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Sustainability Accounting Transformation Through the Application of Digital Technology and AI: An Analysis of ESG Reporting in Energy Sector Companies Listed on the IDX in 2021-2024

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ABSTRACT

This study aims to examine the extent to which the application of digital technology and Artificial Intelligence (AI) affects the quality of Environmental, Social, and Governance (ESG) reporting in energy sector companies listed on the Indonesia Stock Exchange (IDX) during the 2021–2024 period. The research approach used is quantitative-descriptive with multiple linear regression analysis methods, based on secondary data obtained from annual reports and corporate sustainability reports. The analysis results indicate that neither digital technology nor AI has a significant influence on the quality of ESG reporting, either partially or simultaneously. The coefficient of determination (R^2) value of 0.125 indicates that these two variables only explain 12.5% of the variation in ESG reporting quality, while the remainder is influenced by other factors outside the model. This finding indicates that the application of modern technology has not effectively improved the quality of sustainability reporting, which is likely due to limited digital infrastructure, low levels of technological literacy, and the lack of integration of technology use into corporate sustainability strategies.

Keywords: ESG, Digital Technology, Artificial Intelligence, Sustainability Accounting, Energy Sector.

INTRODUCTION

Environmental, Social, and Governance (ESG) reporting is a form of reporting that highlights a company's non-financial performance. Through ESG, companies convey information about their responsibilities and performance in environmental, social, and governance aspects to stakeholders. ESG disclosure is an extension of voluntary reporting practices undertaken by companies and can also serve as a reference for investors in assessing company performance more comprehensively (Riyanto et al., 2024). Global developments in sustainability issues are encouraging companies to focus not only on achieving financial performance but also on environmental, social, and governance (ESG) dimensions. The energy sector, known as a major contributor to carbon emissions and other environmental impacts, faces significant pressure to implement more sustainable business practices. In this context, sustainability accounting plays a crucial role as a tool for assessing and reporting a company's ESG performance in a transparent and accountable manner.

The implementation of ESG in the energy sector is currently closely linked to the digital transformation process, which serves as a key driver of carbon emissions management strategies, particularly for Scope 3 emissions, which are known to be the most complex due to their indirect nature. The case study that is the focus of the discussion is the use of the Greenomina digital platform by PT Pertamina (Persero) as a means to monitor, manage, and ensure accountability for carbon emissions in the Indonesian energy industry (Fitriastuti & Sunitiyoso, 2025).

Although the implementation of Environmental, Social, and Governance (ESG) principles in the Indonesian energy sector has shown progress, the quality of reporting remains relatively low and does not fully align with international transparency standards. Many companies view ESG reporting solely as a form of regulatory compliance, rather than as a strategy integrated with business sustainability values. As a result, the information presented often lacks depth and is not easily comparable across companies. Furthermore, the use of digital technology and artificial intelligence (AI) in ESG reporting remains minimal, despite their significant potential to improve the accuracy, efficiency, and reliability of sustainability data. Barriers such as limited digital infrastructure, low technological literacy, and high implementation costs are key barriers to the adoption of digital-based reporting systems. Research by Eriandani (2023) found that ESG has a positive impact on company performance, but digitalization has not significantly strengthened this relationship. Other studies also confirm that ESG reporting practices in Indonesia are still dominated by manual approaches and have not widely adopted technologies such as big data analytics or blockchain to strengthen transparency and accountability (Accounting, 2025). Thus, there is a significant gap between the potential of digital technology/AI and current ESG reporting practices in the Indonesian energy sector.

Advances in digital technology and AI-based solutions are contributing to the global economic progress that characterizes the Industry 5.0 era. Industry 5.0 is defined as a system in which technological devices or robots are connected to the human brain and operate in partnership with humans as collaborative agents (Eka et al., 2024). With the development of digital technology and artificial intelligence (AI), sustainability accounting practices are undergoing significant transformation. These innovations enable companies to prepare ESG reports more effectively, efficiently, and in real-time. The application of these technologies supports the process of data collection, analysis, and presentation, enhancing the credibility and accountability of sustainability reports.

