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THE IMPACT OF BIG DATA AND AI ON INNOVATION MANAGEMENT PROCESSES

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Received 11 May 2026; accepted 30 July 2026; published 30 September 2026

Abstract. In the era of digital transformation, innovation is becoming a key driver of enterprise competitiveness. This article analyses the impact of digitalisation on the management of innovation processes, focusing on the use of Big Data, artificial intelligence (AI), and advanced analytics as critical enablers of strategic decision-making. It examines how these technologies allow organisations to identify innovation opportunities more effectively, optimise product development and respond flexibly to rapidly changing market conditions. The article further discusses the main challenges associated with implementing digital solutions in the innovation process, including data quality issues, technical barriers, and organisational change. Finally, it offers practical recommendations for managers to support sustainable, agile, and data-driven innovation management.

Keywords: digital transformation; innovation; innovation management; data-driven innovation; Big Data; AI; data analytics; industrial laundry; circular economy

Reference to this paper should be made as follows: Szabóová, D., Kollár, V. 2026. The impact of Big Data and AI on innovation management processes. *Entrepreneurship and Sustainability Issues*, 14(1), 408-422. <http://doi.org/10.9770/b5575887322>

JEL Classifications: M11, M15

1. Introduction

Under the influence of contemporary digital transformation, organisations are undergoing a fundamental shift in how they generate value for customers, establish relationships with them, and develop their products and services. The rapid advancement of technologies, including Big Data, artificial intelligence (AI), and sophisticated data analytics, brings substantial new opportunities to the field of innovation while simultaneously presenting considerable challenges. Innovation and associated processes no longer rely exclusively on managerial intuition or incremental improvement but increasingly leverage comprehensive, systematic data processing, automated methods, and digital solutions and platforms. This paradigm shift results in enhanced operational efficiency, new opportunities linked to digital innovation and its implementation, and the transformation of organisational structures.

The purpose of this article is to examine how digitalisation transforms innovation, innovation processes, and approaches to their management, with particular attention devoted to the roles of Big Data, artificial intelligence, and data analytics. The text is structured around three key thematic axes: the impact of digital transformation, opportunities to utilise data and AI to identify and evaluate innovation opportunities, and the influence of these changes on managerial decision-making and organisational structures within enterprises. In conclusion, the article presents a comprehensive set of concrete recommendations for managers seeking to effectively integrate contemporary technologies to enhance the performance and agility of their innovative activities.

2. Research Methodology

Research Aim and Research Questions

The primary objective of this contribution is to analyse the impact of contemporary digital transformation and the associated management of innovation processes that leverage AI (artificial intelligence), Big Data, and data analytics. The following research questions were formulated to achieve the defined objectives:

- What impact does the approach to digital management of innovation have on enterprises?
- What role do modern technologies in the form of Big Data and AI play in identifying innovation opportunities?
- What are the primary barriers encountered in the implementation of data-driven innovation?
- How is digitalisation manifested in the industrial laundry sector?

Research Approach and Design

The research is grounded in a qualitative approach, within which theoretical-level analysis is combined with elements of a case study. The theoretical part of the contribution draws on a review of academic literature on digital transformation, the utilisation of contemporary data-oriented technologies, and innovation management in enterprises. The practical part of the contribution focuses on the analysis of a selected, specific sector of market services, namely the industrial laundry sector in the territory of the Slovak Republic. The chosen design enables a more detailed understanding of this contemporary phenomenon within its real-world context. It facilitates the identification of concrete relationships between technological tools and specific processes in innovation management.

Data Collection and Processing Methods

The following methods were applied in the development of this contribution:

- Analysis of secondary sources (scientific articles, academic literature, studies focused on the selected topic, and publications that collectively form the theoretical foundation of the subject matter).
- Comparative analysis (through which traditional and modern approaches to innovation management were compared)
- Case study (analysis of the implementation of innovative digital solutions in enterprises within the selected market services sector).
- Descriptive analysis (systematic processing of collected information and subsequent interpretation of findings).

Data on implemented innovations in industrial laundry enterprises (information systems, web portal, RFID) were obtained from secondary sources and from available information in business practice.

Selection of the Examined Market Services Segment

The industrial laundry sector was deliberately selected due to its highly specific nature as a market services area where traditional manufacturing processes are actively integrated with modern digital technologies to enhance operational efficiency and customer satisfaction. The chosen sector enables us to conduct a detailed analysis of:

- The utilisation of IoT sensors and production automation.
- The implementation of data analytics in enterprise operations.
- The impacts arising from digitalisation on operational efficiency and value creation for enterprise customers.

Research Limitations

The research is subject to several known limitations:

- Limited scope regarding the analysed enterprises within the given services sector.
- Reliance predominantly on secondary sources and information.
- Specificity of the selected services segment.

While these stated limitations do influence the research outcomes, the knowledge gained nonetheless provides significant insights into digital transformation and innovation management within the given market services sector.

