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The role of asset management on project performance moderated by environmental dynamism on Indonesia's mining project

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In Indonesia, the success of coal extraction largely depends on the role of mining contractors. One of these successes is determined by proper asset management amidst uncertainty in the coal business, such as sustainability and digitalization issues. However, research that identifies the role of asset management in improving the performance of mining projects is still rare. Therefore, this research investigates the impact of Information technology capability, sustainability practices, and asset management on improving the performance of coal mining contractor projects in Indonesia. This research uses quantitative methods, with questionnaire data filled in by 128 project managers of mining contractor projects spread across Indonesia and analyzed by applying structural equation modeling (SEM). The findings indicate that Information technology capability and sustainability practices have a substantial and beneficial effect on improving asset management, which then enhances the performance of mining contractors. Interestingly, there is no direct impact of Information technology capability and sustainability practices on the operational performance of mining projects, so asset management is highly needed. The originality of this study is in the recognition of asset management as a valuable asset for firms that have integrated Information technologies & sustainability practices, as it promotes improved operational performance of projects, and there is still rarely any previous research that examines sustainability practices and asset management, especially mining projects. This research contributes to developing the resource-based view (RBV) theory and also contributes managerially to the practices that mining contractors must carry out when dealing with uncertain business situations.

1. Introduction

Indonesia is one of the largest coal-producing countries in the world. In addition, based on BP statistics, the World's Energy Review (2021) is the second largest coal exporter in the world, so coal mining is a crucial sector in the country (Indriati et al., 2023). The contribution of state revenue from the coal sector accounts for around 85% of all state revenue from the mining sector (Indonesian Ministry of Finance, 2021). Nevertheless, there has been a decrease in coal output in recent years (Central Statistics Agency, 2021; Indriati et al., 2023). One of the reasons mining contractors are successful is that they understand how to make the most of their assets, which include heavy machinery, to maximize output at the lowest feasible cost. One of the strengths a mining contractor must have is the contractor's ability to provide equipment flexibility (Hassan et al., 2005). Conducting a more comprehensive analysis of mining contractors' asset management practices is one strategy for optimizing asset value. In the current study, many researchers argue that maintenance management is an essential strategy in managing a company because production success is primarily determined by assets operating according to specified targets (Bokrantz, 2020). However, not much current research has comprehensively discussed the role of asset management from a strategic perspective because most of the research focus in this area is practice-oriented and focuses on technical aspects (Gavrikova et al., 2020).

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So, in this research, the objective is to comprehend the critical dimensions of asset management as a strategic approach aimed at long-term sustainable performance improvement with asset portfolios as the core of strategic decisions that will create sustainable competitive advantage throughout the organization. One of the theories underlying this research is resource-based theory (RBT), where it is known that resources and capabilities can become a sustainable competitive advantage (SCA), one of which is physical assets in the form of machines or equipment. Machines can be a sustainable competitive advantage if we use them optimally and efficiently. In reality, it is not easy to implement them successfully because equipment investment is a substantial investment, which is influenced by other critical factors (Nugraha & Putranto, 2019; Waris et al., 2014). When maintenance is considered strategically from an overall business viewpoint, maintenance management, as seen from a holistic perspective, necessitates a multidisciplinary approach. According to Bokrantz (2020), Márquez et al. (2009), Pinjala et al. (2006), and other scholars, maintenance management studies encompass more than simply technical subjects; they also investigate the ways that assets influence corporate strategy (Bokrantz et al., 2020; Pinar Pérez et al., 2016; Pinjala et al., 2006). This asset management plan must align with the organization's overarching strategy. Maintenance managers must integrate maintenance operations, resources, and procedures to support their organization's strategic orientation to boost organizational competitiveness (Al-Najjar, 2007).

Based on the findings of a survey carried out by the Indonesian Mining Institute in 2021, it is stated that one of the abilities to optimize the use of resources & capabilities is utilizing technology, especially in managing heavy equipment (IMI, 2021). Several previous researchers' opinions state that information technology capability plays a significant role in risk analysis and decision-making, as well as helping companies with asset management tasks (Attencia & Mattos, 2022). Chiang (2018) reports that companies use inefficient methods by not utilizing technology to manage their assets effectively (Chiang, 2018). However, little research still discusses the role of Information technology capability in improving asset management. The observation results found that the use of technology in supporting the heavy equipment management process in the coal mining industry is not yet optimal (He, 2020; IMI, 2021; Isometric, 2023). There are challenges in implementing information technology (IT), such as data integration (Attencia & Mattos, 2022). The use of technology in measuring the performance of heavy equipment operations has not been optimal (Indrawati, 2017; Tirabeni et al., 2019). However, further study is necessary since opinions on the impact of IT capabilities on performance are still varied (J. Kim et al., 2017; Kmieciak et al., 2018).