The application of ESG principles actually provides various tangible benefits for energy companies, beyond simply following sustainability trends. By seriously addressing environmental, social, and governance aspects, companies can enhance their reputations with the public and investors. This is particularly important for the energy sector, which is often associated with issues of pollution, carbon emissions, and social impacts on surrounding communities. Companies that are transparent in disclosing their environmental impact, actively implement social responsibility, and have good governance systems generally gain greater market trust. This trust encourages investors to be more confident in investing because reputational and legal risks are reduced. Furthermore, implementing environmentally friendly practices such as energy efficiency and investing in renewable energy can reduce long-term operational costs, benefiting not only the environment but also the company's financial well-being. ESG also helps companies better prepare for increasingly stringent government regulations regarding emissions and sustainability. Several studies have shown that companies with high ESG scores tend to have better financial stability and are more attractive to global investors (Eriandani & Winarno, 2023).

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The study focused on energy sector companies listed on the Indonesia Stock Exchange (IDX) during the 2021–2024 period. The energy sector was selected based on its strategic role in the national economy and its significant contribution to carbon emissions and natural resource use. Due to its significant environmental impact, this sector is a key focus in the application of Environmental, Social, and Governance (ESG) principles. Furthermore, energy companies face strong pressure from government regulations and investor expectations for increased transparency in sustainability reporting. The 2021–2024 timeframe was chosen to capture the latest developments in the digital era and growing awareness of sustainability, where the use of technologies such as big data, artificial intelligence (AI), and digital-based reporting systems is gaining ground. Energy companies listed on the IDX are ideal subjects because they are required to submit annual reports and sustainability reports publicly, enabling objective and measurable analysis. With this focus, this study is expected to provide a concrete picture of the transformation of sustainability accounting in the Indonesian energy sector and identify the role of digital technology and AI in improving the quality of ESG reporting.

LITERATURE REVIEW

Legitimacy Theory

According to Guthrie and Parker (1989), legitimacy theory explains that every organization strives to align its operational activities with societal values, norms, and expectations to gain social acceptance. In the context of sustainability reporting, companies use disclosure of information regarding environmental, social, and governance (ESG) aspects as a means to gain public trust and strengthen corporate image. For companies in the energy sector, which have significant environmental impacts, sustainability reports serve as a form of accountability and communication to the public to maintain operational viability. In line with Junius's (2020) opinion, social responsibility encourages companies to actively contribute to sustainable development.

Stakeholder Theory

According to Freeman & McVea (2005), stakeholder theory explains that organizations need to manage relationships with stakeholders as a primary strategy. Stakeholders include individuals or groups that can influence or be influenced by a company's activities. Therefore, a company's responsibility extends beyond its shareholders to employees, customers, suppliers, the government, and the community. Through effective relationship management, a company can create value and maintain business sustainability.

Signaling Theory

Akerlof (1978) stated that information has significant value because each party in an interaction has varying levels of access to information. Signaling theory explains that companies can send positive signals to the market through the disclosure of non-financial information, such as sustainability reports. Junius (2020) emphasized that one of the primary purposes of disclosure is to convey a signal of goodwill from a company to external parties. By utilizing digital reporting systems based on big data and artificial intelligence, companies can increase the reliability and transparency of ESG data, which forms the basis for investors' assessment of sustainability performance.

Digital Transformation in Sustainability Accounting

Digital transformation refers to the use of digital technology to increase the effectiveness and efficiency of reporting processes, both financial and non-financial. According to Bhimani & Willcocks (2014), digitalization in accounting is crucial for increasing transparency, efficiency, and the quality of the information presented. Meanwhile, Nurita & Sisdianto (2025) stated that implementing digital systems in sustainability reporting not only accelerates data collection but also reduces human error and enables real-time analysis. Technologies such as blockchain, cloud computing, and big data analytics contribute to strengthening the reliability and integrity of ESG reports by providing an immutable data track record, which is particularly relevant for energy companies dealing with complex data and having significant environmental impacts.

Hypothesis 1 (H1): The application of digital technology has a positive impact on the quality of ESG reporting.

