Overcoming Digital Transformation Challenges in Traditional Manufacturing Industries

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Abstract
In the age of Industry 4.0, digital transformation (DT) is no longer optional for traditional manufacturing industries. However, while modern technologies promise greater efficiency, flexibility, and innovation, many legacy manufacturers struggle to adapt. This paper explores the major challenges these industries face—ranging from cultural resistance and skill gaps to technological infrastructure and strategic misalignment—and proposes strategic frameworks and actionable solutions for overcoming them. Through a comprehensive review and case-based insights, the study emphasizes the importance of leadership, employee engagement, ecosystem collaboration, and phased technology adoption in ensuring successful transformation.

Keywords: Digital Transformation, Traditional Manufacturing, Industry 4.0, Organizational Change, Smart Manufacturing, Technology Adoption, Workforce Reskilling

1. Introduction
In today's highly competitive and rapidly evolving industrial landscape, **digital transformation (DT)** has become a strategic necessity rather than a technological luxury [1]. Powered by the rise of **Industry 4.0**, digital transformation integrates advanced technologies, including artificial intelligence (AI), the Internet of Things (IoT), cloud computing, robotic automation, and big data analytics, into core manufacturing operations [2]. These innovations promise to deliver enhanced efficiency, flexibility, productivity, and real-time decision-making capabilities [3].
However, **traditional manufacturing industries**—those that have historically relied on linear production models, legacy machinery, and paper-based workflows—face significant hurdles in adopting these modern technologies. Their existing operational structures are often built on deeply embedded systems, hierarchical decision-making, and a workforce more accustomed to mechanical tasks than digital tools. As a result, the journey toward digitization is often slow, fragmented, and met with resistance [4].
Several global trends are accelerating the need for transformation:

- **Global supply chain disruptions** have highlighted the importance of agility and real-time monitoring.
- **Customer expectations** are shifting toward more customized, faster-delivered, and sustainable products.
- **Regulatory pressures** are demanding better traceability, safety, and environmental accountability.
- **Competitors leveraging smart manufacturing** are gaining significant advantages in cost, speed, and innovation.

While large tech-forward manufacturers like Siemens, Bosch, and GE have made considerable progress in digital integration, **small- and medium-sized manufacturers (SMMs)**, particularly in developing economies, often struggle due to limited resources, lack of strategic direction, and fear of disruption [5,6]. This paper aims to explore the **core challenges** traditional manufacturers face when undergoing digital transformation and propose **practical, human-centered, and strategic approaches** to overcome them. By analyzing case studies, strategic frameworks, and industry best practices, the paper provides insights that can help manufacturing leaders make informed decisions and guide their organizations into the digital era successfully [7].

Ultimately, the goal is to bridge the gap between **legacy manufacturing operations** and the **demands of a digital-first industrial economy**, ensuring that transformation is not only technological but also **organizational, cultural, and sustainable [8]**.

2. Understanding Digital Transformation in Manufacturing

Digital Transformation (DT) in manufacturing refers to the **strategic adoption of digital technologies** to enhance manufacturing processes, increase operational efficiency, and create new value for customers. It is not merely about automation but about **reimagining the manufacturing process** using real-time data, intelligent systems, and interconnected operations [9].

Modern digital transformation is fueled by the principles of **Industry 4.0**, which emphasizes **connectivity, data-driven decision-making, and cyber-physical integration**. This shift marks a departure from traditional linear manufacturing models toward **smart, adaptive, and autonomous systems[10]**.

2.1 Key Components of Digital Transformation

Digital transformation in manufacturing is driven by several interrelated components that collectively enable operational efficiency, innovation, and adaptability. At its core, it involves the integration of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), cloud computing, big data analytics, and cyber-physical systems into manufacturing processes [11]. These technologies help streamline operations, enhance data-driven decision-making, and improve real-time visibility across the production lifecycle. Automation and robotics play a key role in optimizing workflows, reducing human error, and increasing productivity. Additionally, digital transformation includes the deployment of digital twins—virtual replicas of physical systems—which allow for predictive maintenance and performance simulation [12]. Beyond technology, successful transformation also hinges on organizational change, including cultural shifts toward agility, collaboration, and innovation. Upskilling the workforce and adopting flexible, scalable IT infrastructures are also vital [13]. These components work in synergy to help traditional manufacturers transition into smart factories capable of meeting dynamic market demands [14].