3. Theoretical Framework: Digital Transformation and Innovation

Digital Transformation

Digital transformation represents a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies (Vial, 2019). Digital transformation and the resulting business model innovation have fundamentally altered consumers' expectations and behaviours, pressured traditional firms, and disrupted numerous markets (Fitzgerald et al., 2013). The formulation and implementation of a digital transformation strategy (DTS) have become a key concern for many pre-digital organisations, given the transformative impacts of digital technologies on almost all aspects of an organisation's internal and external environments (Fitzgerald et al., 2013; Akis, 2015; Chanas et al., 2019). Despite growing acknowledge of the need for digital transformation, most companies struggle to get clear business benefits from new digital technologies. Digital technologies enable unprecedented replication at almost zero marginal cost once the required infrastructure is in place (Iansiti & Lakhani, 2014).

Digitalisation has emerged as one of the most significant global business trends over the past decade (Uršič & Čater, 2025; Andronikidis et al., 2025). Digital transformation represents a fundamental change that permeates the foundations of corporate strategy, internal business processes, and organisational culture through intensive and coordinated utilisation of modern, advanced digital technologies. This process transcends the scope of conventional software tool implementation or automation of individual tasks and activities – it signifies a fundamental restructuring and reformulation of the manner in which an enterprise operates. The principal components of digital transformation include the utilisation of cloud infrastructures, the Internet of Things (IoT), various mobile applications, diverse Big Data platforms and tools, as well as instruments based on artificial intelligence (AI), which collectively introduce a new level of interconnectedness, analytical capability, and automation. The digital revolution simultaneously creates significant pressure on enterprise agility, compelling organisations to substantially shorten innovation cycles and adapt more flexibly to continuously evolving customer requirements. Equally, pressure is created for more efficient collection, processing, and subsequent evaluation of vast quantities of data to enable informed and rapid decision-making on critical matters. As a result of digital transformation, the competitive landscape changes as barriers to entry for new competitors with digital and innovative business models are minimised, enabling them to operate with significantly lower initial investments and employ more flexible business strategies.

Innovation and Its Management in the Digital Age

Innovation is the process of creating new or significantly improved products, services, processes, or business models that generate value for organisations. Traditional innovation management models were typically based on a linear, step-by-step approach – from initial ideas through development to the market launch of products or services. Organisations increasingly apply open innovation principles, establish collaboration with start-ups, academic institutions, and technology partners, and make decisions based on extensive internal and external data.

Innovation management has become a fundamental component in building the success and sustainability of individual organisations in the contemporary era of digital transformation (Fernandez-Vidal et al., 2022; Fang & Liu, 2024). With the advent of digital technologies, the conceptual framework based on the strategic alignment of processes, tools, and rules that support innovative ideas and solutions has undergone a fundamental change. This era has opened new possibilities and opportunities for innovation, but has also increased the complexity and pace of subsequent management. Enterprises are therefore compelled to continuously innovate and adapt dynamically, as digital transformation increasingly affects sectors worldwide. Modern innovation management requires, above all, digital literacy, agile methodologies, and data-driven decision-making. Overall, innovation management is a dynamic field that continuously adapts to social, technological, and economic changes. Digital tools and technologies have fundamentally transformed the ways innovation is managed. They bring new possibilities for restructuring corporate structures and processes, while simultaneously supporting the emergence of innovative products and services as catalysts for change. Leading this change are technologies like the Internet of Things (IoT), Big Data Analytics, and Artificial Intelligence (AI). These technologies enable enterprises to acquire information, automate their processes and procedures,

and, not least, to accelerate innovation cycles more efficiently. Successful innovation management in the digital age requires a combination of incremental improvements and fundamental changes, while it is essential to manage organisational resistance to transformation effectively.

The effectiveness of innovation management lies primarily in the regular examination of new opportunities, the continuous acquisition of contemporary knowledge, and the smoothest possible acceptance of change, which leads to sustained enterprise development and the formation of long-term benefits for all stakeholders. For an enterprise to achieve optimal innovation outcomes, it is essential to enhance its creative potential continuously and to actively utilise the opportunities offered by implementing digital innovations and solutions.

4. Transformation of Customer Value and Organisational Structures

New Forms of Customer Value

Companies that effectively manage digital technology can expect to gain in one or more of three areas: better customer operations, new lines of business, or new business models (Fitzgerald et al., 2013). Customer experiences reflect the clearest impact of digital transformation. The survey found that improving customer relationships was the area where companies were having the most success with digital technology. Most prominent was improving the overall customer experience, followed closely by enhancing products and services in customer-friendly ways (Fitzgerald et al, 2013). The implementation of digital technologies opens new pathways for creating innovative forms of value for consumers, whether through offerings "tailored to individual needs" or through digital service extensions that accompany existing physical products, subscription-based models, or interconnected service ecosystems. Innovation today does not focus exclusively on the product or service itself but on the overall consumer experience. This represents, from an innovation management perspective, the necessity for regular analysis of customer data, the collection and evaluation of the information obtained, monitoring of customer behaviour in the digital space, and, based on these indicators, the need to develop new approaches. Simultaneously, the relevance of methodologies such as design thinking and human-centred approaches is increasing, as they help enterprises better understand user needs. Digital innovations appear not only in the form of technological modifications but also in service-oriented approaches, where value is created through collaboration with engaged, actively participating customers who cooperate with enterprises. The analysis of big data and sophisticated forms of artificial intelligence enables the acquisition of extensive customer information, leading to innovations that are tailor-made and flexible in adapting to changing customer requirements in the market. Design thinking, conversely, helps empathise with customer needs and develop new solutions, thereby harmonising innovation with actual human needs, requirements, and problems, leading to greater success and customer satisfaction. Digital platforms, therefore, enable open innovation, which operates through the engagement of stakeholders, developers, and other partners in a shared creative process, leading to more diverse and user-focused solutions.