Peran Artificial Intelligence (AI) dalam Pelaporan ESG

Artificial Intelligence (AI) has significant potential to revolutionize the sustainability reporting process by automating the collection, validation, and analysis of ESG data, as demonstrated by PwC (2021). Möller et al. (2025) demonstrated that AI can improve the quality, speed, and accuracy of ESG information. Furthermore, AI facilitates predictive identification of environmental and social risks, assisting management in making strategic, data-driven decisions. In the energy sector, AI can be utilized to assess carbon emissions, energy efficiency, and compliance with environmental regulations, supporting the concept of digital sustainability accounting, which combines sustainability accounting with intelligent technology.

Hypothesis 2 (H2): The application of AI has a positive impact on ESG reporting quality.

Sustainability Accounting and ESG Reporting

Sustainability accounting aims to provide significant information regarding the social and environmental impacts arising from a company's economic activities. ESG, or Environmental, Social, and Governance, is a key tool in assessing sustainability performance. Elkinton (1998), through the triple bottom line concept, emphasized that companies must consider three main aspects: people, planet, and profit. According to KPMG (2022), more than 90% of large companies globally routinely publish sustainability reports as a form of transparency to stakeholders. In Indonesia, OJK regulations (POJK No. 51/POJK.03/2017) require issuers and financial services institutions to prepare sustainability reports in accordance with Global Reporting Initiative (GRI) standards, making ESG reporting mandatory for public corporations (Machillah Afany Durlista and Ickhsanto Wahyudi, 2023).

Hypothesis 3 (H3): Company size and profitability strengthen the relationship between digital technology and ESG reporting quality.

Sektor Energi dan Tantangan Keberlanjutan

The energy sector is a major source of global carbon emissions. According to a 2023 report by the International Energy Agency (IEA), more than 70% of greenhouse gases were emitted from energy sector activities. In Indonesia, energy companies face significant pressure from investors and regulators to increase transparency in sustainability reporting. The use of digital technology and

artificial intelligence (AI) is considered an effective strategy for increasing the efficiency and accuracy of ESG reporting. Therefore, a study covering the period 2021 to 2024 is crucial to capture the latest developments related to digitalization and growing environmental awareness.

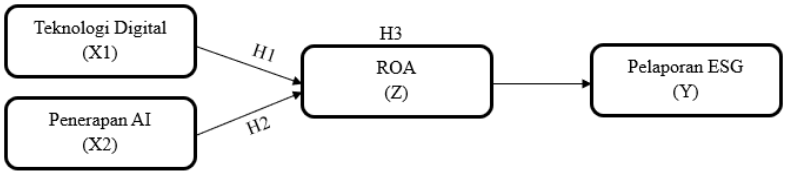

Figure 1. Framework of Thought

RESEARCH METHOD

This research uses a quantitative-descriptive approach with a case study design, with the aim of analyzing how the application of digital technology and artificial intelligence (AI) has impacted changes in sustainability accounting practices, particularly in improving the quality of Environmental, Social, and Governance (ESG) reporting in energy sector companies from 2021 to 2024. The quantitative approach was chosen because it can provide statistically measurable and objective results, while the descriptive approach is used to explain the level of implementation of digital technology and AI in the context of sustainability reporting by companies.

The research subjects were energy sector companies listed on the Indonesia Stock Exchange (IDX) during this period, with a focus on companies that consistently published sustainability reports and annual reports and included information on the use of digital technology and/or AI in their reporting systems.

Table 1. Sample Criteria Used

No	Criteria	Amount
1	Energy sector companies listed on the Indonesia Stock Exchange between 2021-2024.	74
2	Energy sector companies that published financial reports for the 2021-2024 period consecutively.	68
3	Energy sector companies that publish annual reports for the 2021-2024 period.	48
4	Energy sector companies that published sustainability reports during the 2021-2024 period.	36
	Total sample used according to criteria	6
	Total Observations (6 x 4)	24

The sample was selected using a purposive sampling method, meaning the sample was selected based on specific criteria to align with the research objectives. The criteria considered included: (1) active energy sector companies listed on the Indonesia Stock Exchange (IDX) during the research period; (2) companies that regularly publish sustainability reports and annual reports; and (3) companies that include information on the implementation of digital technology and/or AI in their sustainability accounting and reporting processes.

