The impact of engineering skills outsourcing on asset maintenance costs at South African coal mines

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Dedication

This work is lovingly dedicated to my wife, whose unwavering support and strength have been my foundation. To my three beautiful daughters, who inspire me every day with their curiosity, tenacity and infectious success energy. To my distant sons, your presence is felt across every mile. And to all those who persevere and make it against all odds, may this study stand as a testament to resilience, hope and the power of belief.

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To my spouse, I appreciate your friendship, mentorship and companionship.

I am especially thankful to my Supervisor for his patience, prompt feedback, understanding and availability for support.

Declaration

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Wits Business School, University of Witwatersrand. It has not been submitted before for any degree or examination in any other university. I further declare that I have obtained the necessary authorization and consent to carry out this research.

Signature

Date: November 2025

ABSTRACT

This research explored the impact of engineering skills outsourcing (ESO) on asset maintenance costs in South African coal mines. It analysed documentation from relevant coal mining organisations, selected mines or operations, including maintenance cost data and assessments of owner-maintained diesel mobile fleet equipment to understand the drivers of ESO, how it is implemented and how it affects skills development, equipment performance and asset maintenance cost control. The findings revealed a complex dynamic that, while ESO provides access to specialized expertise for improved turnaround times, it also introduces risks related to internal skills erosion and maintenance cost inefficiencies. Notably, frequent ESO engagements did not positively influence maintenance costs or equipment availability.

A key insight was the immediate operational benefit of equipment uptime achieved through access to external expertise, often without thorough maintenance cost implications consideration. Engineering skills outsourcing also enables access to OEM-level diagnostics and technical capabilities, it however inadvertently contributes to a decline in internal maintenance proficiency. Over time, the ESO reliance stagnates internal maintenance teams' development efforts (upskilling and exposure to modern diagnostic tools), creating a cycle of dependency.

The study also presents systemic challenges within local artisan training institutions, which are ill-equipped to keep pace with technological advancements in diesel mobile equipment maintenance and diagnostic demands. Outdated curricula, limited access to modern tools, and weak industry collaboration hinders development of adequately skilled engineering personnel. These gaps exacerbated the need for engineering skills outsourcing thus limits the mines' ability to manage maintenance costs proactively. The research concluded by recommending a hybrid approach, leveraging external expertise while embedding deliberate internal skills transfer and measurable maintenance cost control strategies.

Keywords: Engineering skills; Skills outsourcing; Asset maintenance costs; Maintenance cost control.

TABLE OF CONTENTS

LIST OF ACRONYMS AND DEFINITIONS

Acronyms

ADT	Articulated Dump Truck
ESO	Engineering Skills Outsourcing
KPI	Key Performance Indicator
MARC / MARA	Maintenance and Repair Agreement Contract / Maintenance and Repair Agreement
MQA	Mining Qualifications Authority
OEM	Original Equipment Manufacturer
R&M	Repair and Maintenance
TCO	Total Cost of Ownership
TMM	Trackless Mobile Machinery

Definitions

Agent to OEM	Referring to an enterprise or supplier that has acquired the authorization to act on behalf of the OEM.
Availability	Equipment Availability is a measure of the time that a machine is available to work in relation to Working Time.
Breakdown Order	A purchase order issued for an emergency breakdown, defined as a break in the continuous flow of production that if external assistance is not sourced immediately or on short notice, will cause production losses or a high risk for health, safety or environmental incidents. The purchase order is authorized by senior management only and it does not follow normal procurement/buying procedures. The initial purchase order is issued at a value of R1 and updated retrospectively with actual cost.
Engineering Availability	Equipment availability less operator induced downtime resulting from actions (or the lack thereof) that cannot be controlled by Engineering Maintenance Team. Typical examples include accident damage, machine abuse, machine running out of fuel, tyre damage, and machine bogged down etc.

Non-MARC	Equipment that does not form part of the equipment serviced and maintained by the Original Equipment Manufacturer or their agent under a MARC or MARA.
Original Equipment Manufacturer	Refers to the company that originally manufactured products or major components of products that are sold to customers as new
Physical Availability	Physical Availability is defined as Equipment Availability less all sources of downtime and is most often defined and used by mine production departments.
Purchase Order	Is a commercial legal binding document indicating types, quantities and agreed prices of goods and/or services to be delivered
Working Time	Working Time is the period when the process or equipment was scheduled and capable of working without impact from external issues, i.e. the equipment is only influenced by site controllable issues.

1. CHAPTER ONE – INTRODUCTION

1.1. STATEMENT OF PURPOSE

This research study sought to explore the impact of outsourcing of engineering skills on asset maintenance costs in South African Coal mines. The outcomes of the study are intended to assist coal mines' operators with an informed basis for outsourcing engineering skills to contribute to optimised asset life cycle cost performance. Ultimately, this research contributes to an improved understanding of engineering skills outsourcing as a strategic lever for managing asset maintenance costs in South African coal mines.

1.2. BACKGROUND OF THE STUDY

Outsourcing is defined as a process of using an external organisation to execute or perform services that would have been otherwise performed by company's own employees (Chen et al., 2025). Outsourcing is intended to help with cost reduction (Konina, 2025), assisting businesses to focus on core activities (Shekhar, 2025), transferring of operational risk (Messabi et al., 2020), streamlining operational efficiencies and to assist organisations to access expertise that is lacking in-house (Charles & Ochieng, 2023). In contrast to the outsourcing theory, the results of outsourcing are mixed with few mining organisations declaring outsourcing an outright success (Biswas et al., 2024). Khumalo (2006) reported that mine managers reported that outsourcing initiatives succeeded 25% of the time, supporting an estimate that 70% of outsourcing activities fail (Khumalo, 2006).

While outsourcing maintenance functions has been widely adopted as a strategy to improve flexibility (Falah et al., 2025) and operational efficiency (Hwang, 2024), evidence from certain cases suggests that it does not always yield the anticipated benefits (Shekhar, 2025). In some instances, outsourcing has led to increased maintenance costs or operational inefficiencies (Zaharudin et al., 2024), highlighting the importance of context-specific evaluation in outsourcing decisions.

The mining industry is known to be profitable but highly dependent on two factors it cannot control, namely, changes in currency (Lushibashi & Mweshi, 2023) and global commodity prices (Abaidoo & Agyapong, 2021). The South African mining industry appreciates favourable commodity prices (MCSA, 2023). When commodity prices are unfavourable and margins erode (Lèbre et al., 2021) and miners respond accordingly by reviewing their value chains to 'cut' or optimize costs (Lin & Lan, 2025). One of the first steps in the cost optimisation process is to review the use of contractors or service providers to determine whether the outsourced services can be performed in-house (Rupprecht, 2015). This highlights that, although outsourcing promises value all round, it is continuously suspected that it is ineffective. Generally, outsourcing intends to enhance cost performance (Mutongerwa et al., 2024) but it is largely about the mine's access to expertise/skills and to address internal capacity/facilities challenges particularly in asset management (Summers & Visser, 2021).

In January 2023, Engineering News (2023) placed engineering skills shortage as the 8th risk for South African mining industry (Farmer, 2023). The article, which was written by Jacques Farmer, MD of PRISMA and Roland Innes, Group CEO of Dyna Training, was referring to specifically engineers, artisans and technicians who are key to asset management / maintenance. A month later after the Engineering News article, McKinsey and Company (2023) alluded to the fact that the global mining industry is feeling the squeeze of mining talent due to evolving work that includes mine workers' interests in other professions, automation and changes in life priorities (Abenov, et al., 2023). Over and above these challenges, the unintended consequence of outsourcing is the transfer (Namadi, 2023) of traditionally core competencies to external organisations (Grusenmeyer, 2022). As a result, dependency has been created for specific skills on maintenance (Maphanga et al., 2025) that, to an extent, miners do not have control of cost trajectory of rendering the services by those organisations (Qwathekana & Masilela, 2023).

1.3. PROBLEM STATEMENT

The South African coal mining industry is a cornerstone of the country's energy production and economic stability (Nel et al., 2022). However, the sector continues to face persistent challenges related to the maintenance and reliability of mining equipment (ExxaroResourcesLimited, 2024), which directly affect productivity and cost performance (ThungelaResourcesLimited, 2024). These challenges are primarily driven by a shortage of appropriately skilled maintenance personnel (Akinshipe et al., 2022) which hampers effective execution of optimal maintenance strategies (Mokoena et al., 2025). In response to skills shortages and cost performance pressures, coal miners have increasingly adopted outsourcing strategies, particularly in maintenance functions (Akinradewo et al., 2022).

Although outsourcing offers potential benefits such as access to specialized expertise (Charles & Ochieng, 2023) and improved equipment performance (Mahowa et al., 2025), its implications on asset maintenance costs and internal skills development remain insufficiently explored. Concerns have been raised about the potential erosion of in-house technical knowledge if outsourcing is not strategically managed (Bristol-Alagbariya et al., 2024). Conversely, effective outsourcing practices may enhance internal employee capabilities (Yusoff et al., 2024) and contribute positively to equipment performance if effectively implemented (Mutongerwa et al., 2024).

Despite the widespread adoption of outsourcing in the coal mining sector, there is limited empirical research examining the extent of engineering skills outsourcing in South African coal mines, its direct and indirect impact on maintenance costs and influence on internal employees' skills development.

This study sought to address this gap by exploring how outsourcing engineering skills impact asset maintenance costs and the broader asset performance in South African coal mines.

1.4. RESEARCH OBJECTIVES

In alignment with the research problem outlined in the preceding section, this study set out to achieve the following research objectives:

1.4.1. To explore the main factors driving the outsourcing of engineering skills in South African coal mines.

1.4.2. To assess how engineering skills outsourcing is applied in the coal mining sector.

1.4.3. To determine the effects of outsourcing on maintenance costs and broader asset performance.

1.5. RESEARCH QUESTIONS

Building on the research problem and research objectives outlined earlier, this study sought to address the following corresponding research questions:

1.5.1. What are the key drivers behind the decision to outsource engineering skills in the South African coal mines?

1.5.2. How is engineering skills outsourcing implemented in the South African coal mining industry?

1.5.3. What is the impact of engineering skills outsourcing on asset availability, maintenance costs, and internal employee skills development in South African coal mines?

1.6. RATIONALE OF THE STUDY

Maintenance costs in a mining operation typically accounts for 40-60% of total operational expenditure (Dayo-Olupona et al., 2023). Effective control of maintenance costs is thus essential for sustainable profitability (Mahowa et al., 2025). Therefore, understanding the implications of engineering skills outsourcing on asset availability, maintenance costs, and internal maintenance teams' skills development is hence necessitated. If coal mining companies can gain better insights into how external skills or expertise reliance affects the above, they may be better positioned to explore effective strategies that can balance cost with asset reliability with sustainable internal maintenance skills.

This study aims to highlight the relationship between outsourcing engineering maintenance skills and an upward trajectory of maintenance costs. It also seeks to identify key factors contributing to this trend and explore opportunities to redress, arrest, or reverse it through more strategic outsourcing practices and internal capacity building.

1.7. DELIMITATIONS OF THE STUDY

This study was limited in scope to ensure focused and manageable research outcomes. The investigation was confined to coal mining operations within South Africa and specifically examined the outsourcing of engineering maintenance skills. It did not extend to other mining sectors (e.g., gold, platinum, etc.) or other forms of outsourcing beyond engineering-related maintenance functions. The study also excluded broader operational outsourcing practices and did not assess the impact of outsourcing on non-engineering departments. The study was furthermore confined as follows:

1.8. ASSUMPTIONS

The study was based on several foundational assumptions that guided the research design, data collection and interpretation of findings. These assumptions were necessary to ensure the feasibility and relevance of the study within the defined scope. The key assumptions were as follows:

- Secondary data will be credible and verifiable: The study relied on published reports, industry data, and available relevant academic literature. It is assumed that these sources have undergone appropriate validation and peer review processes, ensuring their reliability for research purposes.
- Relevant secondary data from the past three (3) years was available and sufficient: To maintain relevance and reflect current industry practices, the study assumes that recent data (within a three-year window) is accessible and adequate to support analysis of outsourcing trends and maintenance cost impacts.
- The outsourcing of engineering maintenance skills was a measurable and distinguishable practice within coal mining operations: For the study to assess the impact of outsourcing, it

was assumed that such practices are documented, traceable, and can be differentiated accordingly.

- Maintenance cost increases could be reasonably linked to outsourcing practices: The study assumed that there was a causal or correlational relationship between outsourcing decisions and changes in maintenance costs, which can be identified through secondary data analysis.

2. CHAPTER TWO – LITERATURE REVIEW

2.1. INTRODUCTION

There are currently about 108 active coal mines in South Africa including junior miners (Carmen, 2024). The coal industry has not been spared in the outsourcing strategic wave (Biswas et al., 2024) particularly engineering maintenance (Mahowa et al., 2025). Outsourcing of maintenance activities are partly to benefit from the economies of scale of similar mines with similar equipment by creating an external place of focused maintenance excellence, to benefit the local industry which unintentionally included transfer (Mokoena et al., 2025) of personnel and skills to these specialists with applicable core competencies.

Outsourcing was formerly adopted as a business strategic choice in the late 80's (Mutongerwa et al., 2024) since it was introduced as an alternative business strategy to improve business performance and compete effectively (Usifoh, 2024). Managers and leaders must focus on doing what they can do best and subcontract the rest or areas in which a company has no special ability (Pandey, 2021). However, this is a limited approach to harness the vast benefits outsourcing opportunities provide, including reduction of operating costs and improving organisational focus (Schmitz, 2021) and outsourcing drivers are more strategic and tactical (Yusoff et al., 2024). Complete outsourcing a service is prevalent but partial outsourcing has been a workable option as well to augment or supplement internal resources (Garg et al., 2024).

This research will focus on partial maintenance outsourcing or supplementing of resources on owner-maintained equipment. Engineering maintenance on owner-maintained equipment is attended to by mine employees with large or component repairs largely conducted by external organisations.

2.2. ENGINEERING SKILLS OUTSOURCING LITERATURE

2.2.1. Key Engineering Skills outsourcing drivers

a) Staffing Constraints

Staffing constraints in mining maintenance departments often arise from a shortage of skilled technicians/artisans (Farmer, 2023), high turnover rates or limitations in budget allocations for permanent employees (Akinshipe et al., 2022). These constraints can severely impact a maintenance department's ability to execute even routine maintenance tasks efficiently (Wang et al., 2023). When internal teams lack the capacity or expertise to manage the full scope of maintenance activities, especially across new and aging equipment fleet (Mokoena et al., 2025), the dependability on the maintenance teams to deliver on their duty is often compromised (Rizvi et al., 2025). As a result, outsourcing becomes a practical solution to fill immediate gaps, ensuring that essential maintenance work continues without disruption (Alawadi et al., 2023).