Organisational and Cultural Impacts

Broadly speaking, digital transformation extends beyond the mere implementation of new technologies and is primarily about a profound change in organisational structure and corporate culture, which increases responsiveness to change, fosters collaboration, and strengthens the enterprise's overall innovation performance. Digital transformation and the innovative methodologies associated with it represent fundamental driving forces that, by their nature, trigger bigger changes in organisational structure and corporate culture. Traditional enterprises, characterised by rigid, hierarchical structures, face significant challenges in adapting to the demands of the modern digital era. Such enterprises tend to operate on predetermined rules and procedures, which inhibit the flexibility required for rapid experimentation, continuous improvement, and interdisciplinary cooperation. A key factor in success is the ability to adapt flexibly to constantly changing requirements and to integrate new technologies and innovative solutions into enterprise operations actively. For this very reason, it is critical to build and continually support a corporate culture that helps overcome failure, encourages learning from mistakes, and facilitates knowledge sharing at all levels of the enterprise.

Culture should be directed toward encouraging and motivating all employees to remain open to voluntary experimentation with new, more modern methods, technologies, or procedures, thereby creating an environment that supports innovative thinking and creative problem-solving. In this way, space is opened for continuous

process improvement, which is at the core of digital transformation. It is highly important that enterprise leadership continually focus on investing in the development of their employees, particularly in digitalisation, digital tools, and analysis of critical data, which enable enterprises to achieve higher levels of efficiency and more flexible responses to market challenges. Supporting employees through opportunities for further skills development increases engagement and motivation, and, consequently, they become active participants in various transformation processes, which is essential for building and maintaining lasting value derived from digital innovations.

5. Utilisation of big data, AI, and analytics in decision-making and implementation challenges

Big Data as a Source of Innovation Opportunities

Big Data refers to exceptionally large, complex, and diverse datasets that are generated and updated in real time and are characterised by exceptional velocity. All of this data is acquired from various sources, including intra-enterprise systems such as CRM and ERP, social media, IoT sensors, mobile applications, and external sources such as public repositories or specialised data solutions. The key characteristic of Big Data is not merely the volume of data itself, but rather its diversity (whether structured or unstructured) and, in particular, the velocity of its creation, which offers entirely new perspectives for enterprises across all sectors. In the field of innovation, Big Data holds tremendous value, as it provides comprehensive insights into various aspects of enterprise operations and market dynamics. Through Big Data, enterprises gain detailed information and knowledge about current trends, consumer behaviours, and specific preferences, product, or service functionality, and equally about the effectiveness of specific internal processes, enabling the enterprise to adapt its products and services more rapidly and thus dynamically optimise its offerings and significantly enhance customer satisfaction. Such an extensive data foundation enables enterprises not only to respond flexibly to unexpected changes but also to proactively identify new innovative solutions, opportunities, and strategic growth pathways. Given its extensive possibilities, Big Data is considered a source of energy for creating innovative solutions and decisions in modern enterprises. It provides a solid foundation for generating and managing innovative ideas, concepts, and projects. Big Data enables enterprises to transform raw data into highly valuable information and concrete findings, which in subsequent steps increase competitiveness and help maintain a strong position in a digitally oriented market.

Artificial Intelligence in Innovation Decision-Making

In the context of innovation, AI helps increase and optimise decision efficiency and quality by providing teams and managers with relevant, data-backed information, enabling them to make better-informed decisions. In the field of innovation, AI manifests in various critical applications, such as demand forecasting for the enterprise's new products or services, which facilitates production planning, important resource allocation, and the development of specific marketing strategies with maximum accuracy. Customer segmentation into distinct groups and tailored offerings enables more targeted engagement with different customer groups based on their specific preferences or behaviour, increasing the likelihood of success for innovative solutions. The evaluation of sentiment directly in customer reviews or comments, which are available on social media, provides valuable information about how customers perceive products, services, or the brand itself, bringing important insights in identifying weaknesses or areas where there is considerable room for improvement, or conversely reinforces assertions about the success of innovative elements. When product design is adapted based on feedback, it also signifies the rapid adaptation of products and services through an iterative process, ensuring the best possible alignment with consumer expectations and current market requirements.

Another highly significant application is the automated generation of solution variants, whether in product design or development. In this case, AI can generate multiple alternatives and simulate their potential before production begins and market launch occurs. This added value can save time, optimise costs, and particularly increase the quality and value of products or services. Through these applications, senior management and decision-makers obtain more comprehensive information to inform decision-making. Thanks to them, they gain a better overview of innovation projects in which they can invest, on which they can prioritise and determine how best to direct them.