The data used was secondary data, obtained from sustainability reports, company annual reports, and official publications from the IDX and the Financial Services Authority (OJK). Additional data was also obtained from company websites and international databases that adhere to Global Reporting Initiative (GRI) standards. The data collection technique used documentation and content

analysis to evaluate the level of disclosure of information related to digital technology, AI, and ESG reporting.

The data analysis method used was multiple linear regression analysis, with statistical tests conducted using SPSS or Microsoft Excel software.

Before conducting the regression test, a classical assumption test was first carried out, namely the normality, multicollinearity, heteroscedasticity, and autocorrelation tests, to ensure the validity and reliability of the research model.

The analysis model used is formulated as follows: $ESGQ = \beta0 + \beta1\ (DIGITAL) + \beta2\ (AI) + \beta3\ (Z) + \varepsilon$

Where:
ESGQ = ESG Reporting Quality
DIGITAL (X_1) = Level of digital technology implementation in sustainability accounting and reporting systems
AI (X_2) = Level of artificial intelligence use in ESG data collection, monitoring, and analysis
Z = Control variables in the form of company size and profitability
β_0 = Constant
β_1, β_2, β_3 = Regression coefficients of each independent and control variable
ε = Error or residual

Hypothesis testing was conducted using panel data regression analysis. Significance testing was conducted using partial t-tests, coefficient of determination tests, and F-tests to verify the validity of the hypotheses.

RESULTS AND DISCUSSION

Classical Assumption Testing

Because the CEM research approach is used in this study, it is important to conduct assumption testing. Multicollinearity and heteroscedasticity tests are part of the classical assumption testing for this study. Normality testing is not included in the BLUE (Blue Linear Unbiased Estimator) requirements. Data that is not in time series form (cross-section or panel) will not yield significant information from autocorrelation testing.

Normality Testing

The normality test in regression is used to determine whether the distribution of data within a group or variable follows a normal distribution. Data is considered good if it has a normal distribution. In this study, the statistical method used is the non-parametric Kolmogorov-Smirnov test. If the Asymp. Sig. value (2-tailed) is greater than the 0.05 significance level, the data is considered normally distributed.

Table 2. Normality Test Results

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		24
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	10.86922842
Most Extreme Differences	Absolute	.138
	Positive	.119
	Negative	-.138
Test Statistic		.138
Asymp. Sig. (2-tailed)		.200[c,d]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
d. This is a lower bound of the true significance.

Based on the table above, the Asymp. Sig. (2-tailed) value is 0.200. This indicates that 0.200 > 0.05, thus concluding that the data is normally distributed.

Multicollinearity Test

The multicollinearity test is used to determine whether there is a high correlation between independent variables. Excessive correlation will make the regression coefficient difficult to interpret and the results unstable. This test typically uses the Variance Inflation Factor (VIF) and Tolerance values, with the VIF being less than 10 and the Tolerance value greater than 0.1 to be free from multicollinearity.

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	80.469	6.624		12.148	.000		
Teknologi Digital	1.335	.853	.330	1.566	.133	.959	1.043
AI	.620	1.246	.115	.497	.625	.788	1.268
ROA	-.269	.347	-.177	-.777	.446	.815	1.227

a. Dependent Variable: ESG

Table 3. Multicollinearity Test Results

Based on the table above, all variables obtained tolerance values > 0.10 and VIF < 10.00. It can be concluded that all variables above do not exhibit multicollinearity symptoms.

Heteroscedasticity Test

The heteroscedasticity test is conducted to ensure that the residual variance is constant (homoscedasticity). If the residual variance is not constant (heteroscedasticity), the standard error is invalid and the statistical test results can be misleading. This test can be performed using the Glejser, Park, and White methods, or by observing the pattern in a scatterplot graph between the residuals and predicted values.

