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Innovation as a Mediator in the Influence of Transformational Leadership and Digital Technology on Sustainability Performance

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Abstract

This study aims to examine the relationship between transformational leadership and digital technology on sustainability performance, mediated by innovation. Data analysis used the Structural Equation Model (SEM) method with SmartPLS. Respondents numbered 180 people, obtained through a questionnaire distributed via Google Forms at PT Adaro Energy Indonesia. The results showed that transformational leadership and digital technology influence sustainability performance and innovation. However, innovation does not influence sustainability performance. Innovation also does not mediate the relationship between transformational leadership and digital technology on sustainability performance. Transformational leadership motivates and empowers employees, drives innovation and changes that focus on long-term goals, and instils a vision that considers social, environmental, and economic aspects in a sustainable manner. This increases employee commitment and quality of work so that organizational performance can be maintained in the long term. The practical implications indicate that organizations should prioritize the direct implementation of transformational leadership practices and digital technologies while simultaneously developing organizational capabilities that can leverage innovation for sustainability outcomes.

Keywords: Transformational Leadership, Digital Technology, Sustainability Performance, Innovation

INTRODUCTION

Sustainability has now emerged as a major concern for organizations as it offers opportunities for development, long-term growth, competitive advantage, and financial viability (Sahuri, 2023; Sartika, 2024). The sustainability of organizational performance is not only measured from the economic aspect, but also includes environmental and social dimensions that are increasingly receiving global attention (Asiaei et al., 2021; Fuzi et al., 2022; Rauter et al., 2023; Srisathan et al., 2020). Therefore, organizations are required to integrate sustainable practices into their business strategies in order to survive and thrive in the long term. In this context, innovation plays an important role as a mechanism that connects transformational leadership and digital technology with the achievement of sustainability performance. Innovation enables organizations to create new solutions that are more efficient, environmentally friendly, and oriented towards social value (Huo et al., 2024)

This study examines the influence of transformational leadership and digital technology on organizational sustainability performance, with innovation as a mediating variable. Transformational leaders not only direct a clear strategic vision but also encourage the creation of a culture of innovation that supports the exploration of new ideas, cross-functional collaboration, and the effective application of digital technology in business processes. (Byukusenge et al., 2021) argue that to improve sustainability performance, organizations must dynamically achieve high performance that is valuable in social, environmental and financial aspects. Innovation is needed to increase competitiveness and achieve sustainable performance. The use of digital technologies such as artificial intelligence, big data, and the Internet of Things (IoT) allows organizations to increase efficiency, reduce costs, and create new products and services that are more responsive to market needs (Asiaei et al., 2021; Rauter et al., 2023).

This research is appropriate for companies in various industrial sectors that are facing the challenges of digital transformation in achieving sustainability. Digital leadership plays a role in directing digital strategy and innovation, as well as practitioners and decision makers who are responsible for implementing digital technology to improve sustainability performance. Currently, this research is important because digital transformation and awareness of sustainability are the main priorities of organizations in the 2000s. The rapid development of digital technology and global demands for environmentally and socially friendly business practices make the timing of this research very relevant and urgent.

On the other hand, transformational leadership as a leadership style that emphasizes employee inspiration, motivation, and empowerment has been shown to have a significant positive impact on organizational performance. Transformational leaders not only direct a clear strategic vision but also encourage the creation of a culture of innovation that supports the exploration of new ideas, cross-functional collaboration, and the effective application of digital technology in business processes. Although many organizations have adopted digital technology and transformational leadership, there is still a lack of understanding of how these two factors directly and indirectly (through innovation) affect sustainability performance. Innovation is considered the key linking transformational leadership and digital technology to sustainability performance (Cabrero et al., 2025; Dhyanasaridewi et al., 2024; Maksum et al., 2024).

A quantitative approach with data collection from organizations that have implemented transformational leadership and digital technology is appropriate for this study. Statistical analysis will be conducted to test the direct relationship between transformational leadership and digital technology on sustainability performance, as well as the mediating role of innovation in the relationship. This method allows the study to provide strong empirical evidence regarding the mechanism of the influence of transformational leadership and digital technology on sustainability performance through innovation.

Many studies have confirmed the direct influence of transformational leadership on sustainability performance (Amin et al., 2019; Nasir et al., 2022) Transformational

leadership on innovation (Al-Zu'bi et al., 2025; Yu & Xiang, 2024) digital technology on sustainability performance and innovation. However, the mediating role of innovation as a mechanism connecting transformational leadership and digital technology with sustainability performance is still under-tested. Research on sustainability focuses mostly on financial sustainability (Hanaysha & Al-Shaikh, 2024; Vrontis et al., 2023). In addition, most studies still focus on financial or operational performance in general, without specifically highlighting aspects of sustainability that include economic, environmental, and social dimensions. In fact, sustainability performance is now a major strategic issue in the digital era.