Artificial intelligence, through its capabilities, not only accelerates and improves the accuracy of critical decisions related to innovation but also creates space for new possibilities, testing, experimentation, and continuous learning amid a dynamically evolving digital transformation. Therefore, these technologies must be effectively implemented in enterprise operations, thereby significantly increasing competitive advantage not only in innovation but also in optimising processes and specific business models.

Data Analytics and Innovation Performance Metrics

Modern methods of advanced data analytics serve not only as a fundamental tool for identifying innovation opportunities but also provide the capability to track and evaluate innovation performance across the enterprise systematically and measurably. Through advanced and sophisticated analytics methods and additional tools, enterprises can precisely define and subsequently continually monitor all key performance indicators (KPIs), which provide them with noticeably clear insight into the extent to which their innovation processes are effective and the extent to which they help enterprises in building competitive positioning in the given market segment. The most important metrics enterprises monitor include the revenue share generated by new products or services. The aforementioned share reflects the true significance of innovation to the enterprise's financial results. An especially important factor that helps managers in evaluating innovation potential is the success rate of pilot projects or developed prototypes. They help evaluate the potential of ideas with the objective of further development or commercial implementation.

Data analytics plays a crucial role in all phases of the innovation process – from the selection and evaluation of proposals, through the efficient allocation of all necessary resources (human and financial), to the interim and final evaluation of the results achieved in the innovation process. In this manner, management can gain insight into which innovation activities and projects generate the greatest added value and, subsequently, which processes need further optimisation. A very important challenge, nonetheless, remains ensuring that data is reliable and of high quality, because on the basis thereof, necessary and authoritative analyses are performed. Very often, enterprises encounter barriers such as incomplete data, incorrect categorisation, and outdated or tainted information, which can lead to erroneous or inaccurate interpretations of the results (Agrawal et al., 2025). Moreover, it is necessary to ensure the correct interpretation of analytical data and, subsequently, its implementation into the specific strategic objectives of the enterprise, so that they appear not merely as dry numbers but rather serve as an effective tool supporting decision-making and the continuous improvement of affected processes. The main contribution of data analytics to innovation is that it can measure performance, identify weaknesses, and provide guidance for the strategic, purpose-driven management of innovation projects, thereby strengthening long-term enterprise growth and increasing the probability of success in a clear, impartial way.

Return on investment in research and development provides a perspective on economic efficiency and the long-term sustainability of innovation activities, which is critical for strategic decision-making and optimal resource allocation within the enterprise. This important indicator helps enterprises evaluate and visualise the extent to which their innovation initiatives contribute to growth and the maintenance of competitiveness, and, at the same time, enables the optimisation and efficient management of investments to maximise their market impact.

Implementation Challenges

The potential of data-driven innovation in the form of artificial intelligence, Big Data, and advanced data analytics is enormous, as these technologies offer new, simpler ways to improve the quality and efficiency of individual innovation processes. However, during implementation, various unexpected problems and challenges can emerge that enterprises must confront and overcome as effectively as possible. Among these challenges is, in particular, the lack of qualified specialists, such as data scientists. These specialists possess not only specific technical knowledge, but also a strong ability to connect developing modern technological solutions with the business needs of given enterprises. Another overly critical and troublesome obstacle is the fragmentation and incompatibility of available data sources, which create barriers for enterprises in systematic data acquisition, integration, and subsequent analysis. Necessary data may be stored and available in different formats, systems, or even platforms, representing a high degree of data heterogeneity and consequently requiring coordinated management and unified standards for the data environment. However, we must not overlook issues related to privacy protection, legislation, or data security, as they are equally capable of creating obstacles that an

enterprise must by no means underestimate. Continuous protection and thorough safeguarding of all sensitive and personal data of employees, partners, and customers represent not only a legal obligation for all enterprises but also an important factor in credibility and the maintenance of the enterprise's reputation.

Enterprises often encounter the very natural resistance of employees and customers to change. Transformation from traditional, intuitive decision-making toward modern, data-driven processes places demands on changing mentality and ways of acting in practice at all levels of the business environment. Employees and managers must, above all, be open to adopting new methods of work, trust modern analyses, and be capable of re-evaluating established and customary work procedures. These very transformations in organisational structure and corporate culture are often neglected and underestimated, and yet they are a fundamental prerequisite for success. Management of data-oriented projects and innovations also requires an agile, iterative approach, which can entail something new, unfamiliar, and demanding to implement for some enterprises. Implementation challenges of digital technologies can also entail a high initial investment. These technologies, with their characteristics and the added value they offer, must convince enterprise leadership of their long-term return. They must see the significance of implementation and be able to predict returns over time. Generally, deploying data-driven innovation in enterprise operations is a complex process that demands not only technological resources but also a strategic approach, close cross-enterprise cooperation, and leadership support and motivation. Enterprises that, despite emerging barriers, successfully manage all challenges associated with implementing digital data-driven tools achieve a significant advantage over their competitors in the market and are particularly able to respond flexibly to constantly changing customer and market expectations and requirements.