In addition to digitalization-related concerns, other serious challenges impact the mining industry, specifically sustainability-related ones (IAP, 2022). So, mining contractors need to implement sustainability practices to be able to respond to these conditions (Ahmadi & Pintado, 2022). Nonetheless, Indonesia is still ranked 97th out of all nations in the 2021 Sustainable Development Report for implementing the Sustainability program (Indonesian Ministry of Finance, 2021). This condition is reinforced by research, which shows that the implementation of sustainability practices in the mining sector is still not carried out optimally (IRESS, 2022). Even though several previous studies have shown that sustainability practices that are carried out optimally can improve performance (Chang & Kuo, 2008; Maletič, 2015; Wagner, 2010). However, there has been no research that identifies the role of sustainability practices on the project performance of mining projects. Given the foregoing context, this study will investigate further how Information technology capability and sustainability practices affect heavy equipment management for mining projects in Indonesia to enhance project performance.

2. Literature Review

2.1 Resources-Based View (RBV)

RBV analyzes the reasons behind the success or failure of companies in the marketplace by focusing on the organization's unique characteristics and internal factors (Dicksen, 1996). Valuable, scarce, non-substitutable, and irreplaceable resources (Barney, 1991) help companies to create and preserve competitive advantages and to use these advantages and resources to achieve higher performance (Grant, 2009; Mathur & Chauhan, 2021; Montgomery & Wernerfelt, 1988). Barney claims that a business's most important assets should allow it to act and behave in ways that increase revenue, reduce expenditures, widen profit margins, or improve total financial value (Barney, 1991). Barney further highlights that resources hold value when they empower a company to comprehend or execute plans that enhance efficiency and effectiveness (Barney, 1991). The benefits of the Resource-Based View (RBV) theory may assist company managers in comprehending why competency is regarded as the paramount asset of the organization. Simultaneously, it enables them to recognize how these assets can be used to enhance business performance (Campbell, A and Luchs, 1997; Cornner, 1991).

2.2 Asset Management

According to the American Association of State Highway and Transportation Officers (AASHTO, 2002), asset management is a method for effectively managing vital infrastructure. Mitchell defines Physical Asset Management (PAM) as the comprehensive management of an asset across its complete life cycle, including its design, operation, maintenance, and eventual disposal (Mitchell, 2002). Mitchell defines asset management as a strategic and cultural process that aims to maximize the efficacy, value, profitability, and return of production and manufacturing equipment assets throughout their lives (Mitchell, 2002). Siregar explains asset management as the strategic process of maximizing the use of assets in order to achieve both operational and financial advantages. This approach includes minimizing ownership expenses, optimizing asset availability, and maximizing asset utilization (Siregar, 2004).

2.3 Information Technology Capability

Firms with value, rareness, inimitability, and non-substitutability resources may acquire a competitive advantage by building on the RBV of diversity. As a result, IT can be seen as a tool that produces a competitive edge that results in increased performance (Chen & Tsou, 2012). In his research, Ja Shen Chen divided Information technology capability into 4 main dimensions: Information technology infrastructure, business expertise in information technology, resources for managing relationships in information technology, and human resources specialized in information technology (Chen & Tsou, 2012). The core of IT infrastructure allows businesses to facilitate the dissemination of information among different functions, deliver business applications and services, and adapt to changes in business strategy (Chen & Tsou, 2012). According to Sambamurthy and Zmud (1997), a company with IT business experience can effectively combine its IT strategy and business plan (Chen & Tsou, 2012; Kans, 2018). The company's capacity to leverage IT resources and integrate IT activities into business units is known as relationship resources (Chen & Tsou, 2012). The IT asset base includes IT human resources as a crucial element. These resources are important organizational capabilities and strategic resources.

2.3 Sustainability Practices

Sustainability practices are essential to corporate strategy in almost every industry (Abbas et al., 2022). According to Chang's research, businesses prioritizing sustainable practices can increase their profits (Chang & Kuo, 2008; J. Y. Chong, 2022). Four categories can be used to categorize the outcomes of sustainability: environmental (pollution elimination, waste reduction, reduced energy and resource consumption, and delivery, quality, cost, and flexibility); social (living wages and working conditions); and economic/financial performance (Ahmadi & Pintado, 2022; Maletic et al., 2017). According to Sergio (2022), sustainability practices fall into three primary categories: social, environmental, and economic (Begnini et al., 2022).

2.4 Environmental Dynamism

According to researchers in strategic management (Ruba et al., 2023), there are three aspects of the business environment, one of which is environmental dynamism (ED). The speed and unpredictability of changes in the external environment define Environmental dynamism (Saeed, 2020). Demand fluctuations can make the environment unstable, which reduces the amount of information accessible for decision-making and makes it harder to assess both the present and future trends in the environment (Saeed, 2020). According to Min and Kim (2022), companies must allocate resources in a highly uncertain business environment to take advantage of chances and build new markets. This impacts organizational performance (Akinradewo, 2021; Jin & Kim, 2022). According to Li and Liu (2014) and Petrus (2019), Environmental dynamism illustrates the degree of fluctuation and change seen in the corporate environment. Researchers have identified a variety of elements that contribute to environmental dynamism (Li & Liu, 2014). These could include how much a company's operations change when it implements emerging technologies, the introduction of cutting-edge technologies in the market, shifts in consumer preferences and culture, economic factors, the unpredictable behavior of rivals, changes amidst political and security upheaval, transitions in governmental policies, and additional characteristics of a comparable kind (Ruba et al., 2023). In research conducted by Zhang (2020), he divided environmental dynamism into four constructs: market dynamism, technological dynamism, and regulatory dynamism (Zhang & Sun, 2020).

