022). Multi-dimensional supply chain flexibility and supply chain resilience: the role of supply chain risks exposure. *Operations Management Research*, 15(12), 307-325.

Pratt, J. A., Chen, L., Kishel, H. F., & Nahm, A. Y. (2022). Information Systems and Operations/supply Chain Management: A Systematic Literature Review. *Journal of Computer Information Systems*, 234(13),1-17.

Prinsloo, J., Vosloo, J. C., & Mathews, E. H. (2019). Towards Industry 4.0: A roadmap for the South African heavy industry sector. *South African Journal of Industrial Engineering*, 30(3), 174-186.

Pujawan, I. N., & Bah, A. U. (2022, January). Supply chains under COVID-19 disruptions: literature review and research agenda. In *Supply Chain Forum: An International Journal* 23(1), 81-95.

Que, S., Wang, L., Awuah-Offei, K., Chen, Y., & Yang, W. (2018). The status of the local community in mining sustainable development beyond the triple bottom line. *Sustainability*, 10(6), 17-49.

Ramadhany, A. A. (2021). The Mediation Effect Firm Performance on Green Innovation and Firm Value: Evidence the Mining Industry. *Turkish Journal of Computer and Mathematics Education* 12(3), 1377-1783.

Ranjan, J., & Foropon, C. (2021). Big data analytics in building the competitive intelligence of organizations. *International Journal of Information Management*, 56(3), 102-231.

Rasool, F, Greco, M., & Grimaldi, M. (2022). Digital supply chain performance metrics: a literature review. *Measuring Business Excellence*, 26(1), 23-38.

Rath, K. C., Khang, A., & Roy, D. (2024). The Role of Internet of Things (IoT) Technology in Industry 4.0 Economy. In *Advanced IoT Technologies and Applications in the Industry 4.0 Digital Economy,* 7(13), 1-28.

Reuber, A. R., & Fischer, E. (2022). Putting qualitative international business research in context (s). *Journal of International Business Studies*, 53(1), 27-38.

Rompho, N. (2018). Operational performance measures for start-ups. *Measuring Business Excellence*, 22(1), 31-41.

Sadan, V. (2017). Data collection methods in quantitative research. *Indian Journal of Continuing Nursing Education*, 18(2), 58.

Saffar, N. A. G. A., & Obeidat, A. (2020). The effect of total quality management practices on employee performance: The moderating role of knowledge sharing. *Management Science Letters*, 10(1), 77-90.

Samadhiya, A., Agrawal, R., Kumar, A, & Garza-Reyes, J. A. (2023). Blockchain technology and circular economy in the environment of total productive maintenance: a natural resource-based view perspective. *Journal of Manufacturing Technology Management*, 1(2), 15-27.

Samaranayake, P., McLean, M. W., & Weerabahu, S. K. (2024). Application of lean and quality improvement methods for improving operational performance in coal supply chains: a case study. *International Journal of Quality & Reliability Management*, 25(5), 433-453.

Sazvar, Z., Tafakkori, K., Oladzad, N., & Nayeri, S. (2021). A capacity planning approach for sustainable-resilient supply chain network design under uncertainty: A case study of vaccine supply chain. *Computers & Industrial Engineering*, 15(9), 107-406.

Sharma, M., Luthra, S., Joshi, S., & Kumar, A. (2022). Developing a framework for enhancing survivability of sustainable supply chains during and post-COVID-19 pandemic. *International Journal of Logistics Research and Applications*, 52(4), 334-435.

Shiquan, D., Deyi, X., Yongguang, Z., & Keenan, R. (2023). Critical Mineral Sustainable Supply: Challenges and Governance. *Futures*, 2(8), 103-101.

Singh, C. S., Soni, G., & Badhotiya, G. K. (2019). Performance indicators for supply chain resilience: review and conceptual framework. *Journal of Industrial Engineering International, 1(5)*, 105-117.

Skipworth, H., Godsell, J., Wong, C. Y., Saghiri, S., & Julien, D. (2015). Supply chain alignment for improved business performance: an empirical study. *Supply Chain Management: An International Journal*, 20(5), 511-533.