For a maintenance department, breakdowns or emergency repairs present a challenge under staffing constraints (Javadnejad et al., 2022). Batyrbek and Kabikenov reports that, studies rarely consider the impact of urgent repairs when staffing a maintenance team, let alone organisations (Batyrbek & Kabikenov, 2025). When breakdowns occur, the urgency to restore operations to normality or productivity leaves little room for internal teams to respond adequately if they are understaffed or lack required skills (Allais, 2022). Outsourcing to external service providers with the necessary technical expertise and rapid response capabilities (Alawadi et al., 2023) becomes not just a preference but a necessity (Grusenmeyer, 2022). These providers often have access to broader resources, diagnostic tools, and experience across various equipment types, enabling faster turnaround times and minimizing costly production and safety downtime (Nygren, 2025).

Planned maintenance, which requires strategic planning and scheduling, detailed inspections, and preventive interventions, also suffers under staffing limitations (Javadnejad et al., 2022). Without sufficient personnel to plan and execute these activities, mining operations risk falling behind on maintenance (Messabi et al., 2020), leading to poor equipment condition monitoring, increased wear, safety risks (Commine, 2023), and unplanned outages (Dashtaki et al., 2025). Outsourcing allows mining organisations to maintain compliance with required maintenance performance standards and maintain asset life, while also offering opportunities for knowledge transfer (Lahiri et al., 2022). An unbalanced reliance on external support without efforts to build internal capacity causes organizations to face continuous dependency and erosion of in-house technical competencies (Edvardsson & Durst, 2019).

b) Misaligned maintenance strategies

The effectiveness of a mining operation's maintenance strategy directly influences its ability to manage equipment reliability, cost and availability (Javadnejad et al., 2022). When strategies are underdeveloped, misaligned with operational realities, or misaligned allocated resources, internal teams often struggle to execute maintenance activities effectively (Mahowa et al., 2025). For example, a reactive strategy that prioritizes emergency repairs over preventive care can overwhelm limited internal resources, leading to frequent breakdowns and unplanned downtime (Taimun et al., 2025). Outsourcing then becomes a necessary response to restore functionality quickly to maintain production targets (Alawadi et al., 2023).

Misunderstood or overly complex maintenance strategies can also create confusion and inefficiencies within internal maintenance teams (Mokoena et al., 2025). If artisans and planners are unclear about priorities, schedules or procedures, routine and planned maintenance may be delayed or poorly executed (Dashtaki et al., 2025). This not only increases the risk of equipment failure but also erodes confidence in the internal team's ability to manage assets (Wang et al., 2023). External service providers, with specialized systems and clearer execution models, are often brought in to repair equipment to expected standards and safety requirements (Mahowa et al., 2025).

Furthermore, when maintenance strategies lack integration with broader business goals or fail to evolve with changing equipment profiles (Rosita & Rada, 2021), internal teams find themselves ill-equipped to meet maintenance expectations (Edvardsson & Durst, 2019). For instance, adopting a condition-based or predictive maintenance approach without the necessary tools, training, or infrastructure can leave maintenance teams unable to deliver required results (Jane, 2025). Outsourcing then becomes a dictated fallback not just for execution, but for accessing advanced diagnostics, analytics and specialized expertise (Grusenmeyer, 2022).

c) Technical skills shortage

A shortage of appropriate technical skills within mining maintenance teams poses a significant operational risk (Opperman, 2023) in environments where equipment reliability is critical to production (Mahowa et al., 2025). This narrative is disputed by the South African Artisan Movement that argue that qualified artisans cannot find work (MzabalazoServicesAdvisory, 2022). An artisan skill is honed through exposure, experience, guidance and mentorship (Akinshipe et al., 2022) and therefore the skills gap remain as the 'newbies' often find a mentorship or guidance vacuum due to natural attrition or migration of engineering skills (Akinradewo et al., 2022).

Nevertheless, when internal staff are poorly trained or lack exposure to modern maintenance practices (Mokoena et al., 2025), routine tasks such as inspections, lubrication, and adjustments are inconsistently performed or entirely overlooked (Taimun et al., 2025). This not only accelerates equipment wear but also increases the likelihood of failures (Rosita & Rada, 2021). As a result, maintenance outsourcing becomes a necessary intervention to ensure that maintenance is carried out to prevent unplanned or minimize downtime (Allais, 2022).

Urgent or breakdown repairs demand swift, skilled responses (Farmer, 2023) which is challenging for understaffed or undertrained maintenance teams to deliver (Batyrbek & Kabikenov, 2025). When breakdowns occur, especially on key production or safety-critical equipment, the lack of internal expertise can delay timely recovery (Jane, 2025). External service providers, often equipped with specialized knowledge and tools (Edvardsson & Durst, 2019), are then called in to restore operations quickly (Grusenmeyer, 2022). This reliance becomes more pronounced when internal teams lack familiarity with newer technologies or complex systems introduced into the mine, making outsourcing the only viable option to maintain operational continuity (Maphanga et al., 2025).

Planned maintenance, which requires strategic foresight, technical planning and execution discipline (Mokoena et al., 2025), is also compromised by internal skill gaps (Allais, 2022). As mining operations adopt more advanced equipment and digital monitoring systems, the technical demands on maintenance personnel change and at most, increase (Rizvi et al., 2025). Without ongoing training and development, internal teams are unable to interpret diagnostic data, perform predictive interventions (Taimun et al., 2025), or manage condition-based maintenance schedules (Rosita & Rada, 2021). Outsourcing to vendors with the required expertise ensures that planned maintenance is executed effectively (Alawadi et al., 2023), but it also highlights the growing disconnect between internal capabilities and skills required to match technological advancement (Kamps et al., 2024).

The challenge is further compounded when skilled employees leave the mine to join suppliers or contractors who offer better pay and career growth opportunities (Allais, 2022). This talent migration not only drains internal capacity but also strengthens the outsourcing ecosystem, as former employees now serve the mine from the outside (Edvardsson & Durst, 2019). Therefore, while outsourcing can provide short-term relief, it risks creating long-term dependency and eroding institutional knowledge (Grusenmeyer, 2022). Mining companies must thus invest in technical training, retention strategies, and succession planning to rebuild internal strength to reduce the strategic vulnerability that comes with outsourcing (Maphanga et al., 2025).

2.2.2. Implementation of Engineering Skills Outsourcing

a) Strategic Engineering Outsourcing

Industrial organisations have increasingly adopted strategic maintenance outsourcing as a deliberate, long-term approach to managing maintenance functions (Maphanga et al., 2025). This form of outsourcing is often planned and aligned with broader operational goals, such as cost optimization, access to specialized expertise, and improved asset reliability (Mahowa et al., 2025). By partnering with external providers through formal contracts and service-level agreements, mines can ensure consistent delivery of routine and planned maintenance activities (Yang & Dong, 2024) while focusing internal resources on core business functions (Zaharudin et al., 2024).

Strategic outsourcing is often driven by the recognition that certain engineering capabilities, such as advanced diagnostics, condition monitoring, or OEM-specific maintenance, are better handled by specialists (Taimun et al., 2025). These partnerships allow mining companies to leverage cutting-edge technologies and best practices without the burden of developing those capabilities in-house (Alawadi et al., 2023). Strategic outsourcing can support long-term learning through structured knowledge transfer (Messabi et al., 2020), provided the relationship is well-managed and includes provisions for internal staff development (Driouich et al., 2024). Strategic outsourcing does require careful planning, clear governance, and ongoing performance monitoring (Driouich et al., 2024) to avoid dependency (Messabi et al., 2020).

b) Reactive or Incidental Outsourcing

In contrast, reactive or incidental outsourcing occurs when mining companies engage external engineering support in response to immediate operational pressures, typically equipment breakdowns, skill shortages, or unexpected maintenance demands (Zhou et al., 2024). This form of outsourcing is unplanned and often driven by urgency, leaving little time for vetting providers or negotiating favourable terms (Driouich et al., 2024). While it can restore operations quickly, it may come at a higher cost and with less control over quality and consistency (Maphanga et al., 2025).

Reactive outsourcing for maintenance is common in organisation where internal maintenance teams are overstretched or lack the technical depth to handle complex repairs (Rosita & Rada, 2021). When critical equipment fails and internal staff cannot respond effectively (Batyrbek & Kabikenov, 2025), external specialists are brought in to resolve the issue (Zhou et al., 2024). This can be particularly frequent in operations that have not invested adequately in training or succession planning, or where high staff turnover has eroded internal expertise (Grusenmeyer, 2022).

Although incidental outsourcing can be a lifeline during emergencies (Mutongerwa et al., 2024), it often signals deeper systemic issues, such as poor maintenance planning, inadequate skills development, or misaligned strategy (Summers & Visser, 2021). Over time, frequent reliance on reactive outsourcing can undermine internal team morale (Edvardsson & Durst, 2019), increase operational risk, and inflate maintenance costs (Messabi et al., 2020). To mitigate this, mining companies must balance short-term outsourcing needs with long-term investments in internal capability and strategic planning (Driouich et al., 2024).

2.2.3. Outsourcing impact on own maintenance employees' skills

a) Dependency on external expertise

As noted earlier, one of the unintended consequences of engineering skills outsourcing is the gradual development of dependency among internal maintenance personnel (Edvardsson & Durst, 2019). Over time, employees begin to defer even solvable issues to external contractors, especially when those contractors are perceived as more skilled or better equipped (Lahiri et al., 2022). This behaviour erodes internal initiative and problem-solving confidence, as employees become accustomed to waiting for outsourced personnel to arrive (Kamps et al., 2024), even for tasks they previously handled independently (Bristol-Alagbariya et al., 2024).

This dependency is often reinforced by management practices that prioritize quick fixes over internal capability development (Maphanga et al., 2025). When external teams consistently resolve breakdowns faster or more efficiently (Alawadi et al., 2023), internal teams are sidelined or undervalued. The result is a passive maintenance culture where internal teams lose their technical edge and become increasingly reliant on outsourced support, weakening the mine's long-term resilience and self-sufficiency (Khan et al., 2024).

b) Erosion of Internal Skills and Morale

Outsourcing can also mask underlying skills gaps within the internal workforce, especially when machines continue to operate and production targets are met (Abenov et al., 2023). Management may overlook the need for training and development, assuming that outsourced support is sufficient to maintain performance (Lahiri et al., 2022). This lack of investment in internal skills improvement leads to stagnation, where employees are not exposed to new technologies, diagnostic tools, or advanced maintenance techniques (Edvardsson & Durst, 2019).

The introduction of new equipment or digital systems further widens the gap, as own employees are often left behind without proper upskilling (Alerasoul et al., 2022). Meanwhile, skilled employees may leave for suppliers or contractors who offer better remuneration and more technical growth opportunities (Biswas et al., 2024), deepening the internal capability deficit (Maphanga et al., 2025). For those who remain, morale suffers, they feel undervalued, underutilized, and disconnected from the evolving technical landscape (Edvardsson & Durst, 2019). Without a clear path for development, internal teams risk becoming obsolete (Kamps et al., 2024), and the mine becomes increasingly dependent on external engineering support (Zhou et al., 2024).

2.2.4. Engineering skills outsourcing impact on maintenance cost

a) Loss of cost control in outsourced maintenance

Maintenance cost ratio to operational costs varies among scholars but range between 40-60% of operations costs (Dayo-Olupona et al., 2023), which is a significant operational cost contribution that should attract adequate focus (Anh et al., 2025). When engineering skills are outsourced without robust oversight, it is reported that mining companies often face a loss of control over maintenance costs (Wang et al., 2023). In instances where service providers operate on different cost structures, and without clear performance metrics or cost benchmarks, maintenance cost can escalate quickly (Zaharudin et al., 2024). This is especially true in emergency or breakdown repair scenarios (Yusoff et al., 2024), where the urgency drives up safety concerns and quick return to production but disregards incidental costs (Nygren, 2025). Over time, these unplanned expenditures accumulate, inflating the total cost of ownership for assets (Dashtaki et al., 2025).

If outsourcing contracts are not well-defined or monitored, service providers may over-service equipment, recommend unnecessary replacements, or fail to optimize maintenance schedules (Driouich et al., 2024), resultantly, routine and planned maintenance activities are affected (Mokoena et al., 2025). Internal teams, lacking the technical authority or visibility to challenge these decisions, may inadvertently and even unknowingly approve costly interventions (Lahiri et al., 2022). This weak governance environment makes it difficult for mines to track, forecast, and manage maintenance budgets effectively (Grela & Hofman, 2021), leading to maintenance cost inefficiencies (Maphanga et al., 2025).

b) Reduced predictability of maintenance expenditure

Outsourcing can also undermine the predictability of maintenance costs, particularly when mines rely heavily on reactive or incidental outsourcing (Namadi, 2023). Without a stable internal workforce or a structured outsourcing strategy, maintenance becomes a variable cost, fluctuating based on breakdown frequency, contractor availability, and market rates (Rosita & Rada, 2021). This unpredictability complicates budgeting and long-term financial planning, making it harder for mines to allocate resources efficiently across the operation (Grela & Hofman, 2021).

The introduction of new technologies further compounds this issue specifically if internal staff are not trained to maintain advanced systems/equipment, external specialists must be brought in at premium rates (Kamps et al., 2024). These interventions are difficult to forecast and may not be covered under existing contracts, resulting in unexpected spikes in expenditure (Zaharudin et al., 2024). Over time, this lack of cost predictability can erode profitability and strain capital planning (Maphanga et al., 2025), especially in mines operating under tight margins or volatile commodity prices (Abaidoo & Agyapong, 2021).

2.3. ANALYTICAL FRAMEWORK

2.3.1. Theoretical Framework

a) Organisational Learning Theory

Organizational Learning Theory (OLT) provided a valuable lens through which the strategic outsourcing of engineering skills in asset-intensive industries such as coal mining, was explored. OLT was developed primarily by Chris Argyris and Donald Schön in the 1970s (Schönherr et al., 2023) and it emphasizes how organizations adapt, evolve, and improve by acquiring, interpreting, and retaining knowledge over time (Hamitouche et al., 2025). It distinguishes between single-loop learning (adjusting without changing underlying assumptions) and double-loop learning (re-evaluating and transforming core beliefs and strategies) (Mukibi, 2021).