3. Hypothesis Development

3.1 The correlation between asset management and project operational performance in the mining projects

The primary goal of this research is to maximize invested assets to produce improved performance. Asset management is one of the variables examined in this study model. As demonstrated by numerous prior studies, asset management significantly impacts the operational performance of projects. According to one study finding, Horizon Construction Ltd.'s operational performance and asset management correspond positively with budget allocation, standard compliance, and asset maintenance. This implies that Horizon Construction Ltd.'s operational success and asset management are related. Asset management and operational performance have a significant positive association (R=0.993) (Kayitare Sam, 2021). Numerous studies have examined project performance, corporate performance, and construction equipment management (Samee & Pongpeng, 2015). Maletič et al. (2017) share empirical evidence in another study examining how PAM practices affect sustainability performance (Maletic et al., 2017). Multiple investigations have been carried out to test the correlation between asset management variables and performance, and the findings suggest that these two factors have a positive and statistically significant impact. These studies include the ones mentioned above as well as Han et al., 2021, Maletič et al., 2020, Samee & Pongpeng, 2015, and Damjan et al., 2018 (Maletič et al., 2018; Maletič; et al., 2020; Rivera Baena, 2021; Samee & Pongpeng, 2015).

Hypothesis 1. *The impact of asset management resilience on project operational performance is both positive and statistically significant.*

3.2 The correlation between Information technology capability and project operational performance in the mining projects

Numerous earlier studies have extensively examined the impact of Information technology capability in enhancing business performance. There is a positive correlation between Information technology capability and a company's performance, according to (Kala Kamdjoug et al., 2019) theoretical model, which examines the direct impact of Information technology capability on three dimensions: IT management, IT infrastructure, and IT personnel. The study's findings offer strategies for maximizing Information technology capability to improve business performance (Kala Kamdjoug et al., 2019). Businesses use Information technology capability to maximize business efficiency by boosting revenue, cutting costs, or occasionally doing both. Information technology (IT) in business has revolutionized organizations' operations with developments like the Internet, mobile computing, and enterprise (Cherian et al., 2023). Businesses with high ITC operate better and are more efficient, enabling them to quickly adapt to changes in any unpredictable environment (Cherian et al., 2023). The projected impact of ITC on the company's IT and infrastructure performance is discussed in the literature (Liu et al., 2013) ITC as a mediating element, according to the study, enhances performance (Siagian, 2021).

Hypothesis 2. *The impact of Information technology capability on project operational performance is both positive and statistically significant.*

3.3 The correlations between Information technology capability and asset management in the mining projects

Condition-based predictive maintenance is one example of how technology significantly and favorably affects asset management (Bousdekis et al., 2015). An alternative investigation conducted by Balouei Jamkhaneh and colleagues confirmed a theoretical framework explaining the connection between CMMS, pertinent organizational supporting elements, and TPM (Jamkhaneh et al., 2018). More specifically, the H1 results of this study show that there is a favorable correlation between CMMS concepts and asset management effectiveness. The results of this study align with research by Rastegari & Mobin (2016), which demonstrates that in order to more effectively identify system malfunctions, Strategic planning, effective management, and expert help The administrative functions have the capability to generate preventive maintenance schedules and provide real-time access to these schedules (Rastegari & Mobin, 2016).

This research shows that supporting organizational factors related to technology development (CMMS) increases the role of asset management. This aligns with studies conducted by (Aboelmaged, 2014; Jantunen et al., 2009) highlighting technology utilization. Further research revealed that several Industry 4.0 advanced technologies, such as machine learning and cloud computing, IoT, Big Data, augmented reality, and artificial intelligence, have a significant impact on asset management (Greenblatt & Shaheen, 2015). Apart from the research above, several studies empirically test the Information technology capability variable and asset management and provide research results that show that Both of these factors have a substantial and favorable impact (Attencia & Mattos, 2022; He, 2020; Jamkhaneh et al., 2018).

Hypothesis 3. *The impact of Information technology capability on asset management is both positive and statistically significant.*

3.4 The correlation between Information technology capability and project operational performance mediating with asset management in the mining projects

It was discovered from some literature in earlier research that the Information technology capability significantly affects the performance of companies. Externalities, resource preparedness, entrepreneurial leadership, and externality absorption capabilities as antecedents are the four factors that Zainal Arifin's research has examined as determinants of Information technology capability (Zainal Arifin, 2015). According to the abovementioned research, some studies (Abbas et al., 2022; Michel-Villarreal, 2023; Zhu & Wu, 2022) empirically examine asset management variables that positively influence the connection between Information technology capability and operational performance (Abbas et al., 2022; Michel-Villarreal, 2023; Zhu & Wu, 2022).