This study examines the influence of transformational leadership and digital technology on organizational sustainability performance, with innovation as a mediating variable. Transformational leaders not only direct a clear strategic vision but also encourage the creation of a culture of innovation that supports the exploration of new ideas, cross-functional collaboration, and the effective application of digital technology in business processes.

The use of digital technologies such as artificial intelligence, big data, and the Internet of Things (IoT) allows organizations to increase efficiency, reduce costs, and create new products and services that are more responsive to market needs (Brous et al., 2020; Dhanaraju et al., 2022; Madakam et al., 2015; Motlagh et al., 2020). This research is appropriate for companies in various industrial sectors that are facing the challenges of digital transformation in achieving sustainability. The energy sector, particularly coal mining companies like PT. Adaro Energy Indonesia, represents a critical context where sustainability pressures and digital transformation intersect most intensively.

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This study aims to examine the direct effects of transformational leadership and digital technology on sustainability performance, investigate innovation's mediating role

in these relationships, provide theoretical contributions by integrating RBV and Transformational Leadership Theory and offer practical implications for energy sector organizations pursuing sustainable digital transformation. Theoretical Contributions are integration of RBV and Transformational Leadership Theory in sustainability research, enhanced understanding of innovation's role in sustainability performance, development of a comprehensive model linking leadership, technology, and sustainability. Practical Contributions are strategic guidance for energy sector organizations on sustainable digital transformation, evidence-based recommendations for leadership development and technology implementation and framework for managing innovation in sustainability contexts.

RESEARCH METHO

The study employed a cross-sectional design, with data collected during May–June 2025 to examine the relationship between variables and test the impact of transformational leadership and digital technology on sustainability performance, with innovation as a mediator. The population consisted of all employees of PT Adaro Energy Indonesia, numbering approximately 12,000 across various operational levels. Based on the guidelines of Hair et al. (2011), the minimum sample size was determined to be 180 respondents, calculated from 36 indicators in the measurement model. Purposive sampling was used, targeting employees with direct experience in digital technology implementation and sustainability initiatives. Questionnaires were distributed to managerial and operational employees via Google Forms through email groups.

As a quantitative study, the analysis used the Structural Equation Model (SEM) method with SPSS 26 and SmartPLS 3.0 for data processing. Validity and reliability tests were conducted using factor analysis in SPSS. The Kaiser Meyer-Olkin (KMO) and Measure of Sampling Adequacy (MSA) values from the first 30 respondents were used to assess validity; values above 0.5 indicated suitability for factor analysis. Reliability was tested using Cronbach's Alpha, with values above 0.7 indicating good reliability (Hair et al., 2011). The study included independent variables (transformational leadership and digital technology), a dependent variable (sustainability performance), and a mediating variable (innovation).

Measurement Variables

Transformational Leadership ((Rusmawati & Indriati, 2019)		SA	A	Q	D	SD
1.	Leaders become the pride of the company					
2.	Leaders prioritize common interests					
3.	Leaders can be trusted to bring progress to the company					
4.	Leaders build employee optimism					
5.	Leaders foster employee self-confidence					
6.	Leaders provide innovative input					

7.	Leaders encourage the emergence of creative ideas from employees
8.	Leaders encourage employees to continue learning
9	Leaders support problem solving in innovative ways
10	Leaders are willing to be mentors to foster employees
Sustainability Performance (Yusoff et al., 2019) and (Yong et al., 2019)	
1.	Our business utilizes waste products to generate additional income
2.	Our business saves input/raw materials to achieve a certain level of output/income without neglecting the quality aspect.
3.	To achieve the desired level of income, our business strives to save through waste product management.
4.	To protect the interests and existence of the business, we work together with staff from government agencies
5.	There is an increase in the welfare of stakeholders/stakeholders as a whole.
6.	There is an increase in the social health of the community around the business environment.
7.	There is a decrease in the negative impact or risk of business on the environment and society.
8.	There is an increase in employee health and safety
9.	There is an increase in compliance with environmental regulatory standards.
10.	There is a decrease in air emissions/air pollution levels
Digital Technology (Lazar et al., 2020)	
1.	My organization can adjust budgets to meet changing technology needs.
2.	I work with other teams to create a digital technology plan.
3.	I use flexible and collaborative approaches to develop my skills in using modern technology.
4.	I leverage modern technology (such as cloud and google workspace) to increase speed and ease.
5.	Using digital tools helps me get my work done faster.