2.2 The Digital Transformation Framework

A successful DT implementation involves transformation across three interdependent dimensions:

2.3 Comparison: Traditional vs. Digitally Transformed Manufacturing

Table1.Comparison: Traditional vs. Digitally Transformed Manufacturing

Feature	Traditional Manufacturing	Digital Manufacturing
Production Flow	Linear and manual	Dynamic and data-driven
Machine Monitoring	Reactive maintenance	Predictive and remote monitoring via IoT

Decision Making	Based on intuition & experience	Based on real-time analytics and AI insights
Data Accessibility	Siloed and paper-based	Centralized, cloud-based
Customization	Mass production	Mass customization with digital design
Supply Chain Management	Static, disconnected	Real-time integrated ecosystems
Workforce Role	Manual, repetitive	Digital-enabled, analytical

2.4 Benefits of Embracing Digital Transformation

1. **Increased Operational Efficiency**: Real-time data from machines allows for quick adjustments and minimized downtime.
2. **Enhanced Product Quality**: AI-based quality control reduces human error.
3. **Greater Flexibility**: Smart systems adapt to changing customer demands and production volumes.
4. **Cost Reduction**: Predictive maintenance and optimized resource usage lower operational costs.
5. **Faster Time-to-Market**: Rapid prototyping and digital design tools shorten product development cycles [15].

3. Key Challenges in Traditional Manufacturing Industries

The transition to digitalization is not just a technical upgrade—it's an organizational overhaul. For traditional manufacturing industries, digital transformation (DT) presents a complex, multi-layered challenge. These challenges often emerge from internal rigidity, external competition, and industry-wide legacy dependencies. Understanding these deeply rooted issues is essential for designing effective DT strategies [16].

3.1 Cultural Resistance and Organizational Mindset

One of the most persistent barriers to DT is a deep-rooted resistance to change, especially in long-standing firms with decades-old practices. Many employees view digital tools as threats—either to their jobs or their skill relevance.

- **Causes:**
  - Lack of communication from leadership
  - Fear of job displacement by automation
  - Attachment to existing processes and hierarchies
- **Real-world Insight:**

At a legacy textile manufacturer in South Asia, workers refused to adopt new smart-fabric cutting machines due to fear of being replaced. The management eventually had to involve employees in redesigning workflows and offered retraining to gain acceptance [17].

- Impact: Slow adoption of technology, morale issues, and potential loss of key staff

3.2 Digital Skills Shortage

Traditional manufacturing employees often possess strong mechanical and process skills but lack familiarity with digital tools, data analytics, or software systems. Simultaneously, the sector struggles to attract new digital talent due to its outdated reputation [18].

- **Key Skill Gaps:**
  - Data literacy and analytics
  - Programming and machine learning

- IT/OT (Information + Operational Technology) integration

- **Data Point:**

According to a 2023 report by the World Economic Forum, 72% of manufacturing SMEs globally report significant shortages in digital capabilities.

Table2. 3A: Skills Gap vs. Industry Need

Skill Area	Demand (%)	Availability (%)
IoT/Smart Sensors	78%	38%
Data Analytics	85%	32%
Cybersecurity	69%	41%
AI/Machine Learning	64%	29%
Cloud Integration	59%	35%

- **Impact: Poor implementation of DT tools, increased reliance on external consultants, and project delays.**

3.3 Legacy Systems and Infrastructure Obsolescence

Traditional manufacturers typically operate on aging machinery, outdated ERP systems, and siloed databases, making it difficult to implement cutting-edge technologies [19].

- **Typical Legacy Limitations:**
  - Machines not compatible with IoT sensors
  - Inflexible IT architecture with no API support
  - Paper-based data collection and tracking
- **Real-world Insight:**

A 70-year-old automotive components firm in Germany struggled to integrate its old CNC machines with a new MES (Manufacturing Execution System), resulting in months of interoperability testing and partial digitization.