Hypothesis 4. *The impact of Information technology capability on project operational performance mediated asset management is positive and statistically significant.*

3.5 The correlation between sustainability practices and project operational performance in the mining projects

The production, sale, and use of goods and services are the three main pillars of the economy. Otherwise stated, this influences financially and economically favorable outcomes and the profitability of an organization (Gomes Silva et al., 2022). The environmental pillar is predicated on many strategies for protecting the environment, conserving natural resources, and gradually reducing environmental harm (Gomes Silva et al., 2022). The social pillar is concerned with advancing human resources, including establishing instruments to raise people's standard of living, laws to meet the populace's demands, and improved regulations in fields like security, recreation, and education. In addition, to foster the holistic growth and advancement of every employee who participates, it is essential to foster an atmosphere that promotes genuine and healthy professional relationships (Gomes Silva et al., 2022). Chong et al. (2018) and Wagner (2010) state that a company model prioritizes sustainability can be profitable (L. Chong et al., 2018; Wagner, 2010). A recent study conducted by Maletic et al.

(2015) found that an organization's financial performance improved when it engaged in more sustainability-related activities (Chong et al., 2018).

Hypothesis 5 *The impact of sustainability practices on project operational performance is positive and statistically significant.*

3.6 The correlation between sustainability practices and asset management in the mining projects

A prior study clarified the importance of sustainability practices in developing port operating assets. According to S. Kim and Chiang (2017), these practices significantly contribute to the establishment of a sustainable competitive advantage and enhancing business performance, particularly in terms of operational effectiveness and service quality improvement (S. Kim & Chiang, 2017). Additionally, asset management can have a significant and favorable mediating effect between operational performance and sustainable practices, according to a study conducted by Damjan Maletic (Maletič et al., 2019). In addition to the research mentioned above, several other studies empirically test the variables of asset management and sustainability practices and provide findings indicating a significant and positive relationship between these two variables (Hami et al., 2019; S. Kim & Chiang, 2017; Maletič et al., 2019).

Hypothesis 6. *The impact of sustainability practices on asset management is positive and statistically significant.*

3.7 The correlation between sustainability practices and project operational performance mediating with asset management in the mining projects

In other research, it is stated that asset management is crucial as a mediator between TQM and business performance. Asset management practices will lead to different levels of business performance (Ahmad & Barner-Rasmussen, 2019). Additionally, Li and Liu elaborated on this point, stating that certain sustainability practices have a substantial and favorable influence on superiority in the marketplace (Li & Liu, 2014). In a paper developed by Zahra and George (2002), we contend that dynamic capabilities, including internal innovation initiatives and external knowledge assets, give organizations a competitive edge that empowers them to surmount unfavorable economic circumstances (Zahra & George, 2002). Research conducted by Damjan Maletic shows that asset management mediates significantly between sustainability practices and operational performance (Maletič et al., 2019).

Hypothesis 7. *The impact of sustainability practices on project operational performance-mediated asset management is positive and statistically significant.*

3.8 The correlation between asset management and project operational performance moderating environmental dynamism in mining projects

As the global economy grows more interconnected, new markets are opening up, placing enormous pressure on manufacturing firms to adapt to the shifting needs of their clientele, who expect minimal levels of product and service improvements. Integrating all maintenance-related processes and activities throughout the organization may provide a competitive advantage. In an uncertain and competitive world, maintenance has become one of the most effective corporate methods for achieving meaningful improvements in manufacturing performance (Patel et al., 2017). In addition to the research mentioned above, a number of studies empirically test environmental dynamism variables that moderate the connection between asset management and project operational performance. These studies' findings demonstrate these two variables' significant influence (Maletič et al., 2020).

Hypothesis 8. *Environmental Dynamism influences moderating the relationship between asset management & project operational performance.*

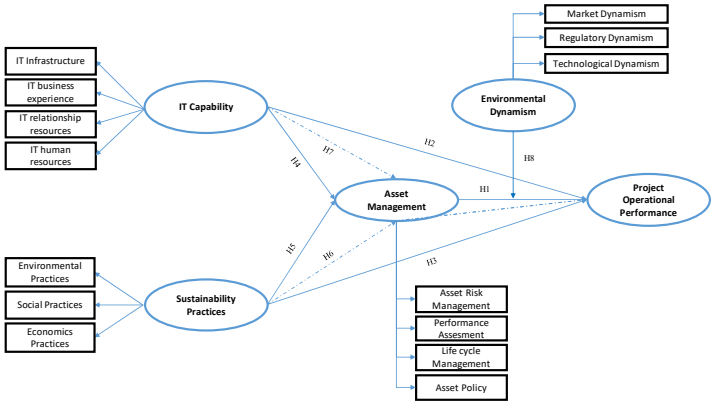

Fig. 1. Research Model

Based on earlier studies, a research model was created and is shown in Figure 1. The relationship between asset management, the main variable, and its effect on the operational performance of coal mining contractor projects is shown in this figure. The information technology capacity and sustainability practices factors will be examined in light of earlier literature research in order to determine their effect on enhancing asset management and project operational performance.