6. Digital Transformation in the Industrial Laundry Sector

Industrial laundries play a significant role in the context of digital transformation, as they develop and implement important innovations in work organisation and service provision. Their growth is enabled by the efficient utilisation of digital and data-based tools and technologies in practice, thereby accelerating innovation processes and strengthening cooperation among various market actors.

Enterprises operating industrial laundries in the territory of the Slovak Republic represent a specific sector of market services, where digital transformation has enormous potential and scope for processes. By introducing modern digital technologies, these enterprises increase their efficiency, the quality of the products and services they offer, and even their energy sustainability. These are particularly manifested in IoT sensors, automated processes and procedures, advanced data analytics, and intelligent control devices in production. Digital transformation in this segment brings a substantial number of benefits and positive impacts, which are manifested in the form of better and more precise control over the entire laundry washing process from textile receipt, through main washing cycles, capacity planning, to predictive maintenance of technological equipment (Sardar et al., 2022; Sarkar et al., 2024). New technologies and innovations contribute to the continuous improvement of product and service quality, as their capabilities minimise downtime, prevent minor and serious malfunctions, and optimise operational costs (Taque et al., 2021). Beyond technological improvements, digitalisation brings positive progress also in the area of sustainability. Digital technologies help industrial laundries efficiently track and optimise resource consumption (water, energy, and chemicals), thereby significantly reducing negative environmental impact. Customers increasingly demand environmental innovations and improvements, and these are equally required by regulatory standards, underscoring the importance of sustainability in the examined market services segment. Thanks to technological capabilities and modern solutions, these enterprises are more competitive and can respond quickly and flexibly to constantly changing conditions and future challenges. Overall, digital transformation is not only reflected in innovation, improvement, and optimisation of operational performance, but forms the foundational pillars that shape the future of enterprises operating industrial laundries in the territory of the Slovak Republic and abroad, whose progress is directed toward "smart" and sustainable services. Innovations and their advantages are systemised in Table 1 below.

Table 1. Innovations and their Advantages

Innovations	Advantages of Digital Innovation
Innovation 1: Integrated Information System	It consolidated various standalone systems into a single, flexible infrastructure, increasing transparency, clarity, and the speed of data access.
	It brought significant cost savings, particularly through the digitalisation of invoices and delivery notes and the reduction of postage expenses.
	It automates processes, thereby reducing manual work, errors, and accelerating document processing.
	It created specialised teams (Power Users) for system support and local customisation.
	Return on investment within a maximum of 5 years.
Innovation 2: Web Portal for Customers	It provides customers with online access to orders, invoices, shipment tracking, and complaint processes, thereby increasing customer satisfaction and efficiency.
	It reduces costs associated with customer support and administration.
	Integration with the internal system enables faster order processing and improves response time.
	Development of a mobile application is a further step toward improving accessibility and service convenience.
Innovation 3: RFID Technology	It enables contactless tracking of textiles through electronic chips embedded directly in the products.
	It increases the accuracy of record-keeping and reduces losses and errors in inventory management.
	It streamlines logistics, inventory management, and operational efficiency.
	The result is higher service quality and process transparency.

Source: own processing based on survey data

These digital innovations represent significant steps toward the modernisation of industrial laundries, which enable them not only to optimise internal processes and reduce costs, but especially to strengthen relationships with customers and build a firmer market position.

All the aforementioned digital innovations help companies fulfil their tasks and achieve increasingly better results (Schneider & Kokshagina, 2021; Verhoef et al., 2021; Tajpour & Dekamini, 2024; Uršič & Čater, 2025).

An enormous benefit of the integrated information system, which connects all departments from production through warehousing to administrative departments, is real-time data management, which is particularly helpful in optimising individual tasks, processes, and inventory management. Thanks to these capabilities, managers can acquire information more quickly and make decisions on important matters, thereby significantly reducing risks and increasing operational productivity. The customer web portal additionally streamlines communication with customers, offers them deeper insights, and provides timely information about their rented items and their record-keeping at every step. This innovation in this segment builds stronger loyalty and increases customer satisfaction by giving customers access to necessary information and data without delay. Thanks to RFID, the company and its customers gain a more precise overview of the movement of rented items, inventory status, submitted requests, and more. Together, these 3 innovations create a single, interconnected whole that, through its capabilities, helps companies not only reduce costs and make decisions more quickly but also respond more flexibly to changing market requirements. All these innovations help enterprises build strong competitiveness and long-term sustainability.

Despite the significant contributions of digitalisation and integrated solutions, complications can arise in practice in large-capacity laundries when implementing new technologies. The initial phase of introducing these tools brings not only high investment costs but also considerable organisational problems, which may be associated, for example, with inadequate employee preparation. Some teams' resistance to change may stem not only from fears of automation but also from insufficient training and subsequent support for new technologies.

As a result of the above, significant delays in daily operational processes can occur. It has been shown that without a clearly defined performance measurement strategy and a definition of key objectives, there is inconsistent use of systems, which can reduce the expected effect not only on efficiency but also on customer experience.