- **Impact:** High upgrade costs, integration issues, and operational downtime during implementation.

3.4 Financial Constraints and ROI Concerns

Digital transformation requires significant upfront investment in infrastructure, software, training, and cybersecurity. For many traditional manufacturers, especially small and mid-sized firms, budget constraints hinder momentum [20].

- **Challenges:**
  - Difficulty securing stakeholder buy-in without short-term ROI
  - High costs for cloud migration and enterprise systems
  - Long break-even periods for automation equipment
- **Cost Breakdown Example:**

Table3. Cost Breakdown Example

DT Component	Initial Cost Estimate (USD)
ERP Integration	$50,000 – $200,000
IoT Sensor Deployment	$25,000 – $100,000
Cloud Infrastructure	$30,000 – $150,000
Employee Training	$10,000 – $50,000

- **Impact**: Delayed or phased implementations, reduced scope, or abandonment of initiatives altogether.

3.5 Lack of Strategic Alignment and Leadership Engagement

Without clear digital leadership or a transformation roadmap, many efforts become scattered and tactical, rather than strategic. Executives may prioritize short-term output over long-term innovation [21].

- **Symptoms:**
  - Siloed pilot projects with no enterprise-wide scaling
  - Misalignment between IT teams and production departments
  - Conflicting KPIs across functions
- **Industry Example:**

In one case, a food processing company implemented advanced supply chain analytics but failed to train the procurement team, leading to underutilization and missed inventory predictions.

- Impact: Poor ROI, employee confusion, digital fatigue, and wasted resources.

3.6 Cybersecurity Vulnerabilities

Digital manufacturing systems—especially those connected to external networks—are increasingly vulnerable to cyberattacks. Traditional manufacturers often lack adequate defenses due to underinvestment in IT and outdated firmware.

- **Risks Include:**
  - Production halts due to ransomware
  - Data breaches involving customer or IP information
  - Manipulation of machine instructions (sabotage)
- **Statistics:**

The manufacturing sector became the top target for cyberattacks in 2022, surpassing even finance, with 1 in 4 manufacturers experiencing a breach (IBM Security Report) [22].

- **Impact:** Loss of revenue, reputational damage, and compliance failures.

3.7 Change Fatigue and Employee Burnout

Frequent, uncoordinated changes across departments—without clear communication or success milestones—can result in change fatigue, where employees become disengaged or hostile toward future transformation efforts.

- **Warning Signs:**
  - Drop in employee morale and retention
  - Increased resistance to minor changes
  - Absenteeism or reduced collaboration
- **Best Practice:** Phased rollout with regular feedback, visible successes, and employee rewards reduces resistance.

4. Strategies for Overcoming Digital Transformation Challenges

Overcoming digital transformation (DT) challenges in traditional manufacturing industries requires more than just introducing new technologies. It involves a multi-dimensional strategy that aligns people, processes, and technology with the organization's long-term vision. This section presents actionable strategies and proven frameworks that manufacturing leaders can adopt to navigate transformation effectively [23].

4.1 Establish a Clear Digital Vision and Roadmap

Without a shared understanding of why digital transformation is necessary, employees often view it as disruptive or unnecessary. A clear digital strategy should:

- Define long-term goals (e.g., predictive maintenance, smart supply chain)
- Link transformation with measurable business outcomes
- Prioritize initiatives based on ROI and strategic alignment

✅ **Best Practice:** Develop a Digital Transformation Roadmap using maturity models and milestone planning.

Table 4. Digital Transformation Roadmap

Roadmap Stage	Action	Tools
Awareness & Visioning	Define DT objectives	SWOT, PESTLE, Vision Boards
Assessment & Gap Analysis	Evaluate current vs. desired state	Digital Maturity Models
Planning & Prioritization	Set short-, mid-, and long-term goals	Gantt charts, OKRs, KPIs
Execution	Implement, test, and monitor pilot programs	Agile sprints, Lean Six Sigma
Scaling & Integration	Expand successful pilots to entire workflow	Enterprise Architecture (TOGAF)

4.2 Invest in Workforce Reskilling and Change Management

Digital transformation must be people-centered. Employees are the enablers of change, not just passive recipients.