4. Research Methodology

Using a quantitative study approach, the research investigated the effects of asset management, environmental dynamic, and sustainability practices, as well as information technology capabilities, on project operational performance.

4.1 Sample Data Collection

In order to collect data for this study, questionnaires will be used. Through the administration of questionnaires, participants will be requested to fill out research instruments designed to measure phenomena. Five response items (numbered from 1 = highly inappropriate to 5 = highly appropriate) will be included in the questionnaire, which will be gathered using the Likert scale approach. The questionnaire aims to collect data from a sample of 128 project managers working for mining projects in Indonesia. Using four construct-related variables at a significance level of 5% and an R2 value of 0.10, the sample size calculation approach outlined in Hair et al. 2017 (Hair et al., 2017) produced the least amount of sample of 113 respondents (Hair et al., 2017). The sampler approach utilized in this research was based on a purposive sampling methodology, a non-probability sampling process. The participants in this study are project managers employed by Indonesian coal mining contracting firms. Data were collected from 128 respondents who completed the surveys that were distributed to all project managers.

4.2 Scale Development

The questionnaire statements were derived from research tools used in prior studies. The asset management component comprises 10 survey statements devised by Maletic et al. (2018). The sustainability practices component consists of 6 survey statements developed by (Begnini et al., 2022). The Information technology capability component comprises 8 survey statements developed by S. Chen & Tsou (2012). The environmental dynamism component comprises 6 survey statements that Harun et al. (2023) developed. Lastly, the project operational performance component comprises 6 survey statements (Abeysekara et al., 2019; Begnini et al., 2022; Chen & Tsou, 2012; Harun et al., 2023; Qamruzzaman & Karim, 2020).

4.3 Model Measurement

PLS-SEM, or part least square with structural equation modeling, was utilized to ascertain the causal connection among the latent variables incorporated in the structural equation. The data was examined using Smartpls 4.0.9.5. The data will be examined and tested using multivariate structural equation modeling (SEM) procedures after the computation method based on the survey results. The data was analyzed using Smartpls 4.0.9.5. The outer and inner models are two stages of the instrument examination. The criteria for the outer model examination are Outer Loading>0.7, Average Variance Extracted (AVE)>0.5, Composite Reliability (Pc)>0.7, Cronbach's Alpha>0.6, and Discriminant Validity (Hair et al., 2017).

5. Results and Discussion

5.1 Sample Description

In this research, 128 project managers represented Indonesian contractors for coal extraction with the following respondent profiles.

Table 1
Respondents Description

Description	Attribute	%	Description	Attribute	%
Age (years old)	<35	2,34%	Overburden per years (BCM)	< 25 Mio	20,31%
	35 – 40	22,66%		25 - 50 Mio	25,78%
	40 – 45	34,38%		50 - 75 Mio	9,38%
	45 – 50	17,19%		75 - 100 Mio	21,88%
	>50	23,44%		> 100 Mio	22,66%
Educational Background	High School	22,66%	Coal per years (Ton)	< 2 Mio	16,41%
	Diploma	12,50%		2 - 5 Mio	26,56%
	Bachelor	58,59%		5 - 7 Mio	17,97%
	Magister	3,91%		7 - 10 Mio	9,38%
	Doctoral	2,34%		> 10 Mio	29,69%
Year in mining contractors (years)	<5	0,00%	Asset Quantity (Unit)	< 100	17,97%
	5 – 10	3,13%		100 - 200	30,47%
	10 – 15	18,75%		200 - 350	24,22%
	15 – 20	40,63%		350 - 450	6,25%
	>20	37,50%		> 450	21,09%

The data shown in the table indicates that the majority of respondents are project managers between the ages of 40 and 45 with a bachelor's degree and have worked for a mining contractor for 15-20 years. The project profile handled is dominated by coal production of more than 10 million tons per year and has total production equipment of more than 100 units.

5.2 Reliability and Validity

1. Outer loadings

Validation and verification of the research instruments employed constitute the subsequent phase, where in validity testing, it is represented by an outer loading value > 0.7 and an AVE > 0.5. A Cronbach's alpha value exceeding 0.6 and a composite reliability value surpassing 0.7 indicate reliability in testing (Hair et al., 2017).