This example highlights that innovation alone is insufficient – success requires comprehensive preparation, timely training, cultural change, and strategic management of digitalisation. Otherwise, there is a risk that instead of growth and improvement, digitalisation will become a source of further complications and increased

costs. When comparing traditional and model approaches to implementing digital innovations, we find considerable differences (see Table 2 below).

Table 2. Traditional Approach vs Model Approach for Successful Implementation

Criterion	Traditional Approach	Model Approach for Successful Transformation
Strategic Planning	Isolated projects, Innovations come ad hoc	Comprehensive digital strategy with clearly defined, concrete objectives
Investment in Technology	Investment in technology without a proper context	Technologies are an integral part of a coherent strategic and development process
Change Management	Weak Change Management, resistance without motivation	Proactive preparation and training of stakeholders.
Culture and Engagement	Resistance and concerns about digitalisation and automation	Support for an innovative culture, a circular economy, and the motivation of employees
Performance Metrics	Metrics are not concretely defined	Clearly established KPIs, proper monitoring and subsequent work with data
Flexibility	Rigid, inflexible systems and processes	Agile approaches, the capability of flexible adaptation to change
Source and Investment	Often ineffective or inefficient	Targeted investments with a focus on return on investment

Source: own processing based on survey data

Digital transformation in enterprises operating industrial laundries is an overly complex and so-called multi-level process that emphasises a systematic and thoughtful approach. Successful implementation of various modern digital technologies is conditional not only on investments in the technologies themselves, but also on the enterprise's competence to flexibly adapt its primary, managerial, and supporting processes, organisational culture, and employee capabilities.

A Holistic Approach to Digital Innovation: Big Data and AI as Catalysts for Enterprise Transformation Toward a Circular Business Model

As enterprises undergo strategic reorientation in the contemporary business environment, a comprehensive perspective on modern technological transformation and innovative solutions is increasingly important, substantially transcending the narrowly focused optimisation of individual organisational operations (Nielsen et al., 2022; Ren et al., 2023; Ozen & Ozturk-Kose, 2024).

This perspective inherently recognises that today's enterprises face the imperative to simultaneously address multiple critical strategic dimensions: enhancing operational performance, fulfilling ecological and social requirements, and utilising insights from advanced data analytics to formulate significant business decisions. Within this framework, Big Data and Artificial Intelligence represent indispensable instruments that enable enterprises to accelerate their transition from linear business models toward regenerative and circular value creation models, particularly within specialised service sectors characterised by pronounced demands on human capital and intellectual resources, such as industrial maintenance and textile cleaning operations (Lv & Chen, 2024; Li et al., 2025).

The incorporation of advanced data analytics and AI-driven technologies into enterprise operations serves dual purposes in supporting the principles of the circular economy (Ciano et al., 2025). First and foremost, these technologies enable comprehensive, continuous collection of critical data at a massive scale and real-time monitoring across all phases of the value creation chain—from the initial inputs of individual resources and components, through product distribution, to final transformation, with the potential for reintroduction into the production process. Sophisticated data processing and interpretation tools are capable of monitoring critical performance indicators (KPIs) focused on resource-efficient effectiveness and optimal utilisation of natural resources (criteria R4: resource consumption optimisation, natural and renewable materials, partial or complete reuse, secondary raw material utilisation) and indicators of business model transformation processes (R10), thereby providing enterprises with precise information regarding where raw material losses occur, where energy losses can be minimised, and where circular economy linkages can be established (Dziallas & Blind, 2019; Chanas et al., 2019). Furthermore, computational systems and algorithms can more rapidly identify non-obvious patterns, complex, atypical regularities, and improvement perspectives within demanding operational

ecosystems that might otherwise remain entirely invisible when applying conventional data analysis methodologies.

In the case of large-scale industrial laundry facilities, for example, predictive models based on automated analysis can anticipate expected fluctuations in service demand, adjust production schedules to reduce water and energy consumption optimally, alert to necessary equipment maintenance before failure occurs, and intelligently organise the movement and flow of textiles through individual equipment to eliminate redundant, unnecessary operations. Forecasting algorithms, derived from training on historical records, continuously refine recommendations for resource and material allocation and distribution, thereby assisting enterprises in achieving more agile transformation toward more sustainable and financially advantageous circular operational procedures (Dorrego-Viera et al., 2025).

Systems for data collection, further processing, and storage of massive volumes of data and information also enable enterprises to undertake continuous monitoring and evaluation of integrated approaches to business model transformation. Real-time interactive dashboards aggregate data from IoT sensors, enterprise production management systems, critical quality control modules, and customer feedback, providing comprehensive, transparent, and up-to-date information necessary for rapid hypothesis validation and agile directional course correction. Such a data- and information-oriented management approach aligns with contemporary change management and organisational development methodologies, which enable enterprises to continuously verify whether implemented circular economy initiatives achieve anticipated environmental and financial benefits and to facilitate adjustments to transformation plans based on empirical observations (Kuzma et al., 2020; Kim et al., 2021).