Table 4. Heteroscedasticity Test

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.956	3.284		3.336	.003
	Teknologi Digital	-.462	.423	-.240	-1.094	.287
	AI	-.047	.618	-.018	-.076	.941
	ROA	.108	.172	.149	.628	.537

a. Dependent Variable: ABS_RES

Based on the table above, all variables have a Sign value > 0.05, so it can be concluded that none of the variables above exhibit heteroscedasticity.

Autocorrelation Test

The autocorrelation test is conducted to detect relationships between residuals from consecutive observations, especially in time series data. If the residuals are correlated, the regression model is considered to not meet the assumption of independence of errors. This test typically uses the Durbin-Watson Test (DW), where a DW value close to 2 indicates no autocorrelation, while a value below 1.5 indicates positive autocorrelation, and above 2.5 indicates negative autocorrelation.

Table 5. Autocorrelation Test

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.388[a]	.151	.023	11.65595	2.008

a. Predictors: (Constant), ROA, Teknologi Digital, AI

b. Dependent Variable: ESG

Given :
d = 2.008
dU = 1.6565
4-dU = 4 – 2.0352 = 2.3435

Based on the table above, it shows that dU < d < 4-dU or 1.6565 < 2.008 < 2.3435, so the null hypothesis is accepted, meaning there is no autocorrelation.

Multiple Linear Regression Test

Multiple linear regression analysis is a statistical method used to determine the relationship between one dependent variable and two or more independent variables and to predict the value of the dependent variable based on the value of the independent variables. The general equation is written as ($Y = a + b_1X_1 + b_2X_2 + ... + b_nX_n + e$), where the regression coefficients indicate the magnitude of the influence of each independent variable on the dependent variable. This analysis process includes data collection, classical assumption testing, regression model development, and significance testing using the F-test and t-test. The results are interpreted based on the coefficient value, significance, and coefficient of determination (R^2) to determine how much the independent variables explain the dependent variable. This analysis is widely used in various fields such as economics, business, and social sciences to understand the influence of several factors on a particular outcome and aid in data-driven decision-making.

T-Test (Partial)

Table 6. T-Test Results

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	78.716	6.169		12.760	.000
Teknologi Digital	1.397	.841	.345	1.662	.111

AI	.203	1.115	.038	.182	.857

a. Dependent Variable: ESG

Note: t-table: 2.07961
The calculated t-value for X1 is 0.111, meaning 0.111 > 0.05. Therefore, we conclude that the x1 value has no significant effect.
The calculated t-value for X2 is 0.857, meaning 0.857 > 0.05. Therefore, we conclude that the x2 value has no significant effect.

The t-test results show that the Digital Technology variable has a significance value of 0.111, and the AI variable has a significance value of 0.857. Both values are greater than 0.05, so it can be concluded that, partially, neither Digital Technology nor AI has a significant effect on ESG reporting. In other words, changes in these two independent variables do not have a significant impact on the ESG dependent variable.

Uji F (Simultan)

Tabel 7. Hasil Uji F

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	400.344	2	200.172	1.502	.246[b]
	Residual	2799.251	21	133.298		
	Total	3199.594	23			

a. Dependent Variable: ESG

b. Predictors: (Constant), AI, Teknologi Digital

Note: F table: 3.47

Based on the table above, the calculated F value is 1.502, which is less than 3.47. Therefore, it can be concluded that the influence of digitalization and AI technology variables on ESG reporting is not significantly significant.

The F test results show that the calculated F value of 1.502 is smaller than the F table value of 3.47, with a significance value of 0.246 (>0.05). This means that the variables of Digital Technology and AI do not significantly influence ESG reporting simultaneously. These two variables, when tested together, are unable to explain significant variation in the dependent variable.

Coefficient of Determination (R^2) Test

Table 8. Test of the Coefficient of Determination (R^2)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.354[a]	.125	.042	11.54546

a. Predictors: (Constant), AI, Teknologi Digital

Nilai diterminasi dilihat dari nilai R Square sebesar 0,125 yang mengandung arti bahwa nilai X1 (Teknologi digital) dan X2 (Penerapan AI) mempunyai peranan sebesar 0,125 x 100 = 12,5% jadi peranan X1 dan X2 mempunyai data sebesar 12,5% terhadap Y.