Table 2
Outer Loading and AVE Test

Variables & Indicators	Outer Loading	AVE	Variables & Indicators	Outer Loading	AVE
Sustainability Practices (SP)			**Information Technology Capability**		
SP1 - Increased productivity	0.775	0.608	IT1 - Budget for hardware	0.782	0.648
SP2 - Cost Efficiency	0.723		IT2 - Budget for software	0.815	
SP3 - Environmental impact	0.789		IT3 - IT Strategy Alignment	0.807	
SP4 - Waste and emissions	0.809		IT4 – IT Business operations	0.830	
SP5 - Commitment to K3	0.799		IT5 - IT Business integration	0.865	
Environmental Dynamism (ED)		0.563	IT6 - Building Collaboration	0.841	
ED1 - Unpredictable market	0.700		IT7 -IT Flexibility	0.727	
ED2 - Regulatory changes	0.711		IT8 - new technology	0.764	
ED3 – Technology Uncertainty	0.785		**Asset Management (AM)**		0.577
ED4 - innovation opportunities	0.799		AM1 - Information system	0.725	
Project Performance (OPC)		0.701	AM2 - Asset history	0.757	
OPC1 - Costs decrease	0.754		AM3 - Life cycle asset	0.816	
OPC2 - Productivity increases	0.873		AM4 - Preventive maintenance	0.705	
OPC3 - Quality increases	0.874		AM5 - Asset Disposal	0.802	
OPC4 - Customer satisfaction	0.893		AM6 - Strategic asset	0.768	
OPC5 - Profit increases	0.837		AM7 - Asset procedures	0.738	
OPC6 - Revenue increases	0.781				

The outcomes of the smartpls evaluation, as seen in Table 3, show that all indications have loading factors more than 0.7, therefore meeting the requirements for a significant convergent validity.

2. Path Coefficient

An additional evaluation in the smartPLS outer model that gauges the reliability of each indication in the model is called the route coefficient test. One indicator that may be evaluated is Cronbach's Alpha, which has to be higher than 0.7. Others may also be considered. In addition, it is required that the extracted average variance value (AVE) be more than 0.5 and the composite reliability value be greater than 0.7 (Hair et al., 2017).

Table 3
Construct Reliability and Validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)
Asset Management	0.877	0.880	0.905
Environmental Dynamism	0.741	0.750	0.837
IT Capability	0.922	0.928	0.936
Project Performance	0.914	0.923	0.933
Sustainability Practices	0.838	0.842	0.886

The results of the examinations of concept validity and reliability are shown in Table 3. As per the assessment outcome, the latent variable has a significant level of reliability if its Cronbach's Alpha score is higher than 0.7. The reliability testing procedure included assessing the data obtained from the exploration instrument for sufficient internal consistency. When determining if discriminant validity requirements are met, the Average Variance Extracted-AVE measurement produced a result larger than 0.5 (Hair et al., 2017).

3. Discriminant Validity

Simulation analysis conducted by (Henseler et al., 2015) demonstrated that the methods mentioned above lack the capability to precisely detect the absence of discriminant validity in commonplace research situations (Hair et al., 2019; Henseler et al., 2015). Hence, in light of the multitrait-multimethod matrix, these authors propose an alternative approach—the heterotrait-

monotrait ratio of correlations (HTMT)—to assess discriminant validity. Henseler, Ringle, and Sarstedt (2015) illustrate the enhanced efficacy of this methodology through a Monte Carlo simulation analysis (Henseler et al., 2015). They do so by juxtaposing it with the Fornell-Larcker criterion and assessing the consequences of (partial) cross-loadings. In conclusion, the authors provide suggestions for addressing challenges related to discriminant validity in variance-based structural equation modeling.

Table 4
Discriminant Validity Result - HTMT

	Asset Management	Environmental Dynamism	IT Capability	Project Performance	Sustainability Practices
Asset Management					
Environmental Dynamism	0.374				
Information Technology	0.782	0.404			
Project Performance	0.642	0.484	0.567		
Sustainability Practices	0.645	0.279	0.513	0.505	
Environmental Dynamism x Asset Management	0.157	0.213	0.070	0.108	0.116

Table 4 presents the responses obtained from the discriminant validity test (HTMT). When two reflectively measured constructs have an HTMT score less than 0.90, discriminant validity between them has been demonstrated. The objective of discriminant validity is to determine the degree to which the latent construct differs from other constructs.

5.3 Hypothesis Testing

1. T Statistic

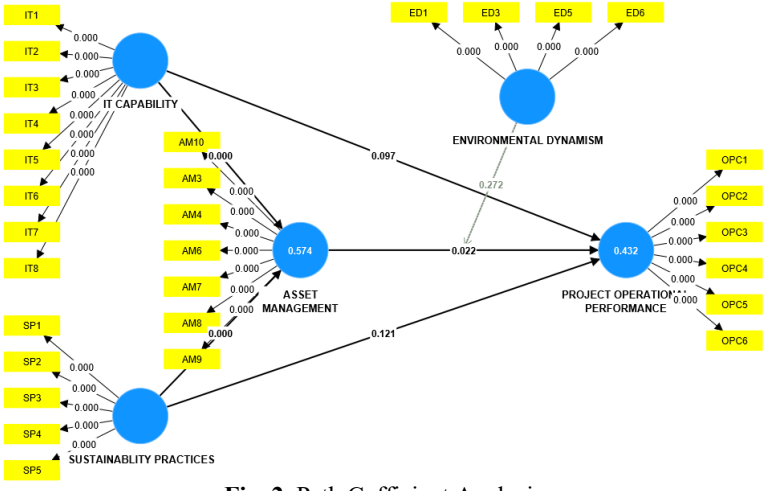

Fig. 2. Path Cofficient Analysis

The route coefficients analysis, which shows the direct impact of exogenous factors on endogenous variables, is shown in Fig. 2 of the smartPLS research. Determining a number of parameters that demonstrate the relationship between endogenous and exogenous variables—including the p-value, T statistic, and path coefficient—is essential for this investigation. When the external variable has a p-value of less than 0.05, it is statistically significant for the endogenous variable.