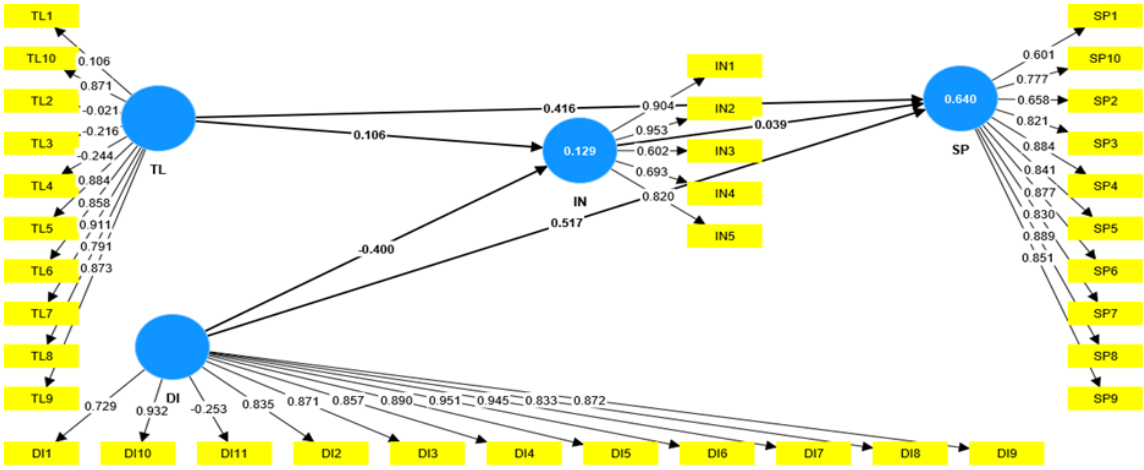
6.	Using digital tools improves my performance.
7.	Using digital tools improves my efficiency.
8.	Using digital tools is clear and easy to understand for me.
9.	My organization measures technology based on business outcomes, not just system uptime
10.	Using digital tools makes it easier for me to exchange knowledge
11.	Using digital tools also helps me in my self-learning process

Innovation (May et al., 2024)	
1.	Driven to bring new ideas to life and advance innovative solutions in the business
2.	Adapt at sharing new ideas in the business.
3.	Enthusiastic to have the freedom and support to implement innovative ideas in the business
4.	Feel there are open channels of communication to promote innovative ideas in the business
5.	Share knowledge, resources or support with employees to drive innovation in the business

RESULTS AND DISCUSSION

Validity and Reliability Test

Before hypothesis testing, construct validity and reliability tests have been conducted previously. In this study, convergent validity (loading factor), composite reliability (CR), and average variance extracted (AVE) tests were conducted. The initial stage of the convergent validity test measures the validity of the reflective indicators by looking at the outer loading value of each indicator. The initial test conducted is a validity test by looking at the outer loading value of all indicators. The outer loading value of each indicator that is below 0.7 is considered invalid and will be removed from further processing. In this data, the indicators with values less than 0.7 for the Transformational Leadership variable are TL1, TL2, TL3, TL4. The Digital Technology variable indicators below 0.7 are DI1, and DI11. For the Sustainability Performance variable, the invalid ones are SP1 and SP2. While for the Innovation variable, they are IN3 and IN4. The path diagram of this research is:



For the reliability test, it can be seen from the AVE and Cronbach Alpha values. According to (Hair et al., 2011) data is declared reliable if it has a Cronbach Alpha value > 0.7 and an AVE value > 0.5. The following are the Cronbach Alpha and AVE values of this data.

Table 1. Value of AVE and Cronbach Alpha

	Average Variance Extracted	*Cronbach Aplha*
Tranformational Leadership	0,771	0,941
Digital Technology	0,697	0,937
Innovation	0,670	0,887
Performance Sustainability	0,760	0,954

Based on the output of the R-square value, Innovation = 0.108, meaning that the transformational leadership and digital technology variables in this study can explain the innovation variable by 10.8%, the remaining 89.2% is explained outside this study. Next, the sustainability performance variable can be explained together by transformational leadership, digital technology and innovation by 50.2%, the remaining 49.8% is outside this study. The following is the R Square value of this data.