Smith, J. R., Yost, J., & Lopez, H. (2020). Electronic data interchange and enterprise resource planning technology in supply chain contracts. *Computers & Industrial Engineering*, 14(2), 106-330.

Spieske, A, & Birkel, H. (2021). Improving supply chain resilience through industry 4.0: A systematic literature review under the impressions of the COVID-19 pandemic. *Computers & Industrial Engineering*, 15(8), 107-152.

Statsenko, L., Jayasinghe, R. S, & Soosay, C. (2024). Supply network resilience capabilities: a social–ecological perspective. *Supply Chain Management: An International Journal*, *29*(1), 1-26.

Story, D. A, & Tait, A. R. (2019). Survey research. *Anesthesiology*, 130(2), 192-202.

Sudusinghe, J. I, & Seuring, S. (2022). Supply chain collaboration and sustainability performance in circular economy: A systematic literature review. *International Journal of Production Economics*, *24(5)*, 108-140.

Sun, J., & Teng, J. T. (2017). The construct of information systems uses benefits: Theoretical explication of its underlying dimensions and the development of a measurement scale. *International Journal of Information Management*, *37*(5), 400-416.

Tallon, P. P., Queiroz, M., Coltman, T, & Sharma, R. (2019). Information technology and the search for organizational agility: A systematic review with future research possibilities. *The Journal of Strategic Information Systems*, *28*(2), 218-237.

Tirkolaee, E. B., Golpîra, H., Javanmardan, A, & Maihami, R. (2023). A socio-economic optimization model for blood supply chain network design during the COVID-19 pandemic: An interactive possibilistic programming approach for a real case study. *Socio-Economic Planning Sciences*, *8*(5), 101-139.

Treiblmaier, H. (2019). Combining blockchain technology and the physical internet to achieve triple bottom line sustainability: a comprehensive research agenda for modern logistics and supply chain management. *Logistics*, 3(1), 10-12.

Troisi, R., & Alfano, G. (2023). Proximity and inter-firm corruption: A transaction cost approach. *Small Business Economics*, 60(3), 1105-1120.

Tseng, M. L., Islam, M. S., Karia, N., Fauzi, F. A., & Afrin, S. (2019). A literature review on green supply chain management: Trends and future challenges. *Resources, Conservation and Recycling*, 14(1), 145-162.

Tutz, G. (2023). Probability and non-probability samples: Improving regression modeling by using data from different sources. *Information Sciences*, 621(3), 424-436.

Unhelkar, B., Joshi, S., Sharma, M., Prakash, S., Mani, A. K., & Prasad, M. (2022). Enhancing supply chain performance using RFID technology and decision support systems in the industry 4.0–A systematic literature review. *International Journal of Information Management Data Insights*, 2(2), 100-184.

Upadhyay, A., Laing, T., Kumar, V., & Dora, M. (2021). Exploring barriers and drivers to the implementation of circular economy practices in the mining industry. *Resources Policy*, 72(5), 102-137.

Van Assche, K., Beunen, R., Duineveld, M., & Gruezmacher, M. (2023). Adaptive methodology. Topic, theory, method and data in ongoing conversation. *International Journal of Social Research Methodology*, 26(1), 35-49.

Vlachos, I., & Polichronidou, V. (2024). Multi-demand supply chain triads and the role of Third-Party Logistics Providers. *The International Journal of Logistics Management*, 35(1), 136-157.

Wallwey, C., & Kajfez, R. L. (2023). Quantitative research artifacts as qualitative data collection techniques in a mixed methods research study. *Methods in Psychology, 8(3), 100-115.*

Wang, C, & Hu, Q. (2020). Knowledge sharing in supply chain networks: Effects of collaborative innovation activities and capability on innovation performance. *Technovation*, 94(12), 102-120.

Wang, J., Zhu, L., Feng, L., & Feng, J. (2023). A meta-analysis of sustainable supply chain management and firm performance: Some new findings on sustainable supply chain management. *Sustainable Production and Consumption*, 38(4), 312-330.