2. Path Coefficient

Table 5
Original Sample Table

HYPOTHESIS	ORIGINAL SAMPLE (O)	T STATISTICS (|O/STDEV|)	P VALUES	RESULT
AM → OPC	0.291	0.127	0.022	Accepted
ED → OPC	0.237	0.085	0.005	Accepted
IT → AM	0.577	0.064	0.000	Accepted
IT → OPC	0.179	0.108	0.097	Not Accepted
SP → AM	0.294	0.076	0.000	Accepted
SP → OPC	0.140	0.090	0.121	Not Accepted
ED X AM → OPC	-0.101	0.092	0.272	Not Accepted

The aforementioned data provides an explanation of the p-value, which is the likelihood of the quantity of observed opportunities according to the test statistic. It is considered successful to have found a significant relationship if the p-value is less than 0.05, which suggests that the study results show a major influence.

Table 6
Indirect Effect (Asset Management as Mediating Variable)

HYPOTHESIS	ORIGINAL SAMPLE (O)	T STATISTICS (|O/STDEV|)	P VALUES	RESULT
IT → AM → OPC	0,168	2,076	0,038	Accepted
SP → AM → OPC	0,085	1,984	0,047	Accepted

According to the above table analysis, asset management has a statistically significant t-value of 1.984 when it comes to mediating the relationship between project operational performance and sustainability practices, and a t-value of 2.076 when it comes to mediating the relationship between environmental practices and information technology capability.

3. R-Square

The effect of the independent variable on the dependent variable is measured using a statistic called R-squared. Ranging from 0 to 1, the R-squared value represents the degree of interaction between independent variables influencing the dependent variable (Hair et al., 2010).

Table 7
R Square

	R^2	R^2 adjusted	Category
Asset Management	0,574	0,568	Moderate
Project Performance	0,432	0,409	Moderate

An R-square value of 0.574, as shown by the assessment results, suggests that 57.4% of the project's operational performance is attributable to independent causes. The remaining 42.6% are impacted by probe findings that have not been verified.

4. Q-Square Predict

Q-square prediction is an analysis stage intended to measure the level of relevance of predictions from a research model. The Q-square value explains that the endogenous variable is correct when predicted by the exogenous variable. Like the R-square value, the Q-square value also has several criteria, including 0, 0.25, and 0.5, indicating that its predictive relevance to the PLS path model is minor, medium, or large (Hair et al., 2019).

Table 8
Q Square Predict

	Q^2	Effect Size
Asset management	0,548	Large
Project Performance	0,310	Medium

In this study, the Q-Square prediction value was obtained, as shown by the Q-square value for all variables greater than 0.25. This condition explains that the predictions for the Asset Management and Project Operational Performance variables are correct or relevant. For example, the Q-square Asset Management value is 0.548 > 0.25, so the IT capability and sustainability Practices variables are appropriate and relevant to use as predictors of the Asset Management variable (Hair et al., 2019).

6. Discussion

As explained in the previous descriptive analysis, almost all coal mining projects use many assets, and these assets are worth a significant investment so that optimal asset management will efficiently support the achievement of coal production targets to improve the project's operational performance. This is following the research results in hypothesis 1 (p-value 0.022 & path coefficient 0291), which states that asset management significantly and positively impacts the enhancement of project performance. This study supports research performed by Maletič et al. (2017). This study investigates the influence of physical asset management (PAM) practices on sustainability performance through empirical research (Maletic et al., 2017). This study presents empirical findings that demonstrate the substantial and favorable impact of PAM practices on sustainability practices. Therefore, PAM practices should be implemented in asset-intensive industries, according to the positive arguments supported by this study. This study provides a scholarly contribution by establishing the construct validity of the PAM and examining its correlation with sustainability performance (Maletic et al., 2017). This also supports research by Samee et al. (2015), which

found that carrying out effective evaluations related to asset management will support increased project performance (Samee & Pongpeng, 2015).