The theory asserts that learning occurs at both individual and collective levels (Akwaowo & Kalio, 2021) and that organizations improve performance by acquiring, sharing, and implementing the knowledge (Dhir & Dhir, 2025). Organizations that embrace learning are typically marked by a shared vision, collaborative learning practices, and systems thinking (Pedraja-Rejas et al., 2025), all of which enable them to respond more effectively to change (Bhasin, 2024).

Despite the theory's valuable contributions, Organizational Learning Theory is not without limitations. One notable critique is its idealistic assumption that all members of an organization are equally willing and capable of engaging in collective learning (Akwaowo & Kalio, 2021). In practice, factors such as organizational politics, power imbalances, and resistance to change can significantly hinder learning processes and knowledge sharing (Mortensen et al., 2021). Another challenge lies in the measurement of organizational learning (Migdadi, 2021). Unlike individual learning, which can be observed through tangible changes in behaviour or skill, organizational learning is inherently more abstract and systemic (Farzaneh et al., 2021). This complexity makes it difficult to assess and quantify learning outcomes at the organizational level (Ferreira et al., 2020), posing challenges for empirical validation and practical application.

In this study, Organizational Learning Theory (OLT) is used to explore how coal mining companies can strategically outsource engineering expertise to not only reduce operational costs but also foster internal growth through knowledge transfer and collaborative learning. This theoretical framework helped to assess the impact of engineering skills outsourcing on asset maintenance costs and long-term organizational performance, emphasizing the potential for improved outsourcing partnerships to contribute to internal capability development.

OLT also provided a framework for evaluating the risks associated with outsourcing, particularly the potential loss of critical in-house technical knowledge (Edvardsson & Durst, 2019). The study considered whether outsourcing hinders or supports the development of internal engineering competencies by examining how such practices affect opportunities for staff to gain hands-on experience and grow professionally. Managing outsourcing relationships effectively is highlighted as essential to ensuring continuous learning and safeguarding internal expertise (Sakib et al., 2023).

Given the skills degeneration concern than often gives rise to supplementary outsourcing, a misapplication or absence of an appropriate learning and development theory (Sharma, 2023) can cause internal skills depletion (Pandey, 2021) thus reinforcing reliance on external support (Charles & Ochieng, 2023). Insufficient planning, continuous and post assessment of an outsourcing activity (Uygun et al., 2022) could impact an organisation's full control and dictation of associated costs and learning (Grela & Hofman, 2021). Also, the lack of a company's clear and understanding and definition of competencies (Juneja, 2025) with appropriate outsourcing models (Charles & Ochieng, 2023) could result in missed opportunities to extract full benefits of engineering maintenance outsourcing leading to incidental outsourcing (Namadi, 2023).

Furthermore, the implementation of organizational learning principles can be challenging (Alerasoul et al., 2022). It requires not just the acquisition of new knowledge (Uddin et al., 2025), but also changes in organizational culture (Shin & Strausz, 2024), structure, and processes, which can be resource-intensive and difficult to achieve (Akwaowo & Kalio, 2021).

2.4. CONCLUSION

Effective outsourcing involves organisational intimate knowledge of core competencies (Shin & Strausz, 2024). In addition, for deliberate and intended outcomes, the business must select the correct outsourcing models (Alawadi et al., 2023) and review its consequences from operational systems impact point of view (Benedettini, 2024).

Incidental outsourcing may result in unintended consequences including loss of internal skills (Chen et al., 2025) and attraction of uncontrollable operational costs, specifically maintenance costs (Edvardsson & Durst, 2019). Coal mining organisations rarely report on success or failure of outsourcing hence there is little to no studies or research on the effectiveness or impact of outsourcing on maintenance costs.

3. CHAPTER THREE – RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter outlines the research methodology employed to explore the impact of engineering skills outsourcing on asset maintenance costs in South African coal mines. It further articulates the exploratory and interpretive analytical approach, the rationale for the chosen research methodology, the justification for selecting the target population and sample, the methods and tools used for data collection and analysis as well as the quality assurance measures implemented to ensure validity of research.

3.2 RESEARCH APPROACH

Given the exploratory nature of the study and the need to understand contextual and strategic dimensions of engineering skills outsourcing practices, a qualitative research approach was deemed most appropriate (Denny & Weckesser, 2022). This approach allowed for examination of patterns and relationships that are not readily quantifiable (Fischer & Guzel, 2022) but important to understanding the complexities of engineering skills outsourcing in the coal mining sector (Lochmiller, 2021). This method further enabled the study to gather appropriate descriptive data from both secondary sources (e.g. websites, financial statements, etc.) and internal sample organisational skills and cost records and reports (Megheirkouni & Moir, 2023). The qualitative method was suitable for examining the relationships between outsourcing practices, maintenance costs and engineering skills development elements (Yadav, 2022).

To achieve the research objectives, the study adopted document analysis (Ahmad & Wilkins, 2024). Document analysis involves the systematic review and interpretation of existing records, reports, policy and procedural documents, websites, financial statements, maintenance logs, outsourcing contracts and available industry publications (Drisko, 2024). This method helped to explore historical and sample organizational data to obtain insights into the extent of engineering skills outsourcing and associated cost and equipment performance outcomes (Lim, 2024).

3.3 RESEARCH DESIGN

The research was exploratory and interpretive (McCarron et al., 2024) in nature and aimed at uncovering patterns and insights from existing documentation on outsourcing of engineering skills. An exploratory and interpretive analysis (Pasupuleti et al., 2024) aims to uncover underlying patterns, meanings, and relationships within qualitative data, especially in contexts where little prior research exists (McCombes & Bhandari, 2023). To facilitate this, the study employed document analysis (Jotform, 2024) as the primary method of data collection which involved the systematic review and interpretation of relevant documents such as equipment maintenance performance reports and engineering skills outsourcing historical costs. These methods provided insights into both the rationale and consequences of outsourcing engineering skills, in line with the following principles:

- Contextual factors: Understanding engineering skills outsourcing within the context of South African coal mines.
- Recurring patterns: Identifying recurring themes and patterns related engineering skills outsourcing impact.
- Conceptual understanding: Interpreting textual and perspective-based data to generate informed insights and actionable recommendations.

3.4 DATA COLLECTION METHODS

To ensure a comprehensive understanding of the impact of engineering skills outsourcing on asset maintenance costs in South African coal mines, the study employed a qualitative research approach (Lim, 2024), primarily utilizing secondary data sources (Jotform, 2024).

3.4.1 Secondary Data Collection

The study relied on existing data from credible and verifiable sources, including:

- South African coal miners' annual reports and sustainability disclosures - Available or published performance (annual) reports.
- Coal mining companies' websites.
- Mining and engineering subject matter experts' websites and reports.

- Academic journals and conference papers relevant to engineering skills outsourcing and engineering maintenance.

3.4.2 Sample Organisation Data

In addition to publicly available secondary sources, a significant portion of the data used in this study was obtained from a sample coal mining organisation, with three large mines that employs at least 1,500 personnel at each mine. Access to internal records was granted by management, allowing to review detailed information including:

- Historical documents and records were collected from the sample company's three coal mines, as follows: Maintenance Policies and Strategies: To understand formal guidelines on when and how outsourcing is permitted or preferred and identify clauses on OEM involvement, internal capability assessments, and deviation protocols.
- Service Level Agreements (SLAs) and Contracts: To examine the scope, cost structures, and performance expectations of outsourced services as well as identification how costs are managed and monitored at these mines.
- Maintenance Cost/performance Reports: To track trends in maintenance expenditure over time, possibly before and after outsourcing decisions.
- Training and Skills Development Records: To assess the level of internal skills development and identify gaps that may lead to outsourcing, review skills matrices, training completion reports, and upskilling initiatives.
- Audit Reports and Performance Reviews - To identify any flagged issues related to engineering skills outsourcing.
- Meeting Minutes (e.g., Maintenance Planning Meetings) - To capture informal discussions and decisions around outsourcing due to backlogs or resource shortages.

This privileged access provided deeper insights into the practical implementation and financial implications of engineering skills outsourcing, thereby enriching the study's findings and contextual relevance.

3.4.3 Data Selection

To maintain relevance, the study applied the following criteria when selecting secondary data:

- Only data published and cost incurred (at sample organisation) within the last three years was considered.
- Sources were selected based on their reliability, such as peer-reviewed journals, official company documents directly from their websites, and reputable industry publications.
- Data had to directly relate to engineering skills outsourcing, maintenance costs, asset performance, or engineering skills development in the South African coal mining sector or at the sample coal mining organisation.

3.5 POPULATION AND SAMPLE

3.5.1 Population

The study covered coal mining industry outsourcing of engineering skills / services. Typical/required unpublished data was collected from three large mines near eMalahleni owned and operated by a large global resources company, with permission. The maintenance scope is wide thus the study focused on owner-maintained earth moving equipment maintenance activities where outsourcing or use of external resources is done to augment site maintenance teams. The analysis excluded mobile equipment where maintenance contracts of longer than 5 years are effective except for cost or maintenance performance comparison purposes.

3.5.2 Sample and sampling method

Outsourced maintenance skills and associated costs data shall not be older than 3 years. Non-probability sampling method specifically the combination of purposive and convenience method (Webster, 2024) was employed as the type of this research is non-random (Tariq, 2025) and that the knowledge on the research subject lies with specific departments coupled with the convenience of access to data points with finite number of maintenance related practitioners (Braun & Clarke, 2024).

3.6 RESEARCH INSTRUMENT

The research utilised existing data from secondary data sources (Ahmad & Wilkins, 2024), both published and unpublished to report on the extent of outsourcing of maintenance work or skills and its contribution on maintenance costs. The source of data included South African coal mining companies' financial statements, industry specific reports, history of maintenance costs (internal), skills training reports, journals, etc. Another source of data was the maintenance history and associated costs sourced from the sample mines and could been unreliable as it is not vetted (Jotform, 2024) however over three years of data did provide representative trends (Cleave et al., 2025).

3.7 DATA ANALYSIS STRATEGY

It was assumed that maintenance history information will clearly indicate the skill(s) used in executing maintenance and that associated costs can at least be separated by parts and labour where the ratio of labour cost to parts cost can be recorded. The data collected for this study was analysed using thematic analysis, a qualitative method that enables the identification, organization, and interpretation of patterns within the data (Lochmiller, 2021). This approach is well-suited to exploring the complex and context-specific nature of engineering skills outsourcing in the coal mining sector (Pasupuleti et al., 2024).

Through a systematic process of coding and theme development, the analysis uncovered recurring ideas, perceptions, and experiences related to outsourcing practices and their impact on asset maintenance costs (Cernasev & Axon, 2023). Thematic analysis allowed for a rich, detailed understanding of the underlying drivers, challenges, and implications of outsourcing, as expressed through documentary evidence (Coker, 2022). The content of the data was coded accordingly for categorisation of textual information (Ahmad & Wilkins, 2024).

3.8 LIMITATION

It was envisaged that the following limitations could affect research findings' generalizability (Braun & Clarke, 2024). Firstly, maintenance cost structure will be limited to the sample mines however the amount of data was relatively large and allayed this concern. Secondly, the documentation described specific company's preferences of managing engineering skills outsourcing, the engagement process as well as issues that compel them to outsource.

3.9 QUALITY ASSURANCE

3.9.1 Transferability

To support transferability, Lim (2024) recommends including detailed, context-rich descriptions of the research setting, data sources and procedures (Lim, 2024). This depth of information enables others to assess whether the findings can be meaningfully applied to similar environments (Denny & Weckesser, 2022). The findings of this study hold potential applicability across other mining contexts, particularly those that share similar operational structures.

Providing rich and contextualized description of participating operations, the report enables readers to assess the degree to which the insights resonate (Fischer & Guzel, 2022) with their own settings thus allowing those familiar with coal mining operations to draw naturalistic generalizations (Drisko, 2024). Participating mines' data is presented with careful attention to nuanced interpretation, allowing for a layered interpretation that reflects both the explicit and implicit dimensions of the reviewed information (Ahmad & Wilkins, 2024). The interpretations are grounded in the data and informed by prolonged interrogation (Yadav, 2022) and iterative analysis to enhance the credibility and depth of the findings (Braun & Clarke, 2024).

3.9.2 Credibility

Credibility in this study was established through rigorous document analysis (Lim, 2024) and the careful selection of secondary sources that reflect a wide range of coal mining operations and perspectives (Denny & Weckesser, 2022). The research drew from publicly available reports, academic publications, coal mining company websites, and commentary from subject matter experts (Ahmad & Wilkins, 2024) on engineering skills broad concerns. These sources were chosen for their relevance, depth, and alignment with the research objectives (Fischer & Guzel, 2022), ensuring that the findings are grounded in authentic and representative data (Braun & Clarke, 2024). By analysing multiple documents across different coal mining operations' contexts and organisations, the study captured a broad spectrum of operational realities and strategic narratives on engineering skills outsourcing within the coal mining sector (Drisko, 2024).

The convergence of insights from industry documentation, scholarly research, and expert commentary allowed for cross-validation of themes and interpretations (Yadav, 2022). This multi-source approach reduced the risk of bias and strengthened the trustworthiness (Cleave et al., 2025) of the findings (Megheirkouni & Moir, 2023).

3.10 ETHICAL CONSIDERATIONS

The research should not harm to participants nor companies and will protect their rights, identity and well-being and comply with regulatory requirements (Enago, 2023). This was achieved as follows (Denison, 2023):

- Documentation used in the study will be stored securely with access only to the University and researcher.
- Pseudonyms and general descriptors will be used in the report findings.
- Data use permission granted in advance.
- Finally, research work must be free of plagiarism (Bhandari, 2021) with no data fabrication/falsification (Enago, 2023).

In considering potential unintended consequences, the study remained sensitive to the implications of the findings (McGregor, 2023), particularly regarding the portrayal of outsourcing practices and their impact on internal employees as well as the indication of lack of leadership to control maintenance costs and/or ensure internal employees competence (Almusaed et al., 2025). Care was taken to present results objectively (Recker, 2021), avoiding any harm to individuals or reputational damage to the participating or referenced organisations (Gaikwad et al., 2024).

4. CHAPTER FOUR – RESEARCH FINDINGS

4.1. INTRODUCTION

This chapter presents the findings of the study of the impact of engineering skills outsourcing (ESO) within the South African coal mining industry as interpreted from sample mining company and its three coal mines' documentation data and processes.

In response to the first research question, this chapter provides feedback on key drivers informing the decisions to outsource engineering skills followed by the manner and circumstances in which engineering skills are outsourced with insights into the prevalence of ESO at the mines (second research question). The findings provide an understanding of how deeply embedded ESO is at the mines to support equipment maintenance strategies or augment internal maintenance teams.

