
The Impact of Digital Monitoring Technologies on Industrial Risk Management and ESG-oriented Enterprise Sustainability

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Abstract

The article examines the potential of digital monitoring technologies to improve the effectiveness of industrial risk management and to support ESG-oriented enterprise sustainability. It is emphasized that digitalization facilitates the transition from reactive to preventive strategies, reduces the likelihood of incidents, and enhances the transparency of non-financial reporting. Particular attention is given to the economic effects, such as cost reduction, resource optimization, and increased investment attractiveness. The practical part of the article includes an analysis of data from enterprises that have implemented digital ESG solutions, aimed at assessing their impact on operational risks and sustainability performance.

Keywords: Digitalization, Monitoring, ESG, Industrial risks, Sustainability, Predictive analytics, Efficiency.

1. Introduction

Against the backdrop of expanding needs in the areas of environmental, social, and corporate governance (ESG) responsibility, digital technologies become ever more strategically applicable as instruments to achieve sustainable industrial development. Modern manufacturing firms are compelled to react to intensifying regulation and widening public expectations for transparency, safety, and efficiency in manufacturing activities. In these directions, electronic monitoring platforms are drawing particular interest as these systems provide real-time monitoring of manufacturing facilities, preventive risk control, and sustainability compliance.

The goal of this study is to analyze the impact of digital monitoring technologies on reducing industrial risks and enhancing ESG-oriented resilience of enterprises. The article explores practical cases of digital solution implementation and assesses their effectiveness in improving risk governance and achieving non-financial performance targets – such as environmental safety, social stability, and the quality of corporate governance.

2. Main part. Strategic management of industrial risks

Industrial risks represent a set of potential threats associated with disruptions in technological processes, equipment failures, unfavorable working conditions, as well as environmental and social consequences of production activities. As production networks grow more complex and additional sustainability and ESG principles are embraced, effective management of risks is increasingly turning into an organic part of strategic management for manufacturing companies.

Considering the scale of industrial processes, the novel dangers can be classified on various grounds: the source origin, the impact nature, the region of occurrence, and potential effects. Such classification enables one to compose the risk landscape, determine the management priorities, and select adequate digital control and monitoring means (table 1).

Table 1: Classification of industrial risks at a manufacturing enterprise [1, 2]

Risk category	Description	Examples of manifestation
Technological	Disruptions related to the functioning of equipment, production lines, and technological processes.	Equipment failure, automation malfunction, overheating, accident.
Environmental	Risks of environmental pollution and non-compliance with environmental protection regulations.	Chemical leak, emission exceedance, water contamination.
Social and labor-related	Threats to workers' health, safety, and social well-being.	Injuries, occupational safety violations, protests, layoffs.
Information-related	Failures or vulnerabilities in digital and IT infrastructure.	SCADA system failure, cyberattack, loss of production data.
Regulatory	Risks of non-compliance with legal and regulatory requirements.	Violation of industrial safety standards, fines, operational bans.
Financial and economic	Risks impacting the economic stability of the enterprise.	Cost escalation, loss of profit, contract disruption.
Logistical and supply chain	Disruptions in supplies, supply chain instability, operational failures.	Raw material shortage, transport delays, price fluctuations.
Reputational	Deterioration of public, partner, or investor trust.	Media coverage of incidents, ESG rating downgrade, client attrition.

Digital monitoring is playing an increasingly important role in preventive risk management. Such systems make it possible to track critical parameters of the production environment in real time, promptly detect deviations from regulatory values, and initiate corrective actions before emergency situations occur. The preventive function of digital monitoring lies not only in ensuring informational transparency, but also in forming a proactive management approach – focused on prevention rather than elimination of consequences. For example, the use of predictive analytics based on vibration and temperature data from equipment allows for forecasting potential failures several days in advance, thereby minimizing downtime and losses.

It is worth noting that, according to Business Research Insights, the global enterprise risk management (ERM) market reached approximately \$5 billion in 2024 (fig. 1).

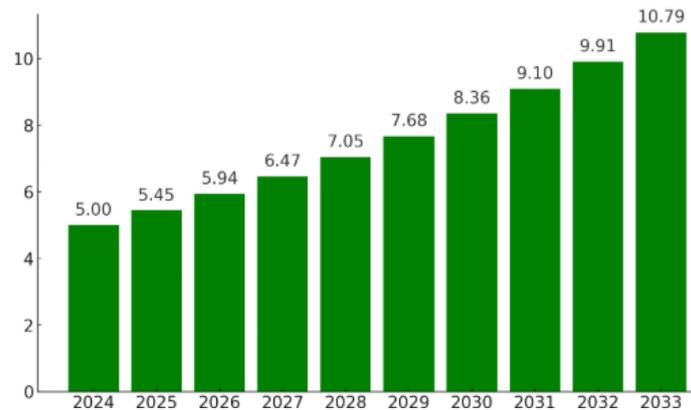


Fig. 1: Global ERM market size, billion dollars [3]

One of the most significant current trends is the transition to data-driven risk management. This approach involves a shift from traditional risk management based on subjective assessments and reactive measures to systematic data analysis (fig. 2).