Table 2. Value of R square

	R Square	**R square adjusted**
Innovation	0,117	0,108
Sustainability Performance	0,510	0,502

Hypothesis testing in this study uses T Value and P Value. If the P Value shows the score <0,05 the hypothesis is accepted. Below are the following results:

Table 3. Hypothesis Test

Hypothesis	Statement	T value	P Value	Information
H1	Transformational Leadership has an effect on Sustainability Performance	3,477	0,000	data supports the hypothesis
H2	Digital Technology has an effect on Sustainability Performance	14,698	0,000	data supports the hypothesis
H3	Transformational Leadership has an effect on Innovation	2,040	0,021	data supports the hypothesis
H4	Digital Technology has an effect on Innovation	5,840	0,000	data supports the hypothesis
H5	Innovation has an effect on Performance Sustainability	0,220	0,413	data does not support the hypothesis
H6	Innovation mediates the relationship between Transformational Leadership and Performance Sustainability	0,176	0,425	data does not support the hypothesis
H7	Innovation mediates the relationship between Digital Technology and Performance Sustainability	0,215	0,415	data does not support the hypothesis

Based on the hypothesis test, 4 hypotheses were accepted and 3 other hypotheses were rejected.

Discussion

The first hypothesis is that transformational leadership has an effect on sustainability performance. Transformational leadership has an effect on sustainable performance because this leadership is able to motivate, inspire, and empower employees to contribute optimally, while encouraging innovation and change that focuses on the organization's long-term goals. Transformational leaders increase employees' intrinsic motivation by providing meaning and purpose behind their work, not just routine tasks. This makes employees more enthusiastic and committed to working with high quality continuously. By encouraging creative thinking and innovation, transformational

leadership helps organizations adapt to change and find new solutions that can support long-term sustainability. This innovation is essential to maintaining the relevance and competitiveness of the organization. Transformational leaders instil a vision that emphasizes the importance of sustainable performance, not just short-term results. They help organizations consider social, environmental, and economic aspects in every decision, which is very important for business continuity. This leadership style also fosters a sense of trust and empowers employees to take greater initiative and responsibility, which in turn increases the effectiveness and flexibility of the organization in facing challenges.

The second hypothesis is digital technology has an effect on sustainability performance. Digital technology has an effect on sustainable performance because it enables operational efficiency, better resource management, product and service innovation, and transparent tracking and reporting on social and environmental aspects. By digitizing business processes, organizations can reduce waste of time, costs, and resources. Automation and the use of real-time data enable faster and more precise decision-making, making processes more efficient and having a positive impact on sustainability. Digital technology presents opportunities for innovation in more environmentally friendly or sustainable products and services, such as green technology-based solutions, digital platforms for circular economy businesses, and others, supporting sustainable performance goals. The use of digital tools helps organizations collect, analyse, and report data related to social and environmental performance transparently and accurately. This increases stakeholder accountability and trust in the company's sustainability commitments. Thus, digital technology becomes the main catalyst in creating sustainable performance that is effective, innovative, and socially and environmentally responsible.

The third hypothesis transformational leadership has an effect on innovation. Transformational leadership has an effect on innovation because this leadership style is able to inspire, motivate, and encourage employee creativity to think outside the conventional boundaries and take the risks needed in the innovation process. Transformational leadership focuses on raising employee enthusiasm and commitment with a strong vision and positive change. This type of leader encourages employees to not only follow the usual routine, but also dare to try new things. By providing space and support for employees to experiment and explore new ideas, transformational leaders create an environment that is conducive to innovation. This also includes accepting failure as part of the learning and innovation process. Transformational leaders are usually visionary and proactive in identifying future opportunities and challenges. They inspire teams to adapt and develop innovative solutions that are relevant to changes in the business environment. Transformational leaders empower employees by giving them greater trust and authority in decision-making. This increases their sense of ownership and responsibility for the innovation initiatives they undertake. By raising employees' intrinsic motivation through inspiration and recognition, transformational leadership makes employees feel that their work is meaningful and important, so that they are

encouraged to contribute creatively and innovatively. Thus, transformational leadership plays a key role in driving innovation in organizations by creating a work culture that supports creativity, continuous learning, and positive change.

The fourth hypothesis is digital technology has an effect on innovation. Digital technology has an effect on innovation because it provides tools, platforms, and infrastructure that enable the creation, development, and application of new ideas more quickly, efficiently, and widely. Digital technology includes various technologies such as cloud computing, big data, artificial intelligence, the Internet of Things (IoT), and various digital platforms that support the innovation process. Digital technology accelerates the development of new products and services through process automation, digital simulation, and online collaboration that facilitates efficient and integrated research and development (R&D). Digital tools enable real-time collaboration across teams and locations, as well as rapid access to global sources of information and knowledge that can inspire and reference innovation. Digital technology is a key enabler that changes the way organizations innovate, making the innovation process more dynamic, responsive, and effective in meeting market needs and modern business challenges.