The synergistic interaction between holistic enterprise organisational design, circular economy principles, and sophisticated modern information technology tools thus creates a highly stable and effective foundation for sustained market positioning and competitive advantage (Hermundsdottir & Aspelund, 2021; Guo, Ali & Xu, 2023; Hamdouna & Khmelyarchuk, 2025).

Enterprises that effectively combine the discipline of individual process management with the capabilities of advanced data analytics of extensive data volumes and optimisation driven by Artificial Intelligence are capable of achieving significantly faster operational excellence, strengthen their commitment to environmental stewardship and organisational agility—thereby transforming what might initially appear as mutually exclusive business objectives into mutually reinforcing and supportive strategic outcomes (Hurtado-Palomino et al., 2022; Jiang et al., 2025). The integration of Big Data and AI into a Holistic Transformation Model Toward the Circular Economy is described in Table 3 below.

Table 3. Integration of Big Data and AI into a Holistic Transformation Model Toward Circular Economy

Model Component	Function and Significance	Big Data and AI Application
1. Process Management	Mapping, monitoring and optimisation of key processes within the service system (reception → washing → pressing → suspension → quality control → collection → balancing → delivery → processing). Identification of quality issues, minimisation of complaints and improvement of service efficiency.	IoT sensors monitor parameters in real time (temperature, humidity, weight); Big Data analytics identify patterns and anomalies in processes; AI algorithms optimise the sequence of operations based on historical data; predictive analytics provides critical feedback before process failures.
2. Transformation Toward Circular Economy Model	Integration of circular economy principles: minimisation of waste, optimal use of water and energy, environmental responsibility for materials, and logistics optimisation. R4 criteria (resource efficiency, renewable inputs, reuse, recycling) – principle of resource efficiency. R10 (process redesign, digitalisation) – metrics for transformation and circular process management.	Big Data captures the complete material and energy balances; AI models identify optimal opportunities for waste reduction and maximum recycling potential; machine learning predicts where to best apply circular principles; real-time dashboards visualise the circularity of processes.

3. R4 and R10 Determinants	R4 (resource efficiency, renewable inputs, optimal utilisation, recycling) – principle of resource efficiency. R10 (process redesign, digitalisation) – metrics for transformation and circular process management.	Advanced analytics measure R4 and R10 metrics in real time; AI-driven benchmarking compares actual performance against best practices; predictive models simulate changes in R4/R10 before implementation.
4. Innovation Management	Active search for innovation opportunities, problem solving, implementation of new technologies and processes, effectiveness measurement, development of employees and organisational culture supporting innovation.	Big Data analytics identify innovation opportunities based on trends and customer needs; AI experiments validate hypotheses quickly; predictive analytics assess innovation potential and risk before implementation; intelligent knowledge management promotes sharing of innovation knowledge across the organisation.
5. Systematic Performance Monitoring and Optimisation	KPI monitoring (revenue, ROI, number of innovations, water/energy consumption, environmental indicators). Continuous process improvement, quality and environmental responsibility.	Real-time BI dashboards visualise KPI metrics in one place; predictive analytics provide trend forecasting and enable proactive adjustments; AI-powered optimisation provides specific recommendations for performance improvement; continuous learning systems automatically incorporate lessons from new data.

Source: own processing based on survey data

7. Description of Findings

Digital transformation and the development of data-oriented technologies fundamentally alter the primary role of innovation processes in contemporary enterprises. These technologies, on one hand, provide the means to achieve a substantially deeper and more precise understanding of customer expectations and requirements through comprehensive data source analysis, and on the other hand, help validate newly emerging ideas and test them in the shortest possible timeframe while most efficiently allocating often limited resources to projects demonstrating the greatest potential. This contribution addresses four fundamental research questions that guide the examination of digital transformation and innovation management in contemporary enterprises. Each question is accompanied by key points that outline the primary impacts, roles, barriers, and manifestations of digitalisation. Table 4 presents a comprehensive overview of these research dimensions, providing a structured framework for understanding how digital technologies reshape innovation processes, organisational structures, and competitive strategies in the industrial laundry sector and beyond.

Table 4. Research Questions and Key Findings

Research Question	Key Points
What impact does the approach to digital management of innovation have on enterprises?	Positive Impacts: More precise customer understanding, shortened time limits, resource optimisation Challenges: Investment costs, cultural change, employee training
What role do Big Data and AI play in identifying innovation opportunities?	Detection of hidden patterns and trends Predictive analysis Personalisation and segmentation Analysis of the competitive environment Optimisation of innovation processes
What are the primary barriers encountered in the implementation of data-driven innovation?	Technical and infrastructure barriers Data barriers Organisational and cultural barriers Management and strategic barriers External barriers
How is digitalisation manifested in the industrial laundry sector?	Modernisation of technological processes (ERP, RFID, web portals) Optimisation of operations Improvement of customer experience Data management and analytics Challenges and benefits

Source: own processing based on survey data

Simultaneously, however, digitalisation and new data-oriented technologies create pressure for the continuous development of employees and their competencies, which represents additional investments in training and efforts toward organisational culture change. Cultural barriers, such as assistance to change, lack of employees' willingness to utilise modern data technologies, and concerns about automation, can significantly impede their implementation and practical application. For this very reason, it is critically important that enterprises actively invest effort in building a corporate environment that supports continuous learning and knowledge sharing, and that motivates further experimentation.