Wang, Q., Zhou, H., & Zhao, X. (2024). The role of supply chain diversification in mitigating the negative effects of supply chain disruptions in COVID-19. *International Journal of Operations & Production Management*, 44(1), 99-132.

Wang, Z., Wang, Q., Lai, Y., & Liang, C. (2020). Drivers and outcomes of supply chain finance adoption: an empirical investigation in China. *International journal of production economics*, 220(43), 107-453.

Welch, C., Piekkari, R., Plakoyiannaki, E., & Paavilainen-Mäntymäki, E. (2020). Theorising from case studies: Towards a pluralist future for international business research. *Research methods in international business*, 12(6), 171-220.

Williamson, O. E. (2010). Transaction cost economics: The natural progression. *American Economic Review*, 100(3), 673-690.

Wireko-Gyebi, R. S., Asibey, M. O., & Baah-Ennumh, T. Y. (2022). Planning for the effective and sustainable management of Ghana's artisanal small-scale gold mining industry. *Resources Policy, 7(6)*, 102-576.

Xu, X., Chen, X., Jia, F., Brown, S., Gong, Y., & Xu, Y. (2018). Supply chain finance: A systematic literature review and bibliometric analysis. *International Journal of Production Economics*, 20(4), 160-173.

Xu, Z., Elomri, A., Kerbache, L, & El Omri, A. (2020). Impacts of COVID-19 on global supply chains: Facts and perspectives. *IEEE Engineering Management Review*, 48(3), 153-166.

Yadav, S., Choi, T. M., Kumar, A., Luthra, S., & Naz, F. (2023). A meta-analysis of sustainable supply chain practices and performance: the moderating roles of type of economy and innovation. *International Journal of Operations & Production Management*, 25(4), 433-453.

Yaiprasert, C., & Hidayanto, A. N. (2024). AI-powered ensemble machine learning to optimize cost strategies in logistics business. *International Journal of Information Management Data Insights*, 4(1), 100-209.

Zhang, X., Zhang, Q., Dai, Z, & Zhang, X. (2023). The impact of carbon markets on the financial performance of power producers: Evidence based on China. *Energy Economics*, 12(7), 107119.

Zhen, L., Huang, L, & Wang, W. (2019). Green and sustainable closed-loop supply chain network design under uncertainty. *Journal of Cleaner Production*, 227(6), 1195-1209.

Appendix 1: Research Questionnaire

Respondents Biodata

Instruction:

1) What is your gender?

Male (1)	Female (2)	Others (3)

2) Level of education

Matric	National Diploma	Bachelor's Degree	Honour's Degree	Master's Degree	Others
(1)	(2)	(3)	(4)	(5)	6

3) Please kindly indicate the level of your experience in mining industry

<5 years	6-10 years	11-15 years	16-20 years	20+ years
(1)	(2)	(3)	(4)	(5)

4) Please kindly indicate your position with the organisation (mark with x inside the box)

Executive Management	Senior Management	Middle Management	Junior Management
(1)	(2)	(3)	(5)

Instructions: Please mark x inside box to indicate the level of agreement to the statement

A	**Supply Chain Network Design**	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A1	Our supply chain network design focuses on improving the value chain's efficiency.							
A2	Our supply chain network design is attentive to improving operational standards in the value chain.							
A3	Our supply chain network design diminishes operational difficulties by connecting all stakeholders.							
A4	Our supply chain network design ensures services in an appropriate means and at the right place in the industry.							

A5	Our supply chain network design focuses on reducing operational expenses and increasing profitability.							
A6	Our supply chain network design provides financial and non-financial support to the collaboration by empowering them to meet lead times.							
B	**Supply Chain Information Systems**							
B1	Our collaboration in the supply chain reduces information irregularity in the value chain within the industry							
B2	Our information systems support inventory management in the value chain to improve operations capabilities.							
B3	Our supply chain information system permits collaborations to reduce operational details in the value chain.							
B4	Our information systems decrease the lead time in the value chain.							
B5	Our information system enables collaboration in the supply chain to reduce information irregularity in the value chain.							
B6	Our information system supports effective decision-making in the value chain.							
C	**Organisational Structure**							
C1	Our organisational structure empowers all stakeholders in supply chain decision-making processes.							
C2	Our organisational structure supports supply chain operational performance.							
C3	Our organisational structure supports collaborative upstream and downstream supply chain management.							

