tujom (2025) 10 (2):87-106

doi: https://doi.org/10.30685/tujom.v10i2.218

TUJOM
ISSN: 2458-9748

Research Article

Digital transformation for quality management, operational excellence, and sales force effectiveness in an Industry 4.0 context: Evidence from Siemens AG

Dijital dönüşüm yoluyla kalite yönetimi ve satış gücü etkinliğinin geliştirilmesi: Siemens AG örneği

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Submitted: 1/09/2025

Revised: 1/10/2025

Accepted: 10/10/2025

Online Published: 25/10/2025

Citation: Daldiran, B., Daldiran, K., & Gullu, K. (2025). Digital transformation for quality management, operational excellence, and sales force effectiveness in an Industry 4.0 context: Evidence from Siemens AG, tujom (2025) 10 (2): 87-106, doi: https://doi.org/10.30685/tujom.v10i2.218

Abstract

This study examines Siemens AG's digital transformation strategies within the Industry 4.0 framework and their effects on quality management and sales force efficiency. By integrating advanced technologies such as AI, machine learning, and real-time data analytics, Siemens enhances both production processes and sales operations to ensure market adaptability and operational excellence. A mixed-methods approach was adopted, combining quantitative analysis with corporate documentation. Time-series, correlation, and regression analyses were applied to Siemens' audited performance data (2021–2023), focusing on defect rates, Net Promoter Score (NPS), and sales performance metrics. Digital investments contributed to a reduction in defect rates (from 15% to 10%), while NPS increased from 70 to 80. Simultaneously, Siemens reported improved sales force effectiveness through the use of predictive analytics, automation tools, and CRM integration. Regression results indicate that a 1% increase in digital investment resulted in a 0.5% improvement in quality performance, as well as significant gains in customer responsiveness and sales efficiency. Unlike previous studies that treat digital transformation and sales strategy separately, this study links digitalisation to both quality control and sales force performance. Siemens AG's transformation demonstrates how unified digital strategies enhance production, marketing responsiveness, and field sales capabilities, offering a replicable model for industrial competitiveness.

Keywords: Digital Transformation, Quality Management, Sales Force Effectiveness, Artificial Intelligence, Production Management, Customer Satisfaction

Jel Codes: M11, M31, M15

Öz

Bu çalışma, Siemens AG'nin Endüstri 4.0 çerçevesindeki dijital dönüşüm stratejilerini ve bu stratejilerin kalite yönetimi ile satış gücü verimliliği üzerindeki etkilerini incelemektedir. Yapay zekâ, makine öğrenimi ve gerçek zamanlı veri analitiği gibi ileri teknolojilerin entegrasyonu sayesinde Siemens, hem üretim süreçlerinde hem de satış operasyonlarında esneklik ve yüksek performans sağlamaktadır. Çalışmada karma yöntem yaklaşımı benimsenmiştir. 2021–2023 dönemine ait Siemens'in denetimden geçmiş kurumsal verileri üzerinde zaman serisi, korelasyon ve regresyon analizleri yapılmış; hata oranları, Net Tavsiye Skoru (NPS) ve satış performansı göstergeleri değerlendirilmiştir. Dijital yatırımlar, hata oranlarında %15'ten %10'a düşüş sağlarken NPS skoru 70'ten 80'e yükselmiştir. Aynı zamanda Siemens, ileri düzey veri analitiği, otomasyon ve CRM entegrasyonu sayesinde satış gücü etkinliğini artırmıştır. Regresyon analizine göre dijital yatırımlardaki %1'lik artış, kalite performansında %0.5'lik iyileşme ve satış süreçlerinde yüksek müşteri yanıt oranları ile sonuçlanmıştır. Dijital dönüşüm ve satış yönetimi genellikle ayrı incelenirken, bu çalışma her iki alanı entegre biçimde ele almaktadır. Siemens AG örneği, dijital teknolojilerin sadece kaliteyi değil aynı zamanda satış gücünü de etkin şekilde dönüştürerek rekabet avantajı sağladığını göstermektedir. Bu yönüyle çalışma, sektöre örnek teşkil eden bütüncül bir model ortaya koymaktadır.