- Launch reskilling and upskilling programs focused on digital tools, analytics, and automation.
- Promote a growth mindset culture where experimentation and learning are encouraged.
- Use change agents or "digital champions" from within the workforce to lead by example.

🎓 Real-world Example: Bosch launched its "Learn@Bosch" initiative, training over 20,000 workers in digital skills, resulting in a smoother transition to Industry 4.0 operations.

4.3 Adopt a Modular and Scalable Technology Approach

Instead of attempting a massive digital overhaul, manufacturers should focus on modular technology adoption—integrating one process or department at a time and then scaling gradually [24].

- Start with low-hanging fruit such as energy monitoring, predictive maintenance, or digital dashboards.
- Choose interoperable tools that integrate with existing infrastructure.
- Use cloud platforms to avoid high upfront infrastructure costs.

🛠 **Example Pilot Projects:**

- Digital shop floor management via tablets
- AI-based demand forecasting in inventory
- Sensor-based machine health monitoring

4.4 Strengthen Cybersecurity at Every Level

Cybersecurity should be embedded from the start. A secure digital transformation involves:

- Conducting regular risk assessments
- Training employees in cyber hygiene

- Investing in multi-layered defenses, including endpoint protection, encrypted communication, and secure access management
- Implementing ISO/IEC 27001 or NIST Cybersecurity Framework

🔒 Best Practice: Appoint a dedicated Chief Information Security Officer (CISO) or create a cybersecurity team if one doesn't exist [25].

4.5 Encourage Cross-Functional Collaboration and Flatten Hierarchies

Successful DT requires that IT, operations, HR, finance, and strategy teams work together, not in silos.

- Use cross-functional teams for digital projects
- Break down rigid hierarchies to foster agile decision-making
- Hold regular "digital huddles" where different departments share updates, feedback, and challenges

🤝 Case Insight: At Tata Steel, the DT initiative was led by cross-functional teams comprising engineers, data scientists, and floor managers—leading to rapid deployment of IoT-based monitoring systems.

4.6 Measure Progress with KPIs and Feedback Loops

A successful transformation is measurable. Define and track Key Performance Indicators (KPIs) aligned with digital goals, such as:

- **Downtime reduction (%)**
- Overall Equipment Effectiveness (OEE)
- Training participation rates
- Employee satisfaction and adoption levels
- Data utilization in decision-making

📊 **Sample KPI Dashboard Layout:**

Table 5. Sample KPI

Category	**KPI**	**Target**	**Status**
Production Efficiency	**Machine downtime reduction**	**-15% per year**	🔄 **In progress**
Workforce Engagement	**Digital tool usage (daily active)**	**80%**	✅ **Achieved**
Cybersecurity	**Number of reported vulnerabilities**	**Zero**	⚠️ **Attention Needed**

4.7 Partner with External Experts and Ecosystems

No company can achieve transformation in isolation. Collaborating with startups, universities, technology providers, and industry alliances brings fresh ideas, resources, and technical expertise [26,27].

- Outsource non-core digital tasks (e.g., cloud infrastructure, data pipelines)
- Co-create solutions with tech partners through innovation labs
- Benchmark against global leaders via consortiums like The Smart Manufacturing Leadership Coalition (SMLC)

4.8 Embrace a Phased, Agile Approach

Avoid "big bang" digital projects. Instead, use iterative pilots with regular feedback, refinement, and scaling.

- Follow the Agile methodology: Plan, execute, review, repeat

- Celebrate small wins to maintain momentum
- Involve users early in design and testing to increase adoption

5. Case Study:

5.1 Background

Siemens AG, a global leader in industrial manufacturing, engineering, and automation, is often cited as a benchmark for successful digital transformation (DT) in traditional manufacturing. Founded in 1847, Siemens had to reinvent its legacy-heavy operations to remain competitive in the digital age [28].

Over the past decade, the company strategically shifted toward becoming a "Digital Enterprise", leveraging advanced technologies like Industrial Internet of Things (IIoT), digital twins, AI, cloud platforms, and cyber-physical systems. Siemens' journey offers a practical and scalable model for traditional manufacturers navigating digital transformation [29].