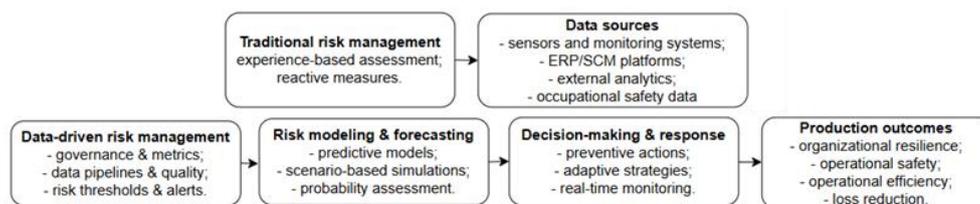


Fig. 2: Transition to data-driven risk management

At the core lies the use of diverse sources of information – production systems, sensors, ERP/SCM platforms, external analytical services, and occupational health and safety data. The structured and unstructured data arrays that are collected by the above process are processed using machine learning algorithms, anomaly detection tools, and Big Data technologies to facilitate the development of digital models and predictive scenarios. Through this, it is able to estimate the probability of events, design adaptive response tactics, and deliver preventive measures that enhance resilience, operational safety, and the efficiency of production processes.

Instituting such analytical systems becomes an issue of incorporating them into existing corporate structures for risk management in order for continuity and consistency to permeate all levels of control. In this context, the integration of digital monitoring with ERM systems and internal control facilitates the formation of a unified informational environment, in which the processes of risk identification, assessment, monitoring, and mitigation occur in an automated and documented manner. According to metrics announced by MetricStream, companies that have been able to successfully adopt risk management programs realize a 63% average reduction in incident occurrence and a 35% reduction in operational loss. This means higher production process controllability, reduced operational and reputational losses, and improved resilience in the ESG agenda, where disclosure and accountability of risk governance become key drivers in the investability and social attractiveness of a company.

Therefore, strategic risk management tools in the digital arena constitute a new industrial safety and resilience paradigm upon which digitalize predictability, response time, and decision-making through data are built.

3. Digital technologies as a driver of ESG sustainability

Digital technologies, including the Internet of Things (IoT), industrial automation systems, big data technologies (Big Data), artificial intelligence (AI), and digital twins, allow enterprises to integrate environmental, social, and governance aspects into the system of operational control and strategic management. According to a report by IoT Analytics, in 2024 the market for sustainability platforms reached \$1.3 billion (fig. 3).

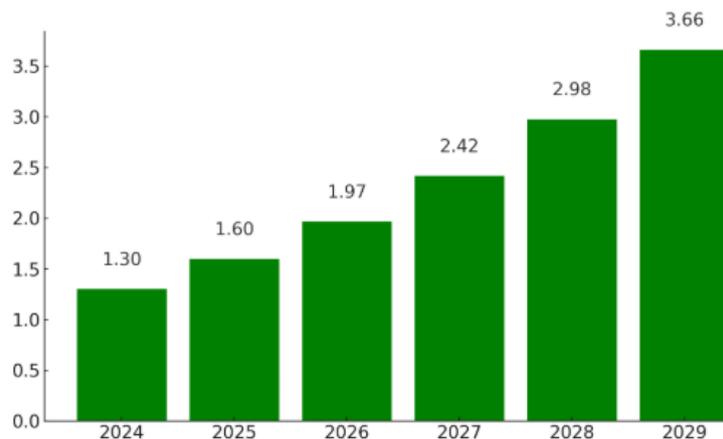


Fig. 3: Market size of sustainability platforms for 2025-2029, billion dollars [4]

From an environmental point of view, digital monitoring systems guarantee measurement and control of the emissions of pollutants, energy and water consumption, and volumes of wastes, necessary for compliance with international environmental standards and policies [5]. Real-time application of sensors and automated systems makes it possible to identify departures from norm values in due time and take corrective action before environmental accidents. For example, according to some studies, the implementation of AI can reduce energy consumption and carbon dioxide emissions by approximately 8-19% by 2050 [6]. In addition, the experience of Cammeby's International emphasizes that smart management of systems allows for energy optimization and cost savings. After 11 months of using BrainBox AI for a high-rise building in New York City, energy consumption related to heating, ventilation, and air conditioning systems was reduced by 15.8%, saving over \$42,000 and reducing carbon dioxide emissions by 37 metric tons.

In the social dimension, digital technologies ensure better control over working conditions and compliance with occupational health and safety standards. Microclimate monitoring systems, video analytics, and biometric solutions ensure constant workplace safety zone monitoring and the ability to respond promptly to arising threats. For example, Gartner research for 2024 states that organizations that use wearable safety technologies had 40% better compliance with safety procedures during the first six months.

In the corporate governance aspect, digital tools provide the foundation for more effective corporate control and accountability. Centralized collection and visualization of data from various divisions of the enterprise enable not only prompt managerial decision-making but also the formation of an evidence base for non-financial reporting. This is especially important in

the context of growing investor and regulator expectations of ESG report quality and reliability. Another reason for this timeliness of the movement towards automated solutions is that, according to Coolset (2024), 47% of businesses are still relying on inaccurate and non-scalable Excel spreadsheets to handle ESG data. This is a reflection of the need to embrace centralized digital solutions such as specialist ESG platforms and visualization systems that ensure non-financial reporting is reliable, thorough, and transparent.