From the enterprise perspective, it is crucial to understand that the mere implementation of modern technologies such as AI, Big Data, and other advanced data analytics does not automatically guarantee success. Their genuine benefit and capacity to transform innovation processes lie in their strategic integration into the overall innovation strategy of the given enterprise. This implies that it is extremely important to define clear and measurable objectives, design and apply appropriate performance metrics, and ensure support for suitable processes, a corporate structure, and the competencies that facilitate the effective utilisation of these technologies. The absence of a strategic approach can introduce unexpected complications and increase organisational complexity in digital transformation, and may even result in chaos and reduced efficiency in innovation activities.

The implementation of digital innovations also depends on the industry and enterprise size, which influence both the capability and manner of its execution. When examining larger enterprises, we observe the availability of extensive resources for investment in advanced, modern solutions (AI, Big Data); however, their size and complexity often result in lower agility and significantly slower adaptation to new technologies and market changes. Conversely, small and medium-sized enterprises rely more substantially on their flexibility and speed of decision-making, yet typically face limited resources required for such innovations. This reality compels these enterprises to seek external partners, suppliers of specific technologies, or develop collaborations within ecosystems to best utilise the potential of modern tools.

This diversity of conditions and opportunities means that no single universal approach exists for managing digital innovation. Enterprises must adapt their strategies, processes, procedures, and necessary investments to the specificities of their size, industry, service segment, and market environment. To achieve successful implementation, it is necessary to analyse detailed challenges and concrete opportunities while simultaneously adapting flexibly to constantly changing conditions, thereby strengthening innovation capability and sustainable growth over the long term.

Digital transformation in the industrial laundry sector brings various benefits; however, simultaneously, it presents multiple challenges and risks that enterprises must critically evaluate. Through the implementation of modern digital technologies (ERP systems, RFID, web portals, and others), companies assume substantial investments in infrastructure, employee training, and organisational structure changes, which may be demanding and not easily accessible for some enterprises. Beyond the aforementioned financial burden, digitalisation brings significant risks associated with dependence on IT technologies, which, in the event of unexpected outages, can disrupt operations and the execution of necessary procedures to meet contractually established customer requirements. Another emerging problem is the protection of personal data and other sensitive information, as large volumes of data are processed, presenting potential security risks. Ultimately, the very dynamics of technological change may reflect the reality that certain solutions rapidly become obsolete, necessitating further investments and subsequent adaptation, which can slow the pace of transformation. For this reason, it is critically important that digitalisation in the laundry segment, which entails substantial investments in required technology, be executed with a thoroughly considered, sound strategy, clearly defined objectives, and a detailed, realistic implementation plan.

8. Conclusion and Recommendations

The era of digital transformation brings new opportunities for innovation and fundamentally influences how innovations are managed. Digitalisation tools provide enterprises with effective instruments for a better understanding of the market, customer expectations and requirements, greater precision in the decision-making

process, and, in particular, the optimal utilisation of necessary resources. So that their potential is not left unutilised, it is extremely important to:

- Strategically integrate and anchor digitalisation and new data analytics technologies into the innovation strategy of the given enterprise, and subsequently determine their objective and expected benefits for the enterprise.
- Create and support an environment open to experimentation and continuous learning, which tolerates possible failures and unsuccessful attempts with the objective of learning from mistakes.
- Ensure the quality and integrity of necessary data, and secure and ethical further handling thereof, thereby creating credibility and relevance of analytical outputs.
- Link technological innovations to customer expectations and requirements, for example, by engaging customers in testing and developing new products or services.

Although digital transformation brings endless new possibilities, human potential remains a key element of success in work processes, whether in industrial laundries or in enterprises across other segments. Artificial intelligence and automation can efficiently process large volumes of data and perform repetitive tasks with very high precision; however, their effectiveness depends on clearly defined tasks, procedures, and objectives that must first be established and assigned by employees. Human creativity, the capability to resolve often unforeseen situations, critical thinking, and intuition are elements that remain irreplaceable, enabling adaptation to changing market conditions and technological environments.

The manner in which this phenomenon will continue to develop and how mutual cooperation between humans and, in this case, artificial intelligence will proceed remains largely unanswered to date. Currently, however, artificial intelligence cannot fully replace human potential; rather, it complements and extends human capabilities with its own. Therefore, it is extremely important to continually invest in the development of employees' capabilities, further training, and creativity, so that the potential of digitalisation can be utilised, particularly without loss of human value in the work process.

Future research on this topic may focus more on detailed examinations of specific case studies of other enterprises that actively implement and support digital transformation, as well as on the resulting benefits. It would be beneficial to monitor and evaluate approaches to digitalisation also by enterprise size, segment, and geographic region, to create a picture of best practices and strategic models tailored to the specific parameters of individual enterprises across various market conditions in the territory of the Slovak Republic.

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