5.2 Strategic Initiatives and Implementation

A. Development of the Digital Enterprise Suite

Siemens launched its proprietary **Digital Enterprise Suite**, a platform that allows end-to-end digitalization of the entire value chain — from product design to manufacturing to lifecycle services [30].

📦 **Key Features**:

- Integration of **Product Lifecycle Management (PLM)**, **Manufacturing Execution Systems (MES)**, and **Automation** technologies
- Use of **Digital Twins** to simulate production processes before physical implementation
- Seamless data exchange between IT and operational layers

B. Emphasis on Interoperability and Open Platforms

Siemens collaborated with partners to develop **MindSphere**, an open IoT operating system that enables:

- Real-time data monitoring and predictive analytics
- Device-agnostic integration across production floors
- Application development for operational optimization

💡 **Best Practice**: Siemens prioritized **open ecosystems** over closed platforms to enhance scalability and third-party collaboration [31].

C. Workforce Transformation Programs

Recognizing the skill gap challenge, Siemens invested in **extensive employee reskilling**, launching internal digital academies and partnerships with educational institutions.

- Over 50,000 employees trained on digital tools and platforms
- Emphasis on hybrid skill sets: mechanical + digital + analytical
- Leadership training for digital governance and agile management

D. Agile and Scalable Rollout Model

Rather than launching large-scale changes at once, Siemens adopted an **agile, phased approach**:

- Start with **pilot factories** (e.g., Amberg Electronics Plant)
- Test and fine-tune technologies
- Scale successful models to global factories

5.3 Outcomes and Achievements

A. Operational Improvements

- **Amberg Factory** digitization led to:
  - Over **99.9% product quality rate**

- Real-time tracking of over **15 million product variations**
- Machine-to-machine communication reducing decision lag

B. Enhanced Customer Offerings

- Siemens transformed from a traditional product manufacturer to a **solution and platform provider [32]**.
- Helped clients across sectors (energy, mobility, infrastructure) in **co-developing custom digital solutions** using Siemens tools.

C. Business Growth

- Digital industries division became one of the **fastest-growing units** at Siemens.
- MindSphere adoption by hundreds of global partners and customers.
- Significant cost savings from predictive maintenance and digital supply chain optimization [33].

5.4 Lessons Learned

Table6. Lessons Learned

Lesson	Application for Traditional Firms
Lead with a clear digital vision	Align digital goals with business objectives
Empower the workforce	Invest in change management and continuous learning
Start small, scale fast	Use pilot programs to validate concepts before enterprise rollout
Build open ecosystems	Collaborate with partners, startups, and academia
Focus on data	Leverage real-time data to drive innovation and decision-making

5.5 Challenges Faced and Overcome

Despite its success, Siemens encountered notable challenges:

- Initial resistance from factory operators accustomed to manual systems
- Integration issues across global divisions with diverse infrastructures
- Cybersecurity risks, addressed through rigorous audits and encryption standards

The company's approach to managing these challenges — through transparency, strategic partnerships, and leadership involvement — was critical to maintaining transformation momentum [34].

6. Conclusion

The journey toward digital transformation in traditional manufacturing industries is both a complex and critical undertaking. As the global industrial landscape becomes increasingly digitized, manufacturers that fail to adapt risk falling behind not only in operational efficiency but also in customer relevance, innovation, and overall competitiveness.

This paper has explored the foundational understanding of digital transformation, its relevance to manufacturing, and the unique challenges that traditional firms face—ranging from legacy infrastructure and cultural resistance to skill gaps and cybersecurity concerns. These challenges are not trivial, but they are not insurmountable either.

Drawing from industry examples, such as Siemens' successful transformation, and a set of strategic recommendations, it is evident that the path to successful digital transformation requires a **balanced approach**—one that integrates **technological modernization with human-centric change management**. Leadership commitment, clear vision, scalable technology adoption, reskilling programs, and a culture of innovation are all essential pillars of this process.