4. Empirical assessment of the effectiveness of implementing digital platforms in production risk management and sustainability

To evaluate the impact of digital solutions on production risk management and sustainability indicators, an empirical study was conducted based on three industrial enterprises that implemented digital monitoring platforms during 2023. All sites belong to the segment of medium-scale production facilities (from 750 to 1,100 employees), operate under continuous production cycles, and use technological equipment management systems.

Description of enterprises:

Enterprise A: manufactures products in the field of mechanical engineering; a modular platform has been implemented to monitor equipment temperature and vibration, featuring predictive analytics capabilities.

Enterprise B: specializes in raw material processing and warehouse logistics automation; the digital solution covers monitoring of climatic and environmental parameters.

Enterprise C: produces materials with high energy density; the monitoring system includes energy consumption sensors, emission indicators, and control of deviations in safety systems.

For the analysis, data were collected as of the end of 2022 (before implementation) and the end of 2024 (one year after operation). The target metrics included incident frequency, response time to deviations, energy consumption, and the maturity of control systems (table 2).

Table 2: Comparison of indicators before and after the implementation of digital monitoring platforms

Indicator	Enterprise A (before / after)	Enterprise B (before / after)	Enterprise C (before / after)
Number of equipment-related incidents	16 / 11	14 / 9	15 / 10
Average response time to critical deviations, h	90 / 55	86 / 54	88 / 53
Energy consumption per unit of output, kWh	103 / 96	102 / 95	98 / 91
Monitoring maturity index	0.46 / 0.74	0.49 / 0.76	0.48 / 0.75

The obtained results demonstrate a consistent positive dynamic across all three enterprises. The reduction in the number of incidents and the decrease in response time to deviations indicate improved efficiency of predictive and real-time control mechanisms. The specific energy consumption indicators confirm the contribution of digital solutions to resource optimization and the achievement of environmental objectives. Particular attention should be given to growth in the Monitoring Maturity Index – a single indicator reflecting the level of automation, the level of coverage of control points, and access to predictive capabilities in monitoring infrastructure. Increase in this indicator not only proves technological advancement but also an increased level of risk management, process transparency, and compliance with the needs of ESG reporting. Thus, the implementation of digital platforms has a comprehensive impact on production sustainability and reduces systemic risks.

5. Economic assessment of the effect of digitalization in the ESG context

The digitalization of processes related to ESG is becoming an important element of the strategic development of enterprises. In addition to ensuring regulatory compliance and strengthening sustainability, digital solutions provide a comprehensive economic effect. This effect manifests itself both in the form of direct benefits (cost optimization, reduction of losses) and indirect advantages, such as enhanced reputation, improved ratings, and reduced financing costs (table 3).

Table 3: Key economic effects of ESG-oriented digitalization [7, 8]

Economic aspect	Before digitalization	After digitalization
Costs from downtime and emergency incidents	High direct losses due to delayed detection and reactive management.	Reduced costs through early detection and automated incident prevention.
Environmental fines and sanctions	Recurring expenses due to insufficient control and regulatory breaches.	Significant reduction in penalties due to real-time environmental monitoring.
Energy and raw material consumption	Resource overuse and untracked inefficiencies.	Increased energy efficiency and lower operational costs.
Occupational safety and labor protection costs	High expenses from incidents, insurance, and compensations.	Reduced accident rates and lower insurance and compliance-related expenses
Costs of preparing ESG reports	Labor-intensive manual data collection and fragmented reporting.	Lower costs through automation and centralized data consolidation.
Audit and compliance costs	Manual document preparation and high administrative burden.	Streamlined and cheaper processes via digital traceability and auto-verification.
Access to financing and investment appeal	Standard financing conditions, no ESG differentiation.	Improved ESG ratings and access to preferential sustainability-linked financing.

Payback period of ESG-related investments	Payback period of ESG-related investments.	Payback period of ESG-related investments.
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All the presented effects confirm that the digitalization of ESG activities has a multi-level impact on the enterprise's economy. It is not only a tool for reducing current expenses but also a factor of strategic development, enabling the reduction of capital costs, optimization of expenditures, and improvement of operational efficiency. Under the growing requirements for non-financial reporting and environmental responsibility, digital platforms provide not only regulatory compliance but also shape a new economic logic of sustainability.

6. Conclusion

Digital monitoring technologies are a key driver of industrial management system modernization, enabling a move away from reactivity and towards proactivity and data-based decision-making. Their use enhances the resilience of manufacturing processes, reduces operation and environmental hazards, and enhances transparency and controllability of corporate decision-making. Digitalization, in conjunction with ESG priorities, assists in strategic reengineering of firms by making them more sustainable, more transparent, and more competitive. Thus, online monitoring becomes not only a technical remedy but also a cornerstone for creating responsible, adaptive, and resistant industrial development.

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