

Digital Twins to Drive Sustainable Business in the Industrial Context

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Introduction & research question

Digital twins offer a wide range of business benefits across various industries to improve productivity and sustainability



Identified challenges collectively highlight that managing innovation in digital twin deployment is not just a technical hurdle, but a strategic organizational and ecosystem-level problem requiring orchestrated ecosystem efforts in standardization, value demonstration, data and asset management, and competence development.

A specific innovation management problem is the lack of a cohesive, standardized, and value-driven innovation ecosystem, leading to fragmented development, high barriers to entry, and difficulty in scaling cross-organizational digital twin solutions

Research question

What are the main business benefits of Digital Twin usage in the industrial context, and how they can be realized?

The main concepts and conducted analysis

The main characteristics of the term ‘Digital Twin’ in the industrial context

Category	Description	References (e.g.)
Virtual representation	A digital twin is a software model that simulates the physical asset or system	Bolton et al., 2018; Fu et al. 2022; Oj et al 2021; Sacks et al. 2020; Kritzinger et al., 2018
Data-driven	It relies on real-time data collected from sensors, devices, and other sources to update its state and behavior	Rodrigo et al. 2023; Collin et al. 2023; Lv et al. 2021; Kim et al. 2022; Kritzinger et al., 2018
Dynamic	It evolves over time, reflecting changes in the physical assets or system it represents.	Wang et al. 2025; Weng et al. 2022; Kim et al. 2022; Liang et al. 2022; Kritzinger et al., 2018
Multi-dimensional	It can encompass various aspects of the physical entity, including its physical properties, operational parameters, performance data, and environmental conditions.	Liang et al. 2022; Xiao et al. 2023; Jagannath et al. 2022; lv et al. 2021
Interactive	It allows for simulations and analysis, enabling users to test different scenarios, optimize processes, and make informed decisions.	Tao et al. 2023; Tao et al. 2024; Nguyen et al. 2021; Li et al. 2023; Kušić et al. 2023

The main business benefits of Digital Twins in the industrial context

Category	Description	Benefits	References (e.g.)
Operational efficiency and optimization	Real-time monitoring and predictive maintenance, e.g. DT provide continuous monitoring of assets and processes, enabling early detection of anomalies and potential failures	This allows for proactive maintenance, reducing downtime and maintenance costs Digital twins can help optimize resource allocation, such as manpower, materials, and energy, leading to cost savings and improved productivity.	Karkaria et al. 2024; Goodwin et al. 2024; Wang et al. 2021
	Process and resource optimization, e.g. by simulating different scenarios and parameters in the digital twin, businesses can identify bottlenecks, optimize workflows, and improve overall efficiency	Digital twins provide a virtual environment to test new ideas, designs, and processes, reducing the time and cost associated with physical prototyping.	
	Sharpen competitive advantage, e.g. by leveraging digital twins, businesses can gain a competitive advantage by improving efficiency, reducing costs, and enhancing product offerings.	By analyzing data from digital twins, businesses can refine product designs and improve quality, meeting customer expectations more effectively.	
Enhanced learning, safety and risk management	Digital twins create safe virtual environments for training employees on complex tasks and procedures, reducing risks associated with real-world training.	For example, datacenters uses digital twins to monitor airflow, heat transfer, cooling, and power metrics	Tao et al. 2024; Nguyen et al. 2021; Li et al. 2023; Kušić et al. 2020
	Digital twins facilitate collaboration between different departments and stakeholders, improving communication and decision-making	Digital twins create virtual replicas of physical systems, allowing learners to practice complex tasks in a risk-free environment	
	By simulating potential hazards and scenarios, businesses can identify and mitigate risks before they occur, improving safety and reducing accidents	Digital twins enable "what-if" simulations, allowing learners to explore different scenarios and outcomes, which is particularly useful in multiple industries	
Sustainability	Digital twins enable remote monitoring and control of assets and processes, allowing for safer operations in hazardous environments.	Digital twins enable remote learning, allowing learners from anywhere in the world to access high-quality training resources	Timperi et al. 2024; Ma et al. 2022; He and Bai, 2021;
	Digital twins can help optimize resource utilization, reduce waste, and minimize environmental impact.	By simulating energy consumption patterns, digital twins help businesses reduce e.g. energy efficiency also at the system level	
	Environmental monitoring and management, e.g. digital twins can be used to monitor environmental conditions, track emissions, and optimize operations for sustainability.	For example, in manufacturing, digital twins can simulate production lines to minimize waste and improve energy efficiency	

The data, methods and the planned next steps

Data

- 5 case companies from diverse sectors, including telecom, energy, manufacturing, mining, and biorefinery
- Total turnover of the case companies exceeding 45 billion euros in 2025
- Target to understand the potential unique characteristics in each vertical

Data collection

- Multiple (4) group semi-structured interviews and workshops in 2024-2026
- Individual (company-specific) case studies (5)
- The selection criteria is based on the assumptions that the objectives, requirements, and status of digital transformation, including the industrial metaverse, vary significantly across industry verticals => a multi-vertical approach

Next steps

- Collect feedback and comments from the ISPIM colleagues
- 2 workshops in 2026 and 1 workshop in 2027 will be arranged to both validate the results and to cover the new emerging themes from the ongoing company-specific case studies
- Summarize the main findings and managerial implications in 1H'2027

Results – Research in Progress

- Based on the analysis conducted by the authors, the business benefits of digital twins can be divided into the following categories: 1) Operational efficiency and optimization, 2) Enhanced learning, safety, and risk mitigation, and 3) Sustainability. Preliminary results of the study show that digital twins empower companies to understand, predict, and optimize their industrial operations with unprecedented accuracy and efficiency
- For example, by continuously capturing and analyzing operational data from physical assets, performance digital twins can predict behavior, especially unwanted behavior such as anomalies or failures. This enables improved proactive maintenance, preventing costly downtime and enhancing equipment reliability.
- Digital twins seems to provide a real-time representation of the current state of a network or operational system, offering better (full) visibility into operations
- The preliminary results also show that the realization of business benefits from digital twins varies across industries due to a confluence of factors related to the nature of their assets, operational processes, regulatory environments, economic drivers, and technological maturity. In other words, while the core capabilities of digital twins are universal, their value proposition is amplified or diminished by the specific operational context, risk profile, and strategic priorities of each industry.

Areas for feedback & development

- The study of digital twins in an industrial context enriches our understanding of innovation management by providing new avenues, challenges, and frameworks for how organizations conceive, develop, and deploy novel technologies. It moves beyond traditional innovation models by introducing a dynamic, data-driven, and ecosystem-based element into innovation management
 - What are the themes, questions etc. that we should raise during the next phase of the study?
 - What kind of (additional) data is potentially needed? Focus on the current case companies or approach new candidates?
 - What other aspects, concepts, dimensions etc. we should take into account to provide concrete value for the innovation management community?

Main research question (original)

What are the main business benefits of Digital Twin usage in the industrial context, and **how** they can be realized?

Thank you