Nilai R Square yang diperoleh adalah 0,125, yang berarti bahwa variabel Teknologi Digital dan AI hanya mampu menjelaskan 12,5% variasi pada pelaporan ESG, sedangkan sisanya 87,5% dijelaskan oleh faktor lain di luar model. Nilai ini menunjukkan bahwa kemampuan model regresi dalam menjelaskan hubungan antarvariabel masih lemah.

The results of a multiple linear regression analysis indicate that Digital Technology and Artificial Intelligence (AI) variables have no significant effect on ESG (Environmental, Social, and Governance) reporting. This finding indicates that the implementation of modern technology within companies has not directly improved the quality of ESG reporting.

One of the main reasons for this insignificant result may be that technology utilization remains administrative or operational, rather than strategic. Many companies may have used digital technology and AI in their daily activities, but have not yet utilized it as a sustainability management tool or ESG reporting tool. Therefore, their impact on transparency and corporate social responsibility remains limited.

Furthermore, organizational and human resource readiness also play a significant role. Implementing advanced technologies like AI requires technical competence, investment, and a robust data infrastructure. If a company does not fully possess these capabilities, its impact on ESG reporting will not be clearly visible. This aligns with the Technology-Organization-Environment (TOE) theory, which explains that the success of technology adoption is influenced by both internal organizational readiness and external environmental factors.

The insignificant results can also be interpreted as indicating the presence of other factors that are more dominant in influencing ESG reporting. For example, government policy, stakeholder pressure, corporate governance, or environmental awareness may play a greater role than the implementation of digital technology and AI. With a coefficient of determination (R^2) of 12.5%, this indicates that 87.5% of the variation in ESG reporting is explained by variables outside this research model, opening up opportunities for further research.

Empirically, the insignificant results do not necessarily mean the relationship between the variables is irrelevant, but rather may reflect an immature stage of development. In the Indonesian industrial context, the application of digital technology and AI for sustainability purposes is still relatively new, so their impact on ESG may become more visible in the long term as company systems and policies become more integrated with these technologies.

Therefore, the results of this study remain important because they demonstrate that digital transformation does not automatically guarantee improved ESG performance, and that more targeted implementation strategies are still needed, including human resource training, the development of technology-based reporting standards, and increased integration between information systems and corporate sustainability policies**.**

CONCLUSION

The results of the multiple linear regression analysis in this study indicate that the use of digital technology and artificial intelligence (AI) has not significantly impacted the quality of Environmental, Social, and Governance (ESG) reporting in energy companies listed on the Indonesia Stock Exchange (IDX) for the 2021–2024 period. This finding reflects that, although digitalization has become a crucial part of modern business transformation, its application in sustainability reporting practices remains limited and has not been optimally integrated with sustainability accounting systems. The coefficient of determination of 12.5% indicates a relatively small contribution of digital technology and AI variables to improving ESG reporting quality, while the largest influence comes from external factors such as government policies, stakeholder pressure, corporate governance, and the level of awareness of sustainability issues.

Conceptually, this study's results confirm that the adoption of advanced technology will not be effective in increasing transparency and accountability in ESG reporting if it is not balanced by internal organizational readiness, supportive policy formulation, and the technical capabilities of human resources. Currently, most companies still use technology for administrative purposes, rather than to promote strategic, real-time sustainability data management. Barriers such as limited digital literacy, limited infrastructure, and high implementation costs are key obstacles to the digitalization of sustainability reporting.

Practically, this study emphasizes the importance for energy sector companies to strengthen the integration of digital technology and AI into their ESG reporting systems. This effort must be accompanied by the development of an efficient and credible reporting system and the enhancement of digital competencies through ongoing training.

Overall, the results of this study demonstrate that the transformation of sustainability accounting driven by digitalization and AI is a gradual process that requires long-term commitment from various parties, including business actors, regulators, and academics. With effective collaboration, it is hoped that an ESG reporting ecosystem can be established that aligns with global technological advances, making digitalization not only a means of efficiency but also a strategic instrument for increasing transparency, accountability, and sustainable competitiveness in the Industry 5.0 era.

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