The last research question is addressed by reporting on ESO implications on asset availability and equipment maintenance costs.

4.2. FINDINGS ALIGNED TO RESEARCH QUESTIONS

4.2.1. First Research Question: What are the key drivers behind the decision to outsource engineering skills in the South African coal mines

The mines are informed where the skills required for equipment maintenance and repair are not retained in-house. The initial determination of a *'…maintenance strategy requires consideration of experience of maintenance personnel…'* for a deliberate definition of when and how external expertise must be brought in. The Maintenance Policy clearly states that, *'…rebuilding of equipment is not the mines core business…'*and must be '*…outsourced to an OEM or an agent approved and appointed by the OEM…*'. The policy does provide provision for deviation from the above in that services may be outsourced to any other supplier if approved by the organisation for that specific skill. This assessment and acknowledgement of mines' internal maintenance capability set outs drivers for ESO.

a) Limited maintenance resources capacity

The *mines* have weekly scheduled planned maintenance meetings where maintenance performance of the past week is reviewed, and an *'…assessment of outstanding work is conducted…'*. This discussion of backlogs prompts maintenance personnel '…*to request for external assistance to manage the backlog…*'. One of the contributors of backlog accumulation, is insufficient manpower or resources to execute maintenance activities as planned or necessitated. A diesel mobile equipment section complement report was reviewed and was found to be 50% understaffed when compared against OEM guidelines for the number of the equipment in the section. The number of skilled personnel in the section was *'…9 (4x Diesel Mechanics, 2x Auto-Electricians, 1x Boilermaker with additional 2x Diesel Mechanics on a shift system) …'* against a recommended manning of *'…19 maintenance persons for the 22x diesel mobile equipment…'*. This is documented in a Zero-Based Resources Budgeting campaign currently underway. Consequently, this section's maintenance team *'…continuously lack the necessary capacity to manage the full scope of maintenance…'* prompting regular outsourcing of engineering maintenance support.

b) Equipment complexity requiring specialised skills

The limited resources capacity is further exacerbated by the increasing complexity and specialization due to modernisation of mining equipment that demands advanced diagnostic and repair capabilities, evidence through the recently delivered Autonomous Drills at all the three mines. The inability to upskill artisans prompts mines to *'…outsource these skills to specialized service providers…'*. An internal report on training of diesel equipment maintenance artisans discussed that artisans are indeed not trained on advanced maintenance techniques but on *'... basics...'*.

c) Own artisans are unprepared for the Pit

A 2022 survey conducted by the Engineering Managers of the three complexes, focusing on a specific artisan training institution used by all local coal mines in Mpumalanga, identified modern workplace misalignment in the relevance and quality of their training programs. The findings highlighted several areas of concern:

- *'…The training content and mock-up equipment are obsolete, limiting learners' exposure to modern industry practices.*
- *The institution lacks access to current technologies and does not incorporate the latest advancements in their training modules.*
- *There is a noticeable absence of collaboration between institution and OEMs or Mines utilizing modern equipment hindering integration of real-world technologies into the learning environment.*
- *Trainees do not have access to up-to-date technical drawings, schematics, or OEM-specific documentation, which are essential for developing diagnostic and problem-solving skills.*
- *There is a lack of structured courses focused on fault diagnosis, a critical skill for modern artisans.*
- *Auto electrician training remains focused on petrol engine systems, despite the industry's shift in more than 2 decades toward diesel-powered machinery.*
- *The current learner curriculum is narrowly designed to meet MQA compliance at the expense of broader skill development.*
- *There are no dedicated facilities or programs aimed at continuous professional development or upskilling of qualified artisans…'*

Meanwhile, OEM training facilities, although basic in nature were reported to offer better facilities with the following feedback:

- *'…The training is more practical.*
- *OEM agents use Virtual Reality facilities for training.*
- *Trouble shooting course was trade and latest technology relevant.*
- *Training facilities are right next door to component repair facility offering learners firsthand experience, the artisans can be exposed to the practical training of opening the components, failure modes and analysis, repair of these components…'.*

In addition, once the artisans are appointed at the mines, the Skills Matrix and Historical Technical Training Records indicates *'…emphasis for artisans training post qualification is on SAFETY and less on technical courses…'.*

4.2.2. Second Research Question: How is engineering skills outsourcing implemented in the South African coal mining industry

To align with the second research question, expenditure reports of the three mines together with a list of purchase order numbers for the three years were analysed for the quantity and cost of instances of ESO. The sourcing procedures requires *'…identification of suppliers for services to determine an engagement strategy…'* for the supplier to deliver services. Subsequently, a system has been developed to manage all identified and approved suppliers including records of how often specific service was outsourced to a supplier. Over a three-year period, 2022 - 2024, external maintenance support was engaged for *'…a total of 9,810 occasions across the three mines...'* (Table 4.8.2). This equates to an average of 3,270 instances per year and clarifies reliance on outside support to augment site maintenance teams. This is an average of 13 external maintenance support per day across the three mines *'...given 252 effective working days per year...'*

Table 4.8.2: *'…3 years' purchase orders issued for maintenance support…'*

	2022	2023	2024
OEM / OEM Agent	1519	2023	1473
Non-OEM	1458	1701	1636
Subtotal	***2977***	***3724***	***3109***
Total	**9810**		

This daily average further breaks down to roughly four to five instances per mine per day, confirming a consistent demand for external technical support. Out of the 9810 ESO activities conducted, 28% of these were issued in distress or in an emergency as *'...breakdown order numbers…'*. Three thirds of the purchase orders are issued in a planned and timeous manner.

In addition, as detailed in the Buying Procedure, these services are sought either through'*…a contract…', '...direct repair (strip and quote service providers) …', '...preferred service providers…'* or to an *'…OEM or OEM Agent…'.* Any other service request or engagement other than for an emergency or breakdown is through a competitive process where at least *'...three quotations are requested, and the most competitive supplier is awarded a purchase order…'*.

4.2.3. Third Research question: What is the impact of engineering skills outsourcing on asset availability, maintenance costs, and internal employee skills development in South African coal mines

a) Equipment maintenance costs

A review of the maintenance cost report and procurement records from 2022 to 2023 revealed an *'…upward trend in asset maintenance expenditure associated with engineering skills outsourcing…'*. For example, *'…the three mines spent R194 million in 2022 and R245 million in 2023 on external engineering maintenance labour used at the mines…'*. There was a notable decline in 2024 where the overall spent on external expertise deployed at the mines reduced to *'…R165 million…'*, a 33% decrease from 2023. This was driven by an internal memorandum instructing *'…all employees with the authority to initiate outsourcing to critically assess their spending and authorize or consider only essential expenditures…'*. The initiative, named Think Twice, encouraged *'…all levels of management to carefully reconsider and justify every expenditure, no matter how small, even a single rand…'*. The initiative was necessitated by a significant drop in global coal prices*'… that fell from over US$400 per ton in 2022 to around US$150 per ton…'* compelling coal mines to review, reassess and reduce their input costs.

The above reported costs primarily relate to equipment not covered by long-term repair and maintenance contracts (MARC). In the absence of these agreements, *'…maintenance expenses tend to be less predictable and more variable…'*. Unlike a MARC arrangement, a 2009 MARC Strategy motivation document states, where costs are pre-agreed and calculated on a rand-per-operating-hour basis, *'…outsourced maintenance activities on non-MARC equipment leads to fluctuations in expenditure, making budgeting and cost control more challenging…'*, especially when a breakdown order process which can be likened to *'…an open check book for a service provider therefore unpredictable to the end user…'*

b) Equipment availability

In terms of asset management KPIs on diesel mobile equipment, *'…the mines monitors and tracks availability (split into engineering and physical availability) and reliability of equipment as well as the use of availability…'*. However, *'…the most concern is that equipment must be available for* *production…'* hence availability is the primary KPI. Six different equipment maintenance service level agreements (SLAs) or MARC across the three mines pegs required *'…availability of 88% for all equipment…'*. Over a three-year period, *'…the average availability of equipment under MARC agreements was 84%...'*, falling 4% short of the contracted target.

The MARC contracts include *'…provisions for penalties when this key performance indicator (KPI) is not met…'*, these penalties are not consistently enforced and in the life of these '…*contracts since implemented almost two decades ago…'*, there no record of a single penalty imposed. Equipment covered under MARC agreements is maintained by *'…personnel from the Original Equipment Manufacturer (OEM) or their appointed agents and must be stationed as resident maintainers at the mine sites…'*. '…*The mines honour a predetermined rate per operating hour…'* and thus these OEM agent's ESO activities are neither visible to nor recorded by the mines.

Non-MARC equipment maintained by the mine's own employees with occasional external support has *'…consistently underperformed compared to equipment maintained under MARC agreements…'*. Over the past three years, this owner-maintained equipment achieved an *'…average availability of 80%...',* falling short of the company's target of 88%. In contrast, equipment maintained by OEM personnel under MARC contracts demonstrated relatively better performance and *'…an average of 84%...'.*

Interestingly, despite significant investments in external engineering support, *'…averaging around R200 million annually…',* the availability of non-MARC equipment did not reflect this investment. In fact, a counterintuitive trend was observed: the higher the expenditure on engineering labour outsourced, the lower the equipment availability. For instance, in 2022*, '…an amount of R194 million was expended on bringing external skills onto the mine for maintenance on non-MARC equipment but only achieved an availability of 81%; in 2023, spending increased to R245 million, yet availability dropped to 78%; and in 2024, engineering skills outsourcing spend reduced to R165 million and availability slightly improved to 82%...'*. This trend suggests that increased ESO expenditure does not necessarily translate into desired equipment performance.

4.3. ESO IDENTIFIED THEMES

The qualitative data presented in the preceding section were analysed using thematic analysis to extract key insights into the influence of engineering skills outsourcing (ESO) on maintenance cost trends and internal skills development within coal mining operations. This approach allowed identification and interpretation of recurring patterns and highlighted themes (Lochmiller, 2021). Initial codes were generated showing key phrases and concepts related to engineering skills outsourcing, asset availability, and maintenance costs. These codes were grouped into broader themes that reflected the underlying issues. After reviewing and refining these themes, meaningful connections were drawn between the data and the theories guiding the study, particularly Organisational Learning Theory and inherently strategic outsourcing theories. The table 4.3a presents an overview of the main five (5) themes and categories of codes identified (developed through).

Table 4.3a: Main identified themes

Codes	**Themes**	**Categories**
Reliance on OEMs and External engineering skills for maintenance	Theme 1: Dependence on ESO	Resources Alignment
		Maintenance Strategy
High ESO expenditure with low availability	Theme 2: Cost-performance trade-offs	Maintenance Cost Management
		Knowledge Transfer
Inconsistent enforcement of poor equipment performance penalties	Theme 3: Contractual accountability gaps	Enforcement and Monitoring
Internal maintenance with lower availability		Incentive Based Outsourcing

Training not aligned with workplace needs	Theme 4: Misalignment of training and job/workplace demands	Training Alignment
Lack of skilled internal artisans		Continuous Skills Development

Table 4.3b tabulate a results alignment between the themes and categories that emerged from the document analysis and the research questions guiding this study. This mapping illustrates how each theme derived from contextual observation responds to specific aspects of the research inquiries, research question denoted by [R1].

Table 4.3b: Themes alignment with research questions

Research Questions	Theme
1.1.1. **[R1]** What are the key drivers behind the decision to outsource engineering skills in the South African coal mines?	**Dependence on Engineering Skills Outsourcing** • Resources alignment • Maintenance strategy **Misalignment of training and workplace demands** • Training alignment • Continuous skills development
1.1.2. **[R2]** How is engineering skills outsourcing implemented in the South African coal mining industry?	**Contractual accountability gaps** • Enforcement and monitoring • Incentive based outsourcing
1.1.3. **[R3]** What is the impact of engineering skills outsourcing on asset availability, maintenance costs, and internal employee skills development in South African coal mines?	**Cost Performance Trade Off** • Maintenance cost management • Knowledge transfer **Contractual accountability gaps** • Incentive based outsourcing

The next section details the themes with references to the research questions.

4.4. THEME 1: Dependence on engineering skills outsourcing [R1]

This theme captures the mining process related reality and reliance on external engineering expertise through MARC agreements and the use of at least OEM personnel. It reflects how outsourcing is not just a *'…supplementary practice but a core component of maintenance strategies…'* at the mines. The theme also explains the embedded nature of outsourcing, where *'…external maintenance skilled personnel are either resident at the mines or are frequently called out to assist…'*. This theme aligns with research question 1 which investigated the key derivers behind outsourcing of engineering skills.

4.4.1. Resources Alignment

An observation mas made at one of the mines documented organisational structure *'…allocated manpower levels were below recommended numbers for the corresponding amount of equipment…'*. The section is reported to be *'…on the backfoot with regards to catching up with maintenance demands…'* An internal feedback report from an attempt to increase maintenance complement cited '*…inefficiency, poor planning, inadequate maintenance strategy as well as inadequate organising of maintenance work…'* in the section thus declining the application.

Whilst '*…the workload is clearly demonstrated on the Computerised Maintenance System (CMS…'),* the section '*…cannot use this data due to the poor discipline of record actual time taken to conduct specific work…'.* This would assist accuracy of the data such that better informed decisions can be made regarding capacitating the section. The employed CMS *'…has capability to schedule resources and identify resource gaps…'*, but its proper functioning depends on the feedback information entered on the system.

With the practical reality that all maintenance tasks are not completed by the mine's maintenance team, the section must rely on external assistance to bridge the resource gap.

4.4.2. Maintenance Strategy

During the maintenance strategy development of new equipment, the mines conduct a skills assessment to match the required maintenance activities and intensity. This is documented in the Maintenance Policy. Therefore, from the on-set, *'…outsourcing requirements to an extent are* *outlined with an indication of the service providers to be in-sourced…'* corresponding to a maintenance strategy. These maintenance strategy formulations also assist in advance to outline the nature of engaging the external expertise, e.g. through a contract or as and when required. The hybrid maintenance approach is evident through *'…the extensive engineering skills expenditure as well as the number of purchase order numbers for maintenance support...'*. As detailed earlier, the strategy of owner maintained together with occasional external skills support is outperformed by maintenance conducted by resident expertise / OEM agents.

4.5. THEME 2: Cost performance trade-off [R3]

This theme in its true form reflects the balance between maintenance cost and equipment availability to support production, although the opposite was observed. This theme aligns with research question 3, which investigated the impact of engineering skills outsourcing on equipment availability and maintenance cost.