References

1. D. E. O'Leary, "Exploiting Big Data from Mobile Device Sensor-based Apps: Challenges and Benefits," MIS Quarterly Executive, vol. 12, no. 4, pp. 179–187, 2013.
2. K. Schwab, The Fourth Industrial Revolution. Penguin, London, UK, 2017.
3. R. D. Evans, J. X. Gao, N. Martin, and C. Simmonds, "Exploring the Benefits of Using Enterprise 2.0 Tools to Facilitate Collaboration during Product Development," International Journal of Product Lifecycle Management, vol. 8, no. 3, pp. 233–252, 2015.
4. D. Schweer and J. C. Sahl, "The Digital Transformation of Industry–The Benefit for Germany," in F. Abolhassan (ed.), The Drivers of Digital Transformation, Springer International Publishing Switzerland, 2017, pp. 23–31.
5. A. Baird and T. S. Raghu, "Associating Consumer Perceived Value with Business Models for Digital Services," European Journal of Information Systems, vol. 24, no. 1, pp. 4–22, 2015.
6. Thomson L, Kamalaldin A, Sjödin D, Parida V (2021) A maturity framework for autonomous solutions in manufacturing frms: the interplay of technology, ecosystem, and business model. Int Entrep Manage J. https://doi.org/10.1007/s11365-020-00717-3
7. Trischler MFG, Li-Ying J (2022) Digital business model innovation: toward construct clarity and future research directions. Rev Manage Sci 17(1):3–32 Tronvoll B, Sklyar A, Sörhammar D, Kowalkowski C (2020) Transformational shifts through digital servitization. Ind Mark Manage 89:293–305. https://doi.org/10.1016/j.indmarman.2020.02.005
8. Tsang EWK, Kwan K-M (1999) Replication and theory development in organizational science: a critical realist perspective. Acad Manag Rev 24(4):759–780. https://doi.org/10.2307/259353
9. Sklyar A, Kowalkowski C, Tronvoll B, Sörhammar D (2019) Organizing for digital servitization: a service ecosystem perspective. J Bus Res 104:450–460. https://doi.org/10.1016/
10. j.jbusres.2019.02.012 Snihur Y, Bocken N (2022) A call for action: the impact of business model innovation on business ecosystems, society and planet. Long Range Plan. https://doi.org/10.1016/j.lrp.2022.102182
11. Solem BAA, Kohtamäki M, Parida V, Brekke T (2021) Untangling service design routines for digital servitization: empirical insights of smart PSS in maritime industry. J Manuf Technol Manage. https://doi.org/10.1108/JMTM-10-2020-0429
12. Sorensen A (2008) Use of QSR NVivo 7 qualitative analysis software for mixed methods research. J Mixed Methods Res 2:106–108 Suarez FF (2004) Battles for technological dominance: an integrative framework. Res Policy 33(2):271– 286. https://doi.org/10.1016/
13. j.respol.2003.07.001 Sydow J, Windeler A, Schubert C, Möllering G (2012) Organizing R&D consortia for path creation and extension: the case of semiconductor manufacturing technologies. Organ Stud 33(7):907–936. https://doi.org/10.1177/0170840612448029
14. E. Katysheva and A. Tsvetkova, "Economic and institutional problems of the Russian oil and gas complex digital transformation," in Proc. Int. Multidisciplinary Sci. GeoConf., SGEM, 2019, vol. 19, no. 5.3, pp. 203–208, doi: 10.5593/sgem2019/5.3/S21.026.
15. M. R. Faridi and A. Malik, "Digital transformation in supply chain, challenges and opportunities in SMEs: A case study of Al-Rumman pharma," Emerald Emerg. Markets Case Stud., vol. 10, no. 1, pp. 1–16, Feb. 2020, doi: 10.1108/EEMCS-05-2019-0122.
16. O. Koseoglu, B. Keskin, and B. Ozorhon, "Challenges and enablers in BIM-enabled digital transformation in mega projects: The Istanbul new airport project case study," Buildings, vol. 9, no. 5,