Anahtar Kelimeler: Dijital Dönüşüm, Kalite Yönetimi, Satış Gücü Etkinliği, Yapay Zekâ, Üretim Yönetimi, Müşteri Memnuniyeti

JEL Kodları: M11, M31, M15

Introduction

Through digital transformation, modern businesses are increasingly driven to achieve operational efficiency and competitive advantage. Traditional production processes have been transformed by the convergence of digital technologies and industrial systems, resulting in improvements in operational effectiveness and quality management (Shehadeh, Almohtaseb, Aldehayyat, & Abu-AlSondos, 2023). Siemens AG, one of the leaders in this revolutionary environment, has reinterpreted traditional methods by incorporating digitalisation into its business plans. One prominent example is the MindSphere platform. It utilises machine learning algorithms and sophisticated data analytics to maximise production quality and operational performance (Annanth, Kishorre, & Rao, 2021). However, the advantages of digital transformation go beyond financial savings and increased productivity. Enhancing the calibre of goods and services is necessary to sustain high levels of client satisfaction (Albino, 2021). Siemens' empirical data demonstrates that the MindSphere platform has improved product traceability by 30% and decreased production errors by 20%, supporting this dynamic. These results, which demonstrate how digital tools enhance accuracy and operational excellence, are outlined in Siemens' 2023 annual report. Moreover, incorporating digital twin technology enables real-time monitoring and predictive maintenance, thereby optimising quality outcomes and reducing operational risks in industrial processes (Schilirò, 2024).

Digital transformation directly impacts customer-facing activities and enhances internal performance. Improved product quality and traceability provide salespeople with a more compelling and credible value proposition when interacting with customers. Through platforms like MindSphere, sales teams can access real-time, high-quality data to conduct knowledgeable, solution-focused consultations, increasing customer confidence and conversion rates (Zhou, Lu, & Mangla, 2024). This synergistic effect between operational excellence and frontline functions reinforces sales force effectiveness through superior back-end performance in digitally mature organisations such as Siemens (Haleem, Javaid, & Singh, 2025).

Despite earlier research acknowledging these advantages, the literature remains divided. First, a significant portion of current research separates the effects of digital transformation on external sales and marketing from those on internal quality management, without thoroughly examining their interdependence. Second, although Siemens is widely acknowledged as a leader in Industry 4.0, there is a lack of empirical research systematically connecting its digital initiatives to the effectiveness of its sales force and quality management outcomes. Scholarly knowledge of how digital production systems influence both operational performance and market responsiveness is limited by these gaps.

By analysing Siemens AG's digital transformation strategies within the context of Industry 4.0, this study aims to close these gaps. It specifically examines how the company's digital initiatives, such as MindSphere and digital twins, enhance sales force performance and affect quality management outcomes. Thus, the following is the guiding research question:

RQ: How do Siemens AG's digital transformation strategies improve quality management procedures, which in turn boost the efficiency of their sales force?

The study employs a mixed-methods research design, combining qualitative insights from corporate reports and case evidence with quantitative analysis of Siemens' audited performance data (2021–2023) to answer this question. This dual strategy provides a thorough understanding of the organisational impact of digital transformation by allowing triangulation across defect rates, Net Promoter Score (NPS), and sales performance indicators.

This study makes two significant contributions to the literature by directly tying digital transformation to sales performance and quality outcomes. It first illustrates how digitalisation at the production level can foster synergies between frontline sales effectiveness and back-end efficiency. Second, it provides Siemens AG with empirical data that demonstrates how integrated digital strategies can serve as a replicable model for strategic alignment and industrial competitiveness in Industry 4.0 settings.

Literature review

Since the inception of Industry 4.0, digital transformation has become an essential component of strategic thinking in today's business environment. It is now recognised that digitalisation —the

incorporation of digital technologies into all aspects of business to increase competitiveness and productivity —is a key component of organisational strategy (Vial, 2019). Substantial productivity, efficiency, and quality control improvements have been achieved through its integration into production processes (Huber, Oberländer, Faisst, & Roeglinger, 2022). By enabling continuous product and service upgrades, technologies such as big data analytics, machine learning, and the Internet of Things have radically changed quality management. Notably, it has been demonstrated that automating quality control processes enhances precision and efficiency (Javaid, Haleem, Singh, & Suman, 2021). Considered together, such developments reflect how digitalisation has transformed customer satisfaction and operational reliability.

Empirical research indicates that digital transformation increases customer satisfaction, reduces error rates, and enhances the effectiveness of quality management. For example, Fantozzi et al. (2025) attribute improvements to the use of digital twin technologies, real-time analytics, and proactive maintenance, while Kraus et al. (2021) highlight how digitisation increases process efficiency. By utilising these technologies to identify potential issues before they escalate, businesses can minimise downtime and improve product quality. Similarly, by enabling enterprises to better meet customer expectations, digital strategies have altered the fundamentals of quality management (Mihu, Pitic, & Bayraktar, 2023). IoT solutions improve supply chain traceability and offer real-time monitoring to identify and resolve quality issues (Boehmer, Shukla, Kapletia, & Tiwari, 2019). When considered as a whole, these examples demonstrate how digital transformation enhances operational efficiency while promoting a new paradigm of quality-focused corporate strategies.