4.5.1. Maintenance Cost Management

It was found that the level of engineering skills outsourcing assessed from cost incurred and equipment performance in terms of availability did not have an intuitional linear relationship. Cost saving is *'…least emphasised when outsourcing engineering skills especially when in an emergency or breakdown situation…'*. As stipulated in the Breakdown Order Memorandum, restoring circumstances *'…to safe levels or returning a machine as quickly as possible to production…'* is traded off with cost predictability.

This disarms maintenance personnel from having adequate maintenance cost control when they only know of the *'…actual costs incurred after equipment has been repaired and booked back to production…'*. The decision to urgently engage external service providers through a breakdown process is *'…reactive does and not support asset cost management controls…'*. The Sourcing Policy acknowledges that *'…cost management and control increases with the degree of predictability…',* a trait that is absent when services are requested in a hurry or using the breakdown order number process.

4.5.2. Knowledge Transfer

Although the engineering skills outsourcing cost was relatively lower in 2024, *'...at R165 million, the number of issued breakdown order numbers was higher than for 2022 and 2023 (2022 – 902; 2023 – 912; 2024 -956…')*, confirming continuous and consistent reliance on external expertise. One of the monthly cost reports pointed out that this is *'...typical indication of absence of knowledge transfer as breakdown orders are dominantly issued for fault finding on site…'*. The 2024 November Outstanding Business Actions report noted the *'...increase in breakdown order numbers...*' which is concern as the breakdown order issuing, although *'...key to supporting the mine's performance and productivity or making safe, does compromise procurement processes hence must be controlled…*'.

4.6. THEME 3: Contractual accountability gaps [R2 & R3]

The outsourcing of engineering skills at the coal mines is thus far from a policy driven response to internal capacity constraints but also in accordance with a developed maintenance strategy. Services are secured *'...through a purchase order or a contract…'* which introduces legal and contractual dynamics that should influence asset availability and equipment maintenance costs if implemented effectively. This theme is aligned with research questions 2 and 3, which investigated how outsourcing is conducted at mines and sought to explore the impact of engineering skills outsourcing on availability and maintenance costs of production equipment at the mines.

4.6.1. Enforcement and Monitoring

There are *'...two significant MARC contracts at each of the three opencast mines, one for rubber tyred equipment and the other for tracked equipment (Large Excavators and Face Shovels) which are primary earth movers…'*. The average availability of the equipment under these agreements failed consistently '…*to achieve contractual availability of 88%...'*, with no contractual penalty implemented. The penalty, if implemented *'...is relatively insignificant, about 0.03% of the monthly contract value…'* thus is discouraging for the client *'...to exercise this option which is viewed as administratively demanding…'*.

This emerging perspective misinterprets the intent and function of the penalty clause (Driouich et al., 2024). While the financial impact on the supplier may be minimal, the imposition of such a penalty can serve as a reputational marker (Lahiri et al., 2022), signalling non-compliance that can be used for future business credibility and performance reference. The reviewed MARC agreements (SLAs) however, also include a reciprocal clause that *'… allows the contractor to impose penalties on the mine if the equipment was not operated for the agreed minimum number of hours within a given month…'*.

As a coal mine is not a 'cheese factory', there is typically at least one category of equipment of which the client may seek compensation due to poor performance, however, there is often another category of equipment also that may have failed to meet the required production hours, giving the contractor grounds for a counterclaim. This dynamic can understandably lead to ongoing disputes and a cycle of blame between the parties. As a result, *'…contractual performance clauses particularly linked to availabilities of equipment are not enforced…'* undermining the intent of outsourcing maintenance in the first place.

4.6.2. Incentive Based Outsourcing

While *'…MARC contracts typically include performance targets and penalty clauses…'*, albeit inconsistently enforced or not enforced at all, *'…non-MARC outsourcing is void of a structured process where suppliers can be held accountable…'*.

In these owner-maintained equipment where services are often *'…requested through a straight purchase order…'*there are no contractual provisions linking contractor compensation to equipment performance. This absence of pain-gain sharing mechanisms means that service providers are not financially motivated to minimize equipment failures, for example, through sharing of knowledge. In fact, *'…the more frequently equipment fails, the more maintenance work is generated…'*. Frequent equipment failures therefore translate into increased revenue for the external skills providers.

This misalignment of interests is likely one of the direct contributors to *'…uncontrollable maintenance costs and reduced equipment availability…'* on non-MARC equipment. Without contractual levers to enforce accountability, clients bear the full financial burden of inefficiencies, while outsourced providers operate only *'...with workmanship and warranty risks...',* as often referenced in their Service Proposals (Quotes).

This category depicted the critical need for incentive-aligned short term skills outsourcing process for owner-maintained equipment.

4.7. THEME 4: Misalignment of training and workplace demands [R1]

This theme is aligned with research question 1, which explored key drivers behind ESO. One of identified drivers behind the decision to outsource engineering skills at the mines *'…is misalignment between the training provided to artisans and the actual demands of modern mining equipment…'*. This theme explores how the disconnect between formal training programs and real-coal mine maintenance requirements contributes to the engineering skills outsourcing trend.

4.7.1. Training Alignment

A critical challenge contributing to the outsourcing of engineering skills in coal mines is *'…the outdated nature of artisan training programs…'*. Many of the current artisans have graduated from institutions that still rely on *'…legacy training methods and obsolete technologies…'* leaving them ill-prepared for the demands of modern mining operations. Once employed on-site, *'…these artisans are typically only granted access to basic technical refresher courses with emphasis on safety…'*, which do little to bridge the growing gap between their existing skills and the *'…advanced diagnostic and maintenance capabilities required for today's sophisticated mining equipment…'*.

A Human Resources Training and Development Report laments that this limited exposure to continuous, technology-aligned training results in a persistent skills lag. As mining equipment becomes increasingly digitized and reliant on integrated control systems, *'…the mines' in-house artisans struggle to keep pace...'* with the evolving technical landscape. Consequently, mines are compelled to *'…rely heavily on external specialists, particularly those from Original Equipment Manufacturers (OEMs) who are continuously equipped to perform complex fault-finding and* *system diagnostics…'*. This creates a vicious cycle of dependency, where internal capacity is continually sidelined in favour of outsourced expertise, further eroding the development of in-house proficiency.

4.7.2. Continuous Skills Development

As discussed in the previous section, *'…OEMs are continuously adapting and advancing their equipment technologies, integrating more sophisticated systems into modern mining equipment…'*. For coal miners to keep up with the maintenance skills requirements these developments, an internal study reiterated that *'...it is essential to invest in continuous learning and upskilling programs for the maintenance personnel...'*.

The study report further outlined that, *'without ongoing training, internal teams quickly fall behind, unable to effectively diagnose or repair newer equipment models…'* acknowledging that *'…continuous development not only equips employees with the latest technical competencies but also fosters a culture of learning and adaptability within the organization…'*. Over time, *'…this can reduce reliance on external service providers, as in-house teams become more skilled in fault-finding and specialized maintenance…'*. Currently, when internal staff are unable to resolve equipment issues, *'...mines experience delays of up to four hours while waiting for external technicians, resulting in significant production losses…'* but can be minimised *'…if relevant and up to date technical skills continuous development is prioritised...'*.

4.8. CONCLUSION

The analysis of maintenance expenditure and equipment availability across the three coal mines painted a counterproductive relationship between engineering skills outsourcing and maintenance performance. While outsourcing has been a deliberate response to internal capacity gaps, particularly for non-MARC equipment, the data shows that increased spending on external engineering support has not translated into improved equipment availability. In fact, a paradox emerges: higher outsourcing costs have coincided with lower availability. The lack of structured, performance-based contracts for non-MARC equipment, combined with inconsistent enforcement of penalties in MARC agreements, further exacerbates cost unpredictability and weakens cost control measures.

The analysis of procurement records from 2022 to 2024 clearly illustrates the scale and structured nature of engineering skills outsourcing across the mines. While a significant portion of these engagements were planned, nearly 28% were reactive, issued under emergency breakdown conditions. This ratio suggests that while mines have developed a deliberate outsourcing strategy for engineering maintenance, the mines are vulnerable to unplanned equipment failures attracting unplanned costs. The well documented and practical procurement procedures showcased the formalization of outsourcing practices, with clearly defined sourcing avenues ranging from OEMs and preferred suppliers to competitive bidding processes.

Mines have formally acknowledged that certain maintenance functions, for example component rebuilds, fall outside their core capabilities and must be outsourced to OEMs or their agents. This is compounded by chronic understaffing in critical maintenance sections, where internal teams operate at nearly half the recommended capacity, leading to persistent backlogs and frequent calls for external support. Furthermore, the increasing complexity of modern mining equipment demands advanced diagnostic skills that internal artisans often lack due to outdated training curricula and limited exposure to current technologies. As a result, the mines remain locked in a cycle of external dependence.

5. CHAPTER FIVE – DISCUSSION OF RESULTS

5.1. INTRODUCTION AND STUDY PURPOSE REVIEW

Chapter 5 discusses the results as explored by this study that set out to explore the impact of outsourcing engineering skills on maintenance costs within South African coal mining operations. By analysing available and internal documentation sampled at three large coal mines, the research discovered patterns and implications associated with external expertise engagement for maintenance support, discussed herein.

5.2. DRIVERS OF ENGINEERING SKILLS OUTSOURCING AT MINES

Two emerged themes addressed this research question (1): Theme 1 – Dependence on Engineering Skills Outsourcing and Theme 4 – Misalignment and of Training and Workplace Demands. Theme 2 links well with Theme 1 as when and where employees' skills and are mismatched with requirements of their duties, outsourcing occurs (Akbari, 2024) and failure to rectify this misalignment leads to external expertise dependence (Mutongerwa et al., 2024). The themes were characterised by four categories, discussed below.

5.2.1. Resources Misalignment

A significant finding under this category was the misalignment between mine or section allocated maintenance resources and equipment services demands or maintenance workload. The allocated manpower levels in the reviewed diesel mobile equipment section were significantly below the recommended staffing norms (Bugarski & Ritter, 2025) relative to the number of assets maintained by the section.

Such staffing misalignment typically places the section in a reactive posture , consistently struggling to meet maintenance requirements and contributing to a backlog of unresolved tasks, as also reported by Abdullah et al when considering leveraging Artificial Intelligence to address maintenance backlogs (Abdullah et al., 2024). Organisations can create a competitive edge with their resources (Olalla, 2023), but they must have them in the appropriate quantities that matches the organisation strategies. Understaffing generally places additional workload on employees with a variety of consequences on the employees (Senek et al., 2022) as well as accumulation of backlog coupled with poor quality work (Ogumeyo & Ekeh, 2023).

The Computerised Management Maintenance System (CMMS) is designed to support resource planning and workload scheduling, however, is underutilized due to poor data discipline, which compromises the accuracy of the system's outputs. Inability to utilise provided systems compromises maintenance strategies further (Yazdi, 2024). Maintenance best practices recommendations advise that, a CMMS is a must for site to achieve acceptable maintenance maturity (Nur'afini Dzulkifli et al., 2021). However, a properly planned and maintained system can increase maintenance efficiency of the organisation or section (Velmurugan et al., 2022) and even then, only when its full capability is deployed (Balachandran, 2024).

The referenced section is unable to complete all required maintenance tasks using internal resources alone leading to a reliance on external engineering support. This finding invites theoretical reflection on the relationship between resource allocation (Yazdi, 2024) and organisational requirements (maintenance performance). It aligns with perspectives from resource-based theory, which emphasizes the resource focused importance of aligning internal capabilities with operational demands (Barney et al., 2021). These reflections also align with the contingency theory, particularly the extent to which organizational structures and systems in this case are not adapted to fit mining realities (Geurtsen et al., 2023).

5.2.2. Maintenance Strategy Outcome

The study found that the development of maintenance strategies for new equipment at the mines includes a deliberate assessment of internal skills against OEM defined maintenance interventions for that specific the equipment. This formalised maintenance strategy development process enables early identification of maintenance effort over the life of the equipment (Geurtsen et al., 2023), outsourcing requirements (Balachandran, 2024) and the specification of preferred service providers that will be engaged through long-term contracts or on an as-needed basis (Drummers & Visser, 2021), thereby setting in outsourcing expectations into the asset management framework.

This hybrid maintenance approach (Yazdi, 2024), combining owner-maintained functions with selective external support, reflects a flexible (but structured) maintenance model (Abdullah et al., 2024), and is prevalent across the mines although often unplanned discovery (Balachandran, 2024). However, this model underperforms when compared to fully outsourced arrangements managed by resident OEM agents. This is opposite to available literature that favours such a model for minimising long-run maintenance cost (Liu et al., 2022). The stance is likely due to assuming ideal mining operations when considering the hybrid model (Geurtsen et al., 2023) or that the maintenance strategy basis is not on sound Reliability-Centred Maintenance (RCM) basics that could maximise equipment availability as it provides clear estimation of an equipment maintenance workload (Rosita & Rada, 2021).

While also observed that an outright OEM maintenance resource model did not achieve desired or targeted availability, it is perhaps unfair to discredit a hybrid model (Esposito et al., 2023) and the difference could be the theoretical considerations of these models (Yunusa-Kaltungo & Labib, 2021) yet in practice, they yield different results. Perhaps these results are testament to Khumalo (2006) that found that, outsourcing succeed 25% of the time and the mine managers then agreed that it does not work (Khumalo, 2006). This is unlikely as mines currently outsource just about any activity that can be justified (Biswas et al., 2024) based on some of the drivers found by this study.

5.2.3. Training Misalignment and Lack of Continuous Skills Development

A significant contributor to the reliance and driver for outsourced engineering skills is the analysed misalignment (Akinradewo et al., 2022) between artisan/apprentices' training programs and the evolving technological demands (Abdullah et al., 2024) of modern mining equipment. Once the artisans are employed, their continuous development is non-existent but only focusing safety courses. McKinsey and Company alluded to this fact that the mining industry is experiencing a talent squeeze due to evolving workplace demands (McKinsey&Company, 2022), especially those due to modernisation of equipment (Akinradewo et al., 2022). Change in equipment technology has been inevitable (Benedettini, 2024) thus skills mismatch is an evolving reality (Khan et al., 2024) that must be embraced and dealt with.

This gap between training content and actual job requirements together with the absence of technical skills' continuous development (Abenov et al., 2023) undermines the mines' ability to build required skills competency (Opperman, 2023). A 2024 discussion paper on Human Resources and Educational mismatch places the responsibility of the mismatch on inadequate human resources practices (Berloffa et al., 2024). But, leadership principles affirm that, (for any change to occur especially for a s specific culture (Hallenbeck, 2023)) desired change must be responsibility of everyone in the organisation to ensure that employees training matches its competitiveness requirement (Bristol-Alagbariya et al., 2024). Probably extreme and unlikely practical to implement. A better proposal would be to aggregate the responsibility at the supervisor level (Yazdi, 2024), as they are in the coal face of skills mismatch challenges.