pp. 1–24, 2019, doi: 10.3390/buildings9050115.
17. S. E. Zaharia and C. V. Pietreanu, ‘‘Challenges in airport digital transformation,’’ Transp. Res. Procedia, vol. 35, pp. 90–99, Jan. 2018, doi: 10.1016/j.trpro.2018.12.016.
18. L. I. Malyavkina, A. G. Savina, and I. G. Parshutina, ‘‘Blockchain technology as the basis for digital transformation of the supply chain management system: Benefits and implementation challenges,’’ in Proc. 1st Int. Sci. Conf. Modern Manage. Trends Digit. Econ., Regional Develop. Global Econ. Growth (MTDE), vol. 81, A. Nazarov, Ed. Paris, France: Atlantis Press, 2019, pp. 10–15.
19. K. Li, D. J. Kim, K. R. Lang, R. J. Kauffman, and M. Naldi, ‘‘How should we understand the digital economy in Asia? Critical assessment and research agenda,’’ Electron. Commerce Res. Appl., vol. 44, Nov. 2020, Art. no. 101004, doi: 10.1016/j.elerap.2020.101004.
20. U. Ahrend, M. Aleksy, M. Berning, J. Gebhardt, F. Mendoza, and D. Schulz, ‘‘Challenges of the digital transformation: The role of sensors, sensor networks, IoT-devices, and 5G: Invited paper,’’ presented at the 1st Int. Conf. Societal Autom. (SA), 2019, Kraków, Poland, 2019, doi: 10.1109/SA47457.2019.8938077.
21. M. Kaneko, ‘‘Surviving in the digital transformation era; technical trends and issues from the perspective of the telecommunication technology committee,’’ NTT Tech. Rev., vol. 17, no. 10, pp. 50–57, 2019.
22. S. Mendhurwar and R. Mishra, ‘‘Integration of social and IoT technologies: Architectural framework for digital transformation and cyber security challenges,’’ Enterprise Inf. Syst., vol. 15, no. 4, pp. 565–584, Apr. 2021, doi: 10.1080/17517575.2019.1600041.
23. A. Hadjimanolis, “Barriers to Innovation for SMEs in a Small Less Developed Country (Cyprus),” Technovation, vol. 19, no. 9, pp. 561–570, 1999.
24. D. Bilgeri and F. Wortmann, “Barriers to IoT Business Model Innovation,” in Proceedings of Wirtschaftsinformatik, St. Gallen, Switzerland, 2017.
25. B. Distel and N. Ogonek, “To Adopt or not to Adopt: A Literature Review on Barriers to Citizens’ Adoption of e-Government Services,” in Proceedings of the European Conference on Information Systems (ECIS), Istanbul, Turkey, 2016.
26. A. C. Boyton and R. W. Zmud, “An Assessment of Critical Success Factors,” Sloan Management Review, vol. 25, no. 4, pp. 17–27, 1984.
27. C. R. Sunstein, Worst-Case Scenarios. Harvard University Press, Cambridge, MA, USA, 2009.
28. S. Erol, A. Schumacher, and W. Sihn, “Strategic Guidance towards Industry 4.0 – A Three-stage Process Model,” in Proceedings of the International Conference on Competitive Manufacturing (COMA), Stellenbosch, South Africa, 2016, pp. 495–502.
29. S. Berghaus and A. Back, “Stages in Digital Business Transformation: Results of an Empirical Maturity Study,” in Proceedings of the Mediterranean Conference on Information Systems (MCIS), Paphos, Cyprus, 2016, pp. 1–17.
30. V. Venkatesh, B. A. Susan, and H. Bala, “Bridging the Qualitative-Quantitative Divide: Guidelines for Conducting Mixed-Method Research in Information Systems,” MIS Quarterly, vol. 37, no. 1, pp. 21–54, 2013.
31. J. Strübing, “Was ist Grounded Theory?,” in J. Stübing (ed.), Grounded Theory, Springer, Wiesbaden, Germany, 2014, pp. 9–35.
32. R. K. Yin, Case Study Research: Design and Methods, Fifth Edition. SAGE, Los Angeles, CA, USA, 2014.

33. C. Helfferich, Die Qualität qualitativer Daten, VS Verlag für Sozialwissenschaften, Wiesbaden, Germany, 2011.