C4	Our organisation supports supplier base rationalisation in our value chain.							
C5	Our organisational structure supports excellent customer service to all stakeholders in the value chain.							
D	**Operational Performance**							
D1	Our supply chain focused on operational aspects rather than supply chain finance.							
D2	Our supply is agile to market changes to improve its products and services in the industry.							
D3	Our supply chain strategy supports operational performance in the mining industry.							
D4	Our supply chain can address bottlenecks in the industry to improve industry performance.							
D5	Our supply chain strategy can reduce operational intricacies in the supply chain to improve industry performance.							
E	**Supply Chain Finance Performance**							
E1	Our organisational employs a chain strategy to increase the industry operational and supply chain performance.							
E2	Our supply chain strategy has a significant role in rationalizing operational and financial activities.							
E3	Our supply chain strategy supports supply chain innovations and customization of products to improve the financial performance.							
E4	Our supply chain practices are flexible to support distributional channels in the industry to improve financial performance.							
E5	Our supply chain strategy has a positive effect the industry financial performance.							

E6	Our supply chain strategy has an impact on supply chain finance performance.							
F	**Supply Chain Strategy**							
F1	Our supply chain strategy in the mining industry benefits the stakeholder because it introduces new products and services in the value chain.							
F2	Our supply chain strategic decision is critical in developing new products for the mining industry.							
F3	Our supply chain strategy supports the mining industry supply chain network system.							
F4	Our supply chain strategy supports the procurement and execution of a suitable information system.							
F5	Our supply chain strategy offers high-quality products or services to all supply chain partners.							
F6	Our supply chain strategy supports internal and external communication among employees, suppliers, and customers.							
F7	Our strategic decisions determine the overall direction of collaboration in the supply chain.							
F8	Our collaboration strategy helps to use effective long-term material planning and implement low-cost production.							
F9	Our collaboration strategy enables sharing of the supply chain's future vision with supply chain partners							

Table 1: Conceptual Framework Construct Measurement

Construct	Interpretation	Measure	References
Supply Chain Network Design	The design and structure of the supply chain network to optimize operational performance in the supply chain	Optimization of the supply chain; real time decision making in the supply chain	Durmaz, & Bilgen, (2020); Golan, Jernegan, & Linkov, (2020). Joshi, (2022); Sherafati et al. (2020)
Information Systems	Use of block chains to measure and control supply chain processes; examine information asymmetry in the supply chain	Supply chain information capabilities, information process, information quality, systems quality, service quality, intention to use, system benefits and net benefits	Helo, & Shamsuzzoha, (2020); Liang, (2015); Sun, & Teng, (2017).
Supply Chain Strategy	Ability to develop supply chain strategy to respond to institutional pressure, manage supply chain network and operation	Measure coordination of supply chain processes; activities performed in upstream and downstream of the supply chain	Ivanov, D. (2010). Kotzab, Bäumler, & Gerken, (2023)

Organisation Structure	Understand the impact of organizational structure on the performance of the supply chain.	Collaboration, partnerships, performance metrics;	Perkmann, Salandra, Tartari, McKelvey, & Hughes, (2021); Cillo, Petruzzelli, Ardito, & Del Giudice, (2019); Tallon, Queiroz, Coltman, & Sharma, (2019).
Supply Chain Financial Performance	Understand the supply chain finance practices and performance across the supply chain. Social, economic, and environmental performance	Factoring, vendor management, Credit management, leasing, reverse factoring debt financing, financial ratios	Gelsomino, Mangiaracina, Perego, & Tumino, (2016); Xu, Chen, Jia, Brown, Gong, & Xu, (2018). Jia, Zhang, & Chen, (2020); Chakuu, Masi, & Godsell, (2019).
Operational Performance	Improvement of firm performance	Measure firm capabilities;	Rompho, (2018); Csiki, Demeter, & Losonci, (2023). Battesini, ten Caten, & de Jesus Pacheco, (2021).