These findings points out the organisation's obliviousness of the human capital theory that argue that investment in employee development yields long-term performance benefits (Kang & Mok, 2022) for the organisation including that employees can be adequately equipped to face and resolve maintenance challenges. The risks of misaligned training and underinvestment in continuous development manifests through external reliance of resources (Akbari, 2024).

5.2.4. Implications

The findings of this study carry important implications for coal mining operations seeking to optimize their engineering maintenance strategies. The persistent reliance on outsourced engineering skills, driven by internal capacity constraints (Barney et al., 2021), outdated training systems (Andreev, 2024), and underdeveloped maintenance strategies (Gomes et al., 2021) points to a need for a more integrated approach to workforce planning (Bugarski & Ritter, 2025)and capability development. Mines must move beyond reactive outsourcing (Schmitz, 2021) and invest in building internal competencies through targeted upskilling, modernized training partnerships, and better utilization of maintenance planning tools. Doing so could reduce long-term costs and improve equipment availability (Yusoff et al., 2024).

This section demonstrates the importance of aligning maintenance policies with organizational learning and human capital development. The current hybrid model, while flexible, risks entrenching dependency on external providers if not supported by a deliberate skills transfer. Therefore, mining companies must critically assess not only the cost implications of outsourcing but also its long-term impact on institutional knowledge.

5.3. PROCESSES OF ENGINEERING SKILLS OUTSOURCING AT MINES

The mines typically engage external maintenance support through established agreements such as contracts or service level agreements, standard purchase orders or via urgent requests initiated through the breakdown order process. A single emerged theme responded to this research question (2): Theme 3 – Contractual Accountability Gaps. Although the category primarily suggests concerns related to contract management, its examination surfaced the intricacies of the mines' engineering outsourcing processes and, more importantly, identified significant issues within the processes. The concerns are not unique in that they are prevalent where outsourcing is adopted as a strategy (Yusoff et al., 2024), that is, the terms and conditions or contractual clauses must be enforced and honoured to derive intended benefit of such engagements (Khan et al., 2024). The theme was explored through two characteristics discussed below.

5.3.1. Inadequate Contract Performance Monitoring

The three opencast mine manages long term contracts as well as short term contractors or service providers. As expected, where there are contracts in place, there are performance clauses (Babirye et al., 2024) for both parties (Driouich et al., 2024). However, penalty clauses for underperformance have never been enforced, largely due to their minimal financial impact as well as the administrative burden (burden of proof) associated with invoking them (Colgan, 2021).

The lack of accountability on both sides weakens the strategic intent of outsourcing (Grela & Hofman, 2021) and consequences of weak contract enforcement mechanisms in performance-based agreements (Gomes et al., 2021) is evident in the failure to achieve of required KPIs. Outsourcing strategies, such as those formalised and structured to support maintenance activities, need to be supported by contract performance clauses enforcement (Garg et al., 2024). Indeed, outsourcing will not work if performance requirements in agreements are not observed (Benedettini, 2024).

5.3.2. Incentive Based Outsourcing

Non-MARC outsourcing lacks structured incentive mechanisms (Drummers & Visser, 2021) that link contractor compensation to equipment performance or some form of pain-gain sharing process. In owner-maintained equipment scenarios, services are often procured through simple purchase orders, with no contractual provisions for performance-based rewards (Balachandran, 2024) or penalties. This absence of outcome-based incentives means that external service providers are not financially motivated (Yusoff et al., 2024) to sustainably prevent equipment failures or even transfer the know-how knowledge to internal teams (Grela & Hofman, 2021). Frequent breakdowns can generate more billable work (Dashtaki et al., 2025), creating a misaligned incentive structure that benefits the service provider at the expense of the mines (Biswas et al., 2024).

This misalignment contributes to escalating maintenance costs (Akbari, 2024) and persistent underperformance in equipment availability (Javadnejad et al., 2022). Performance based contracting is important to align incentives to ensure mutual accountability (Driouich et al., 2024) and value creation in outsourced service arrangements (Yang & Dong, 2024).

5.3.3. Impact

The analysis of incentive structures and contract enforcement validated that engineering skills outsourcing in South African coal mining is conducted within a framework that is often procedurally formal but strategically misaligned. While outsourcing is widespread and embedded in executional or maintenance procedures, the mechanisms that should ensure accountability and performance such as penalty clauses and incentive-based contracts are either loosely enforced or entirely absent in non-MARC arrangements. This undermines the effectiveness of outsourcing as a strategic tool for improving equipment reliability and cost efficiency.

The lack of performance-linked incentives and the reluctance to enforce contractual penalties create a low-accountability performance environment (Driouich et al., 2024), where external service providers are not financially or reputationally motivated to optimize outcomes (Yusoff et al., 2024). This results in a transactional outsourcing model (Driouich et al., 2024) that prioritizes short-term fixes over long-term capability building (Biswas et al., 2024). Consequently, outsourcing in this context is not just a response to internal resource gaps, it becomes a self-reinforcing dependency, where poor internal performance and weak external accountability perpetuate poor performances. These findings suggest that for outsourcing to truly add value, coal mines must adopt performance-based contracting models and strategic supplier partnerships that align incentives, enforce performance requirements, and foster mutual accountability, regardless of the value of the order number.

5.4. IMPACT OF ESO ON MAINTENANCE COST AND EQUIPMENT AVAILABILITY

A prominent outsourcing theme in this study has been that misaligned outsourcing strategies (Benedettini, 2024) or failing to enforce performance agreements affects equipment availability and associated costs negatively (Garg et al., 2024). The easy access to a 'quick fix' perpetuates reliance on outsourcing that internal capacity building and skills development is overlooked.

Two emerged themes addressed this research question: Theme 2 – Cost Performance Trade Offs and Theme 3(b) – Contractually Accountability Gaps, however as discussed in section 5.3. These sentiments were substantiated through the below discussed categories.

5.4.1. Maintenance Cost Management

There was no clear or consistent correlation between the cost of outsourcing engineering skills and equipment availability. This is contrary to the literature that outsourcing intensity has direct positive organisational performance (Benedettini, 2024) and it is against the accepted rationale for outsourcing (Biswas et al., 2024). The cause of this performance contradiction is likely due to the finding that, cost control considerations are often deprioritized during emergency or breakdown scenarios (Balachandran, 2024), where the overriding objective is to restore equipment to on-production status as quickly as possible (Akbari, 2024), regardless of the cost.

As a result, maintenance personnel are frequently unaware of the actual costs (Balachandran, 2024) that will be incurred specifically with emergency orders until after the equipment is repaired (Bugarski & Ritter, 2025) and the actual costs are advised.

This reactive approach to outsourcing undermines proactive cost control (Mutongerwa et al., 2024) and deviates from structured asset cost management principles (Balachandran, 2024). These finding agrees with Yusoff et al. who suggested that reactive outsourcing strategies are often suboptimal in complex in-service environments (Yusoff et al., 2024). The disconnect between production or safety urgency and financial oversight presents a significant shortcoming in the maintenance cost control strategy (Yazdi, 2024), likely overlooked. Coal mining is a volume business (Makgetla & Patel, 2021) where often high volumes translate to lower cost per ton that can mask over expenditure (Biswas et al., 2024). It is often during low productivity phases as well as low commodity prices that every expenditure is scrutinised (MCSA, 2023). A singular equipment KPI for cost performance (Balachandran, 2024) that can be published and interrogated monthly may resolve this oversight.

5.4.2. Skills and Knowledge Transfer

The consistency of outsourcing engineering skills as observed suggests a lack of effective knowledge transfer (Khan et al., 2024), particularly in fault diagnosis (Allais, 2022), as internal teams continue to rely on outsourced specialists for recurring technical issues. Over a three-year period, a decline in external interventions would have been a good indicator that internal capacity was being developed (Bugarski & Ritter, 2025) through structured learning or shadowing.

Knowledge transfer, although often internal, has the potential to improve the performance of organizations (Argote, 2024). Akinradewo emphasized that ESO without deliberate mechanisms for experiential learning and skill internalization can inhibit rather than enhance internal capability development (Akinradewo et al., 2022). This appears to be an unintended consequence of outsourcing as reported by Mahowa et al., in that, suppliers are dependant on getting work at the mines thus to ensure that they continue to get work, they withhold knowledge (Mahowa et al., 2025), creating a dependency loop (Drummers & Visser, 2021).

5.4.3. Outcome

ESO practices in South African coal mines have significant implications and significant role to play for both asset availability and maintenance cost control, if implemented with reference to the study findings. The reliance on reactive, breakdown-driven outsourcing, often initiated without prior cost estimation leads to unpredictable and escalating maintenance costs. This lack of cost visibility and control, particularly in non-MARC arrangements, undermines the strategic intent of outsourcing and weakens the mines' ability to manage asset life cycle costs effectively.

Simultaneously, the persistent use of external service providers for fault diagnosis and repairs, without structured mechanisms for knowledge transfer, hinders needed skills development of internal maintenance teams. Testament to this is the increasing number of breakdown orders over time, despite fluctuating outsourcing expenditure which confirms that internal teams are not acquiring the skills needed to reduce future reliance on external maintenance expertise.

5.5. DISCUSSION OF FINDINGS IN RELATION TO A MANAGEMENT THEORY

The findings of this study reveal a complex and layered relationship between engineering skills outsourcing (ESO) and asset maintenance costs in South African coal mines. These findings are best understood through the lens of the OLT management theory that framed the study.

5.5.1. Organizational Learning Theory

The study demonstrated that ESO functions in South African coal mines, while beneficial for accessing specialized expertise, has contributed to a decline in internal skills development and somewhat limited access to structured engineering maintenance training (Bhasin, 2024). This reflects a breakdown in organizational learning processes (Dhir & Dhir, 2025), where knowledge is not effectively captured, shared, or retained within the organization. Mines that do not invest in post maintenance qualification development, mentorship and knowledge retention mechanisms risk stagnation in maintenance capability, even when outsourcing is used to fill immediate skill gaps. The findings support the theory's view that learning is essential for adaptive performance (Akwaowo & Kalio, 2021).

5.6. CLOSING REFLECTION

In conclusion, the outsourcing of engineering skills in South African coal mines, while addressing immediate resources gaps based on outsourcing theories and literature, has challenges in cost control and asset performance as well as internal skills development.

The lack of integration between outsourced service providers and internal training programs means that valuable technical insights gained during outsourced interventions are not captured or institutionalized. For outsourcing to be effective, its inputs and outputs must be monitored and corrections made so as to fully benefit from the process.

6. CHAPTER SIX – CONCLUSION AND RECOMMENDATIONS

6.1. INTRODUCTION

This chapter presents the concluding insights from the study and offers recommendations based on the findings discussed. It synthesizes the key outcomes related to the outsourcing of engineering skills in South African coal mines, particularly its impact on asset availability and maintenance cost management. The conclusions reflect the broader implications of current outsourcing practices, while the recommendations aim to guide coal mining operators toward more deliberate, KPI driven, and sustainable outsourcing models.

6.2. CONCLUSIONS

This report has explored the multifaceted relationship between engineering skills outsourcing and asset maintenance costs within South Africa's coal mining sector. Drawing on the document analysis, it clear that while outsourcing offers access to specialized expertise, it also presents risks, particularly in terms of internal skills erosion, equipment availability and maintenance cost control. The following conclusion synthesizes these findings and offers a perspective on how coal mines can navigate this complex engineering skills outsourcing landscape to achieve and improve functional and maintenance performance through informed ESO strategies. The study's initial research questions and thematic direction informed the conclusions drawn from the findings:

a) What are the key drivers behind the decision to outsource engineering skills in the South African coal mines are engineering services and skills outsourced in SA coal mining industry

The investigation into the key drivers of Engineering Skills Outsourcing (ESO) at coal mines returned complex interplay between internal capacity limitations, evolving equipment demands, and systemic training inadequacies. While policy frameworks acknowledge the need for outsourcing in areas beyond the mine's core capabilities, the practical realities on the coal face such as chronic understaffing, increasing equipment sophistication, and outdated artisan training have made ESO not just a tactical choice but an operational necessity. The mines' reliance on external support is not merely reactive but stems from structural constraints that hinder the development and capacitating of in-house technical expertise. The key causes that necessitate ESO are as follows:

- Maintenance resourcing misalignment.
- Modern equipment technological complexity requires specialized skills that current in-house teams are not equipped to handle.
- Artisan apprenticeship training misalignment, outdated training programs and insufficient post-qualification development leave artisans unprepared for real coal face demands.

b) How are engineering services and skills outsourced in SA coal mining industry.

The findings of this report illustrated sustained reliance on outsourced engineering services within the coal mining sector. Congruent to the transaction cost economics theory relating to the uncertainty and frequency of outsourcing (Cuypers et al., 2021), it has been internalised by the coal mines. This trend is largely driven by the need for specialized expertise, cost optimization, and access to advanced technologies as well as capabilities often more readily available through OEMs and external service providers. To this extent, ESO is structured and formalised through predetermined outsourcing processes, governed by internal procedures and procurement policies.

c) Examination of engineering services and skills outsourcing impact on asset/equipment maintenance costs.

The outsourcing of engineering services and skills in the coal mining sector has had a mixed and unexpected impact on asset performance and equipment maintenance costs. Reliance on OEMs and external expertise has not yielded the expected performance in equipment, for example reduction of downtime for a better equipment uptime.

Mines that lack skilled in-house artisans and capacity become dependent on costly external interventions made worse by the absence of internal fault-finding expertise and limited access to relevant training resources. Generally, poor investment in internal skills development and weak integration between internal teams and outsourced services diminishes the benefits of outsourcing, leading to high total cost of equipment ownership and stagnancy of internal skills.

6.3. RECOMMENDATIONS

Mines should undertake a comprehensive review of their maintenance staffing levels using a zero-based budgeting approach, assessing current resource adequacy against industry benchmarks for manning levels in accordance with the current maintenance strategies. This is underway at the sampled company but to ensure objectivity and access to a broader range of maintenance resourcing models, it is recommended that this evaluation be conducted by an independent external consultant or academic expert. This approach will help mitigate internal bias and overcome knowledge limitations that may exist within current management structures. It is also recommended to consider leveraging artificial intelligence predictive analytics which can minimise the frequency of emergency repairs and improve planning accuracy, reducing the need for urgent outsourcing and allow for more resource and cost-effective maintenance planning/scheduling.