Furthermore, innovation has an effect on sustainability performance is not proven in this study. Innovation does not always have a direct effect on sustainable performance because its influence can be influenced by various contextual factors and organizational conditions, such as the level of environmental concern, the type of innovation carried out, and moderation from other factors such as environmental management and organizational culture. Although innovation is often considered a major driver of sustainability, several studies have shown that the effect of innovation on sustainable performance is not always positive or significant. This is because innovation itself has many forms and has uneven impacts on social, environmental, and economic aspects. The relationship between innovation and sustainable performance can depend on the context, such as industry, organizational culture, and level of environmental concern. For example, green innovation will only have a positive impact on sustainable performance if it is supported by strong environmental concern at the managerial level.

The next hypothesis innovation mediates the relationship between transformational leadership and sustainability performance was not proven in this study. Innovation was not proven to mediate the relationship between transformational leadership and sustainable performance due to several factors such as the complexity of the innovation process, the role of other moderating or mediating variables, and the characteristics of innovation that are not always in line with sustainability goals. Transformational leadership does encourage creativity and innovation, but the innovation that emerges does not necessarily have a direct impact on sustainable performance. This process can be very complex and is influenced by how the innovation is implemented and directed. It is possible that the relationship between transformational leadership and sustainable performance is mediated by other more relevant variables, such as environmental management, organizational culture, or managerial environmental concerns. Innovation itself may need to be focused on the sustainability aspect (green

innovation) in order to strengthen the influence of leadership on sustainable performance. Not all innovations support sustainable practices; innovations that are oriented solely towards economic efficiency without considering social and environmental impacts may not be enough to improve sustainable performance. This reduces the mediating power of innovation in the relationship.

The next hypothesis innovation mediates the relationship between digital technology and sustainability performance is also not proven in this study. Innovation is not proven to mediate the relationship between digital technology and sustainable performance because the process of transforming digital technology into innovation that truly contributes to sustainability is very complex, and the resulting innovation does not always focus on sustainability aspects, so the mediation effect is not significant. Digital technology does provide the foundation and tools for innovation, but not all innovations that emerge from digital technology are directed or implemented to support sustainable performance. The influence of digital technology on sustainable performance can occur directly without going through innovation as an intermediary. The success of digital technology in improving sustainable performance through innovation is highly dependent on the organization's strategy, culture, and focus of the innovation itself. If innovation is more oriented towards economic efficiency alone without considering social and environmental impacts, then the innovation is not an effective mediator. Digital technology can directly affect sustainable performance through increased operational efficiency, transparency, and monitoring of environmental impacts, so innovation as a mediator is not always needed to explain the relationship. Several studies have shown that innovation is not always a significant mediating variable in the relationship between digital technology and sustainable performance because of the direct role of digital technology in improving organizational processes and outcomes.

Due to the limitations of a longitudinal approach, a more in-depth and sustained analysis of the relationship between transformational leadership, digital technology, innovation, and sustainability performance is highly recommended. Further research should also expand the scope of study to other sectors and regions, such as logistics, transportation, and digital services, to test the consistency of the relationships among the variables identified in this study.

Theoretical Implications

This study makes several theoretical contributions:

1. Integration of RBV and Transformational Leadership Theory: The study demonstrates how leadership and technological resources can directly influence sustainability performance, providing an integrated theoretical framework.
2. Contingency Theory Application: The findings suggest that innovation's mediating role is contingent on organizational and industry context, supporting contingency theory perspectives in innovation research.
3. Sustainability Performance Theory Development: The study contributes to sustainability performance theory by identifying direct pathways from leadership and

technology to sustainability outcomes that bypass traditional innovation mediation models.

CONCLUSION

The study found that transformational leadership and digital technology significantly influenced sustainability performance and innovation, although innovation itself did not directly affect sustainability performance nor mediate the relationship between the two. Transformational leadership encouraged employee motivation, creativity, and long-term commitment, while digital technology enhanced operational efficiency, transparency, and the innovation process through tools such as AI, IoT, and big data. However, the effectiveness of innovation in improving sustainability performance appeared to depend on organizational context, including environmental awareness, culture, and management practices. Therefore, companies should promote transformational leadership styles, integrate digital technologies strategically, and cultivate a culture of innovation oriented toward sustainability goals. Future research should explore other possible mediating or moderating variables—such as green organizational culture or environmental management practices—to better explain how innovation contributes to sustainability performance across different organizational contexts.

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