IT capability is something that is highly needed in managing company assets. From the descriptive data, it is stated that the majority of respondents have a considerable amount of heavy equipment in one project. This heavy equipment is high technology and uses sensors installed on the heavy equipment to monitor the health condition being operated. IT capabilities are crucial in supporting the management of high-tech heavy equipment assets. Sensors installed in heavy equipment units need to have their data managed very well to be used for strategic decision-making regarding optimizing the life of the heavy equipment being operated. However, sensor data cannot be used optimally if a project does not have the infrastructure in the form of wireless devices that can capture the data in real-time. The conditions above will operate effectively when a project has provided a funding budget that supports the required hardware or software availability. The research results in hypothesis 3 (p-value 0.000 & path coefficient 0.577) show that IT capability positively and significantly affects improving asset management. The above hypothesis is in accordance with previous research conducted by Jamkhaneh et al. (2018), where it was stated that the existence of a computerized maintenance management system (CMMS) had a positive impact on the effectiveness of asset management in companies (Jamkhaneh et al., 2018). These findings align with previous research by Rastegari & Mobin (2016), which demonstrates that preventive maintenance schedules can be developed and provided in real-time by the planning, management, and assistance administrative functions in order to more effectively detect system components malfunctioning (Rastegari & Mobin, 2016). However, hypothesis 2 (p-value 0.097 & path coefficient 0.179) shows that IT capability has no significant impact on the operational performance of a project. Some previous studies also support the rejected research results (H. J. Kim, 2017; Kmieciak et al., 2018). Furthermore, hypothesis 4 (p-value 0.038 & path coefficient 0.168) shows that asset management positively and significantly mediates the relationship between IT capability and project performance. This is also supported by several previous studies which show the same research results (Abbas et al., 2022; Michel-Villarreal, 2023; Zhu & Wu, 2022).

The research results in hypothesis 6 *(p-value 0.000 & path coefficient 0.294)* show that sustainability practices have a powerful effect on improving asset management. This is in accordance with the previous study, which explains that sustainability practices have an essential impact on building port operating assets (S. Kim & Chiang, 2017). In the descriptive analysis, it is stated that the project's commitment to increasing productivity impacts heavy equipment asset management activities. This is in accordance with the project strategy to be able to obtain production as large as possible at the most efficient cost possible through optimal use of heavy equipment. However, hypothesis 5 *(p-value 0.121 & path coefficient 0.140)* shows that sustainability practices have no significant impact on project operational performance. Several previous studies also support the rejected findings (Jin & Kim, 2022). Furthermore, research conducted by Damjan Maletic explains that asset management can provide significant and positive mediation between sustainability practices and operational performance; this supports hypothesis 7 *(p-value 0.047 & path coefficient 0.085)* (Maletič et al., 2019). So, the conditions above can provide the view that sustainability practices have an impact on improving the company's asset management.

From the test results in hypothesis 8 (p-value 0.272 & path coefficient -0.101), environmental dynamism was not proven to strengthen the relationship between asset management and project operational performance. The initial hypothesis of this research actually shows that environmental dynamism is proven to moderate the relationship between asset management and project operational performance, This aligns with the findings of a study carried out by Stav Fainshmidt (2017), asset management capabilities that develop in a broad environment will cover the spectrum of routine change activities and thereby increasing the MNE's ability to react in the global economic crisis (Fainshmidt et al., 2017). However, this research provides different results, such as environmental dynamism not being proven to strengthen the relationship between asset management and project operational performance. This rejected viewpoint is consistent with prior investigations, which state that environmental dynamism does not have a moderating impact on project operational performance, such as findings conducted by Ruba et al., (2023), which conducted a cross-sectional study where The investigation failed to provide insight into the temporal implications of environmental dynamism on the correlation between asset management and the performance of the firms above (Ruba et al., 2023). The reason the hypothesis in this research was rejected is thought to be because, in the research, there were 30% of mining projects had a large coal production capacity of more than 10 million tons of coal per year, and 19.5% of projects used more than 450 units of heavy equipment. On the one hand, the large quantity of heavy equipment provides flexibility when there is a sudden increase in production so that the project can optimize the use of these heavy equipment assets to achieve coal production targets. This condition is also caused by several factors, such as mining projects who are used to changes and competition in the market, so this is not too influenced by environmental dynamism.

7. Conclusion

From the conditions above, it can be concluded that asset management is crucial for coal mining projects because the managed heavy equipment largely determines the success of coal production. The descriptive data analysis and inferential data analysis above show that the project manages a large number of heavy equipment assets with large investments so that effective asset management will support the increased performance of coal mining contractor projects. From the conditions above, it can be concluded that IT capabilities that are well implemented in projects can improve the performance of asset management owned. As also illustrated in the descriptive analysis, some research respondents have implemented IT capabilities in projects to

manage heavy equipment assets. Sustainability practices that are implemented well in projects can improve asset management. As also shown in the descriptive analysis, the majority of research respondents have implemented sustainability practices in projects to realize optimal heavy equipment asset management. Sustainability practices and IT capability are essential foundations for projects to improve asset management so that they can impact and improve project operational performance in uncertain mining business situations.

Although this research shows interesting results that there is no direct effect of IT capability and sustainability practices on project performance, this enriches the view in theory based on RBV. One of the study's limitations is the methodology employed in the data collection process. A research questionnaire is used as part of the survey approach used in the data collection process. Of course, one of the research's limitations that will affect the accuracy of the findings is the subjectivity involved in confirming each statement. It is recommended that future research use similar but different variables for respondents who hold coal mining concessions in Indonesia. The present study offers a comprehensive understanding of the potential implementation of this technique between coal concession owners and mining projects in Indonesia.

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