With the realisation that engineering skills outsourcing can have mixed results for a hybrid-maintenance strategy, the study overarchingly recommends that coal mines should adopt a dual-track outsourcing strategy (Cai & Canales, 2022) that coordinates external expertise outsourcing with internal capability/skills development so as to exploit the benefits of engineering skills outsourcing. Indeed, outsourcing should be applied to access latest fault-finding techniques and OEM-specific knowledge where internal capacity and skills are limited but must be complemented by deliberate investment in internal artisans upskilling program. This will require a collaboration between training institutions, OEMs/external expertise and the mines and this process can be facilitated by the current coal mining (SACMA) and engineering (SACEA) associations which should also including revamping apprenticeship programs.

Effective management begins with accurate measurement; therefore, mines must prioritize continuous evaluation of value derived from engineering skills outsourcing (equipment performance and maintenance costs) and the value of existing maintenance systems, such as the Maintenance Management System, which is currently underutilized due to weak operational discipline. By systematically identifying and highlighting inefficiencies, mines can generate actionable insights that can drive cultural shift toward greater accountability (both internal and external) for alignment with organizational ESO objectives.

6.4. LIMITATIONS OF THE STUDY

Although appropriate effort was made to ensure the rigor and relevance of the research, several limitations influenced the scope and depth of the findings as follows:

i. **Restricted Access to Proprietary Data**
Limited access to South African coal mines' detailed maintenance cost records, outsourcing contracts, and internal performance metrics (Wilkinson & Walker, 2023). As a result, the study relied on publicly available data and data from the sample organisation which may not fully reflect the complexity of the entire sector's outsourcing arrangements and impact.

ii. **Limited Generalizability**
The study focused exclusively on coal mining operations in South Africa. Findings may not be directly applicable to other mining sectors (e.g., gold, platinum, etc.) or to small coal mining operations in South Africa or other countries with different regulatory, economic or operational contexts.

iii. **Complexity of Shortage of skills and Cost Attribution**
While this study seeks to identify potential correlations between engineering skills outsourcing practices and equipment maintenance costs, it is important to acknowledge the inherent complexity in attributing costs within mining operations. Maintenance expenditures are influenced by a multitude of interrelated factors beyond outsourcing alone (Mahowa et al., 2025). These include, but are not limited to, the age and condition of equipment, the intensity and variability of operational demands, site-specific procurement strategies and the availability of skilled personnel.

The presence of a skills shortage, for instance, may lead to increased reliance on external service providers, but it may also affect internal efficiency and cost structures in ways that are difficult to isolate. Furthermore, mining companies often adopt diverse procurement and maintenance models tailored to their strategic priorities, which can complicate direct comparisons across operations and coal mining houses.

6.5. RECOMMENDATION FOR FURTHER RESEARCH

As the South African coal mining industry continues to navigate the complexities of engineering skills outsourcing, it becomes increasingly important to deepen the understanding of its implications, again on asset maintenance costs and internal capability development. While current findings confirm both the operational benefits and risks of ESO, several critical knowledge gaps remain. Addressing these gaps through targeted research will enhance ESO decision-making for the coal mines. The following further research areas are recommended:

a) Explore Organizational and Cultural Impacts of Outsourcing on Engineering Teams

Beyond cost and skills, outsourcing can affect team dynamics, morale, and organizational culture. Future research should investigate how outsourcing influences internal engineering teams' motivation, job satisfaction, and career progression. Qualitative studies involving interviews and case studies across different mining operations could uncover how outsourcing reshapes internal roles and whether it fosters collaboration, creates silos or cause skills stagnancy. These insights would be crucial for designing outsourcing strategies that not only manage costs but can also preserve a healthy, skilled, and engaged internal teams.

b) Assess the Effectiveness of Skills Transfer from OEMs to Internal Teams

Another critical area for exploration is the extent to which outsourcing arrangements can facilitate or hinder skills transfer to internal personnel. Research could identify and evaluate the presence and effectiveness of knowledge-sharing mechanisms within or without service-level agreements, such as joint maintenance programs (hybrid), on-site training, or mentorship. Understanding how and when outsourced engagements contribute to internal capacity building would help shape more sustainable outsourcing models that support sustainable deliberate skills development.

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APPENDIX A: Complex A Engineering Organisational Structure and Maintenance Section Staffing

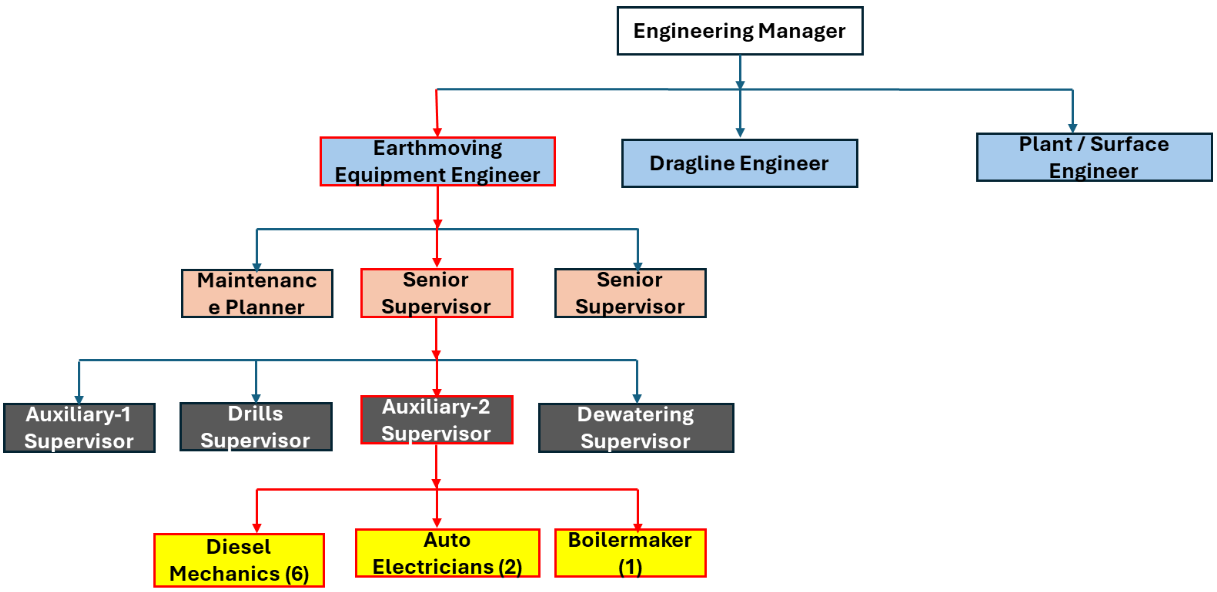
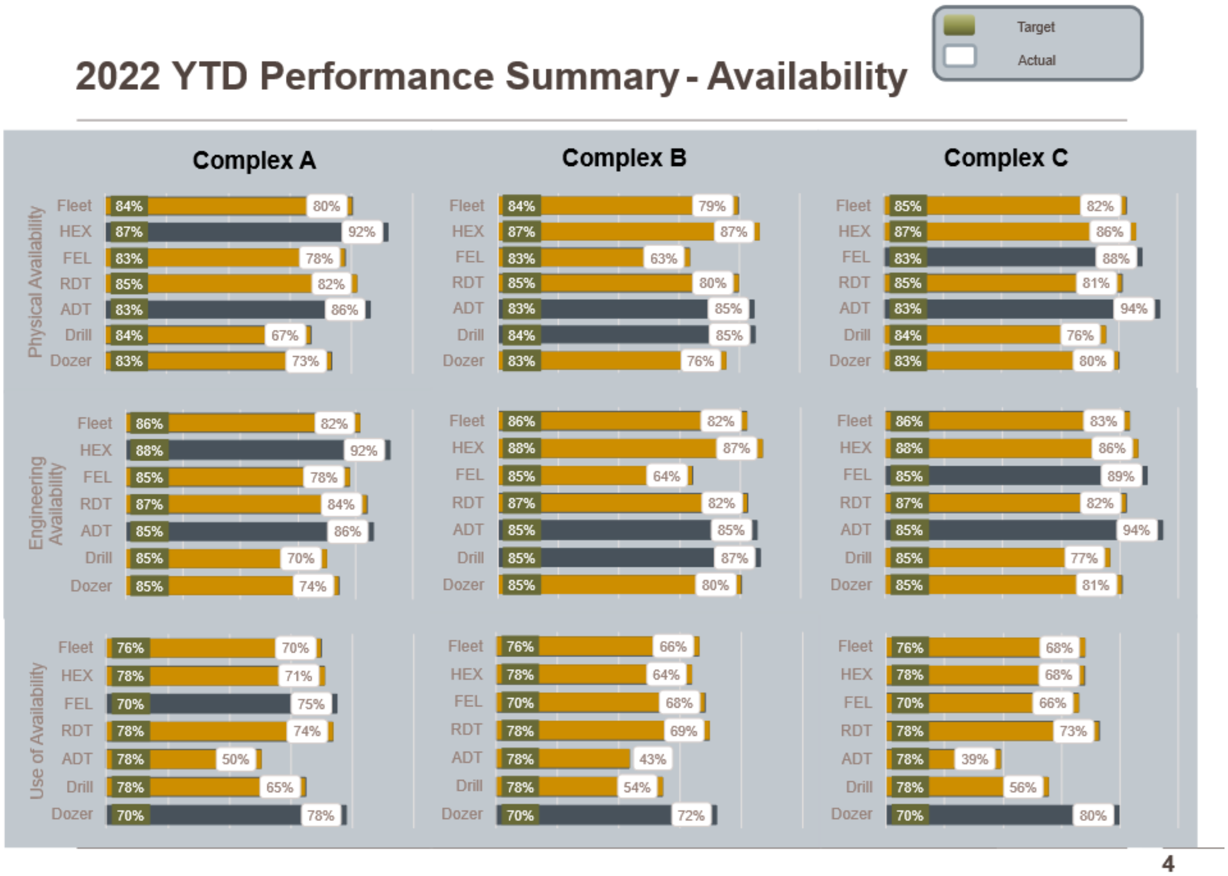


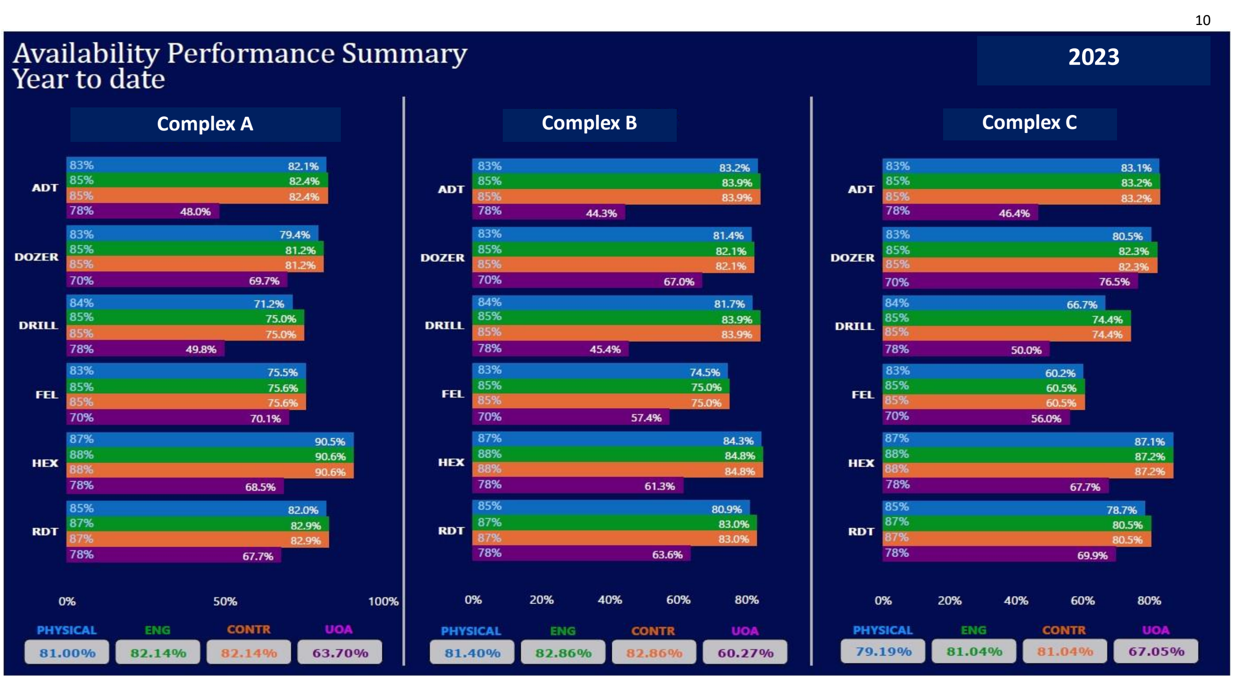
Figure A: Engineering Maintenance Management

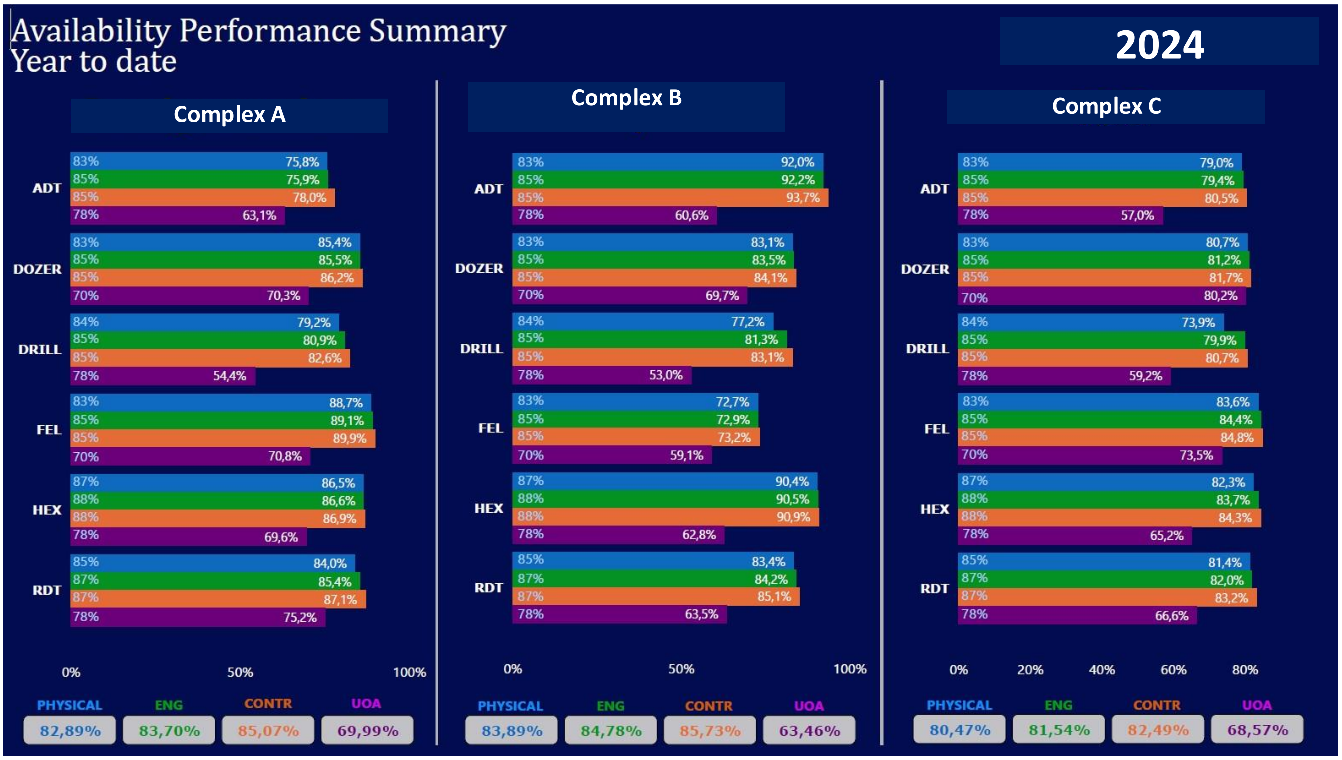
Table A: Recommended Maintenance section versus Actual Staff (OEM/CAT guidelines)

	Equipment Type	Equipment fleet	Maintenance ratio (M&Rhrs/ Ohrs)	Operating hours	Bechmark Maintainer Hours	Required Maintainers	Current Structure Maintainers.(2xAE , 1xBM, 4xDM). Maintenance	Current 4x4 shift DMs unscheduled work	Total current structure
Auxilliary-2 Workshop	ADT (CAT740 & Volvo A	13	0.12	65139	7816.72	9.6			
	RDT 777 waterbowser	3	0.16	15032	2414.44	3.0			
	ADT diesel bowser/con	5	0.12	25054	3006.43	3.7			
	RDT 785 Lowbed	1	0.4	5011	2004.29	2.5			
			0.1	0	0.00	0.0			
	Total equipment	22							
					Total Labour requirements	18.7	7	2	9

APPENDIX B: FLEET MANAGEMENT SAMPLE REPORTS

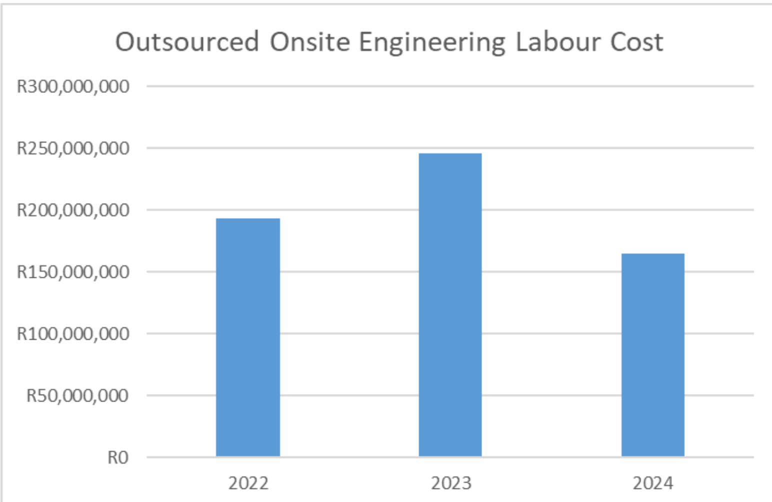




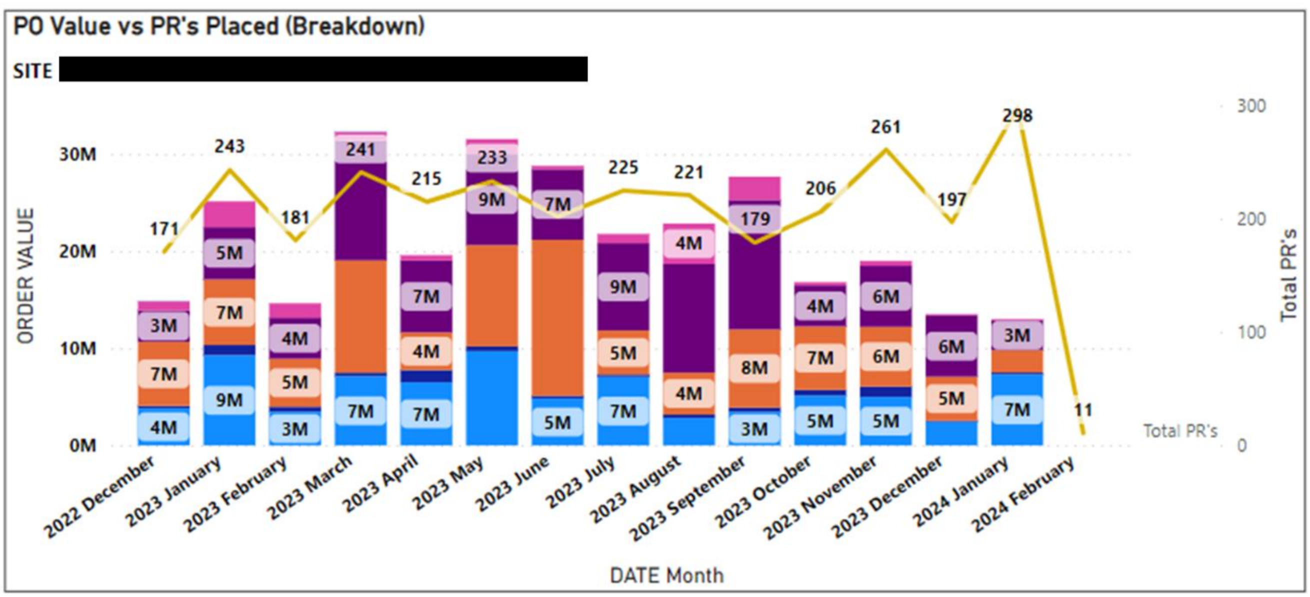

Availability Performance Summary
Year to date
2024
Complex A
Complex B
Complex C
ADT
DOZER
DRILL
FEL
HEX
RDT
PHYSICAL
ENG
CONTR
UOA
82,89%
83,70%
85,07%
69,99%
83,89%
84,78%
85,73%
63,46%
80,47%
81,54%
82,49%
68,57%

APPENDIX C: COST AND BREAKDOWN ORDERS SAMPLE REPORTS

3-year Outsourced Engineering Skills Labour Cost



Breakdown Order Numbers Monitoring Report



Breakdown Order numbers issued to OEMs / non-OEMs

	2022	2023	2024
Number of Breadown Orders Issued	902	912	956
Number of involved Suppliers	54	61	63
Percentage of OEM / OEM Agent Suppliers	38%	42%	40%

APPENDIX D TURNITIN SCORE

Turnitin Originality Report

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The impact of engineering skills outsourcing on asset maintenance costs at South African coal mines Patrick Dyondzisa Ndlovu 2855966 A study report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Management. Johannesburg, 2025 CLASS: BLOCK – 2023/2025 COURSE CODE: BUSA7417A COURSE: Research Project LECTURER: Dr. Jacques Totowa SUPERVISOR: Dr. Tsele Moloi DUE DATE: 30 June 2025 WORD COUNT: 11909 (excl. abstract, contents, references and appendices) i Dedication This work is lovingly dedicated to my wife, whose unwavering support and strength have been my foundation. To my three beautiful daughters, who inspire me every day with their curiosity, tenacity and infectious success energy. To my distant sons, your presence is felt across every mile. And to all those who persevere and make it against all odds, may this study stand as a testament to resilience, hope and the power of belief. Acknowledgements Above all, I am deeply grateful to Almighty God, whose Grace made this MBA journey possible. I extend heartfelt thanks to my family, friends, colleagues, lecturers and classmates for their encouragement, occasional guidance and patience throughout my studies and completion of this research. To my spouse, I appreciate your friendship, mentorship and companionship. I am especially thankful to my Supervisor for his patience, prompt feedback, understanding and availability for support. Declaration I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Wits Business School, University of Witwatersrand. It has not been submitted before for any degree or examination in any other university. I further declare that I have obtained the necessary authorization and consent to carry out this research. Signature Date: 30 June 2025 ii ABSTRACT This study explored the interest in the trend of engineering skills outsourcing (ESO) in South Africa's coal mines and its impact on asset maintenance costs and internal engineering skills development. Through analysis of various documentation from the sample mines and company's owner-maintained diesel mobile fleet equipment maintenance cost and maintenance skills reviews and assessment, the research investigates how outsourcing is conducted at mines as well as how it affects skills development, equipment performance and asset management cost control. The findings demonstrated a complex dynamic where ESO offers advantages and potential risks in relation to maintenance skills, TMM performance and total cost of diesel mobile equipment ownership (TCO). The study found that, frequency of ESO did not impact mobile equipment maintenance cost and availability positively. A notable insight from the study is the immediate gain on equipment uptime from using external expertise without cost implications consideration by the mine. While outsourcing provides access to specialized original equipment manufacturer (OEM) expertise among others with advanced diagnostics, often resulting in better maintenance turnaround and reduced downtime, it can also lead to decline in maintenance skills proficiency as personnel fall out of practice. Dependency on external providers remained the same over the years which corresponded with flatlined specialised maintenance training for internal maintenance personnel. Employee inadequate training or exposure to modern diagnostic tools and OEM-specific advance knowledge creates engineering skills outsourcing dependency vicious cycle. The research also presented systemic challenges within a local artisan training institution, which is ill- equipped to meet general technological advancements and evolving maintenance or diagnostics demands of diesel mobile equipment. The institution's outdated curricula, limited access to modern equipment and weak industry partnerships hinders development of adequately skilled engineering maintenance personnel. These gaps intensify the reliance on engineering skills outsourcing thus limits the coal mines' ability to control/manage maintenance costs predictively. The study then concludes and recommends an integrated approach that combines external expertise engagement for deliberate internal skills transfer coupled with measurable cost control effort. iii TABLE OF CONTENTS Dedication .... ii Acknowledgements .... ii Declaration .... ii ABSTRACT .... iii LIST OF ACRONYMS AND DEFINITIONS .... viii 1. CHAPTER ONE – INTRODUCTION..1 1.1. STATEMENT OF PURPOSE...1 1.2. BACKGROUND OF THE STUDY...1 1.3. PROBLEM STATEMENT...2 1.4. RESEARCH QUESTIONS ....3 1.5. RATIONALE OF THE STUDY ....3 1.6. DELIMITATIONS OF THE STUDY ....4 1.6.1. Sample Size ....4 1.6.2. Access to Information ....4 1.7. ASSUMPTIONS ....4 2. CHAPTER TWO – LITERATURE REVIEW...5 2.1. INTRODUCTION...5 2.2. LITERATURE REVIEW ....6 2.2.1. Effective Outsourcing ....6 2.2.2. Outsourcing impact on skills ....6 2.2.3. Outsourcing Impact on Maintenance Cost ....7 2.3. ANALYTICAL FRAMEWORK...8 2.3.1. Theoretical Framework ....8 2.3.2. Conceptual Framework ....8 2.4. CONCLUSION...9 3. CHAPTER THREE – RESEARCH METHODOLOGY .... 10 3.1 INTRODUCTION... 10 3.2 RESEARCH APPROACH .... 10 3.3 RESEARCH DESIGN .... 10 iv 3.4 DATA COLLECTION METHODS .... 11 3.5 POPULATION AND SAMPLE .... 12 3.5.1 Population .... 12 3.5.2 Sample and sampling method .... 12 3.6 RESEARCH INSTRUMENT .... 12 3.7 DATA ANALYSIS STRATEGY

APPENDIX E ETHICS CLEARANCE

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

Wits Business School

Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number: WBS/BA2855966/175

This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below).

This certificate is only valid if accompanied by formal permission from the relevant stakeholder(s).

Project title	The impact of engineering skills outsourcing on asset maintenance costs at South African coal mines
Investigator / Researcher	Mr Patrick Ndlovu
Nature of Project	MBA (Research Article)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed anonymity and confidentiality.
Issue Date of Certificate	24/10/2024
Expiry date	Date of submission of the project / research report
Chairperson	Dr Ayanda Magida ☎ +27 11 717 3953 ayanda.magida@wits.ac.za

Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.

	21 | 11 | 2024
Signature	Date:

APPENDIX F: DATA USAGE – ORGANISATION'S PERMISSION

Ndlovu, Patrick (Group Services Witbank - ZA)

From:	Du Plessis, Willie (Melrose - ZA)
Sent:	Wednesday, September 25, 2024 6:24 AM
To:	Ndlovu, Patrick (Group Services Witbank - ZA)
Subject:	RE: Request for Permission to conduct study and collect MBA research data at Glencore Coal SA Operations

Hi Partick

It is fine with me. There is a NDA document that we normally complete for this – should be able to obtain from legal team.

Regards

Willie Du Plessis
Glencore Operations South Africa (Pty) Ltd
T: +27 11 772 0651
M: +27 60 997 6952
Willie.DuPlessis@glencore.co.za
www.glencore.com/southafrica

From: Ndlovu, Patrick (Group Services Witbank - ZA) <Patrick.Ndlovu@glencore.co.za>
Sent: Monday, September 23, 2024 5:49 PM
To: Du Plessis, Willie (Melrose - ZA) <Willie.DuPlessis@glencore.co.za>
Subject: Request for Permission to conduct study and collect MBA research data at Glencore Coal SA Operations

Hi Willie,

Trust that you are well.

Attached please find request for permission to access and use Glencore Coal SA's data for my MBA research project.

I hypothesize that through supplementary outsourcing of maintenance activities specifically on (owner maintained) mobile equipment, we have boxed ourselves in the industry in that:

- We have created an environment of heavy reliance on external support that has impacted negatively on the skills of our own workforce: organisations do not share knowledge and expertise to maintain their competitiveness and/or likely 'demotivates' maintenance personnel from learning as well since there is quick accessible alternative solution which results in absence of effective care and maintenance due to insufficient knowledge;
- The above reliance, adds up in maintenance costs due to the inability to influence repair costs but also the inability to adjudicate associated rates (e.g. labour);

1