Comparative industry data further demonstrates these advantages. Siemens AG has led the way with its MindSphere platform, which optimises quality management through digital twins, analytics, and the Internet of Things (Lysenko, Buriak, & Shevchenko, 2024). Applications from MindSphere have improved data accuracy, raised product test ratings by 30%, and decreased production errors by 20% (Methuselah, 2024). According to Xing et al. (2024), General Electric's Predix platform has demonstrated how industrial IoT systems can enhance operations and product quality. Crucially, these enhancements impact both customer-facing tasks and production. Improved traceability and dependable quality control boost consumer confidence and produce more attractive sales pitches. Sales teams receive precise, customised information when production feedback is integrated into CRM systems (Wang, Kumar, Kumari, & Kuzmin, 2022). Additionally, consultative marketing is supported by digital twins' predictive insights, which ultimately increase conversion rates and retention (Zhong, Xia, Zhu, & Duan, 2023). These findings suggest that future studies should focus on the effects of digital transformation on operations, including its potential impact on the efficacy and market performance of sales teams.

Key studies in the literature

A critical review of previous research reveals that digitalisation has a significant impact on quality control. As Arunachalam, Kumar, and Kawalek (2017) report, integrating digital technologies into business processes enhances the quality and efficiency of business operations. Additionally, because widespread engagement enhances managerial success, their research implies that organisations should encourage diverse stakeholders to participate directly in decisions related to adopting digital technologies. Ghobakhloo and Iranmanesh (2021) suggest that digitisation enhances several manufacturing processes, enabling managers to exert greater control over quality outcomes. Organisations can improve the consistency of their output and ensure higher levels of customer satisfaction by implementing digital technologies into their production processes, such as automated flaw identification. Quality control has implications closely related to digital transformation, suggests Martinčević (2022), who argues that the application of electronic technologies enhances, first, businesses' competitiveness and, second, their capacity to adapt to changing customer demands. As individual pieces of research, they reflect the significance of digital transformation for organisational improvement and quality management. Scholars have reported strategic spillover effects stemming from market-facing functions and managerial control over internal operations. Wang et al. (2020) illustrate, for example, how digital technologies can accelerate production processes by providing sales representatives with detailed product capabilities, stock traces, and improved delivery estimates. These tools improve customer communication and responsiveness. Furthermore, Worm, Bharadwaj, Ulaga, and Reinartz (2017) argue that salespeople's use of real-time production data during negotiations increases their credibility by fostering trust and reducing information asymmetry. Collectively, these

studies demonstrate the importance of integrating digitalised production systems with frontline sales tactics, a subject that is increasingly recognised as vital to marketing research and operations management.

Table 1: The CDBP Test Results

Authors (Year)	Study Focus	Key Technologies
Vial (2019)	Definition and strategic relevance of digital transformation	Digital strategy
Huber, Oberländer, Faisst, & Roeglinger (2022)	Impact of digital tech on manufacturing quality and efficiency	IoT, Automation
Javaid, Haleem, Singh, & Suman (2021)	Automation of quality control through digital tools	AI, Big Data
Kraus, Jones, Kailer, Weinmann, Chaparro-Banegas, & Roig-Tierno (2021)	Efficiency and customer satisfaction via digitalisation	Digitalisation, Analytics
Fantozzi, Santolamazza, Loy, & Schiraldi (2025)	Real-time analytics and digital twin applications	Digital Twin, Analytics

Source: Designed by Authors

Implications for future research

Building on this literature, several researchers have verified the close connection between quality management and digital transformation. Siemens AG's MindSphere platform and other digital projects serve as excellent examples of this relationship, demonstrating how cutting-edge technologies can be integrated into organisational quality systems. Similar lessons can also be learned from General Electric (GE), whose early adoption of digital platforms to enhance quality control systems has been primarily responsible for its success. These examples demonstrate how businesses across various sectors can leverage digital innovations to improve their quality control procedures and remain competitive. In the future, further academic research will be necessary to explore the revolutionary possibilities of cutting-edge technologies, such as blockchain, artificial intelligence, and sophisticated data analytics. It is anticipated that these technologies will play a larger role in transforming quality management procedures as they evolve. A more comprehensive understanding of the global impact of digital transformation on quality management can be gained through comparative studies across various industries and geographical regions.

To further clarify how improvements in production-side digitalisation lead to measurable sales force outcomes, more empirical research is required. Possible performance indicators include reduced sales cycles, improved lead qualification, and higher customer retention rates. Given that they provide a more comprehensive understanding of the firm-level effects of digital transformation, integrative analytical models that incorporate both marketing key performance indicators (KPIs) and operational quality metrics are necessary for this line of research (Pookandy, 2023). These disclosures point to significant real-world implications for managers. To support data-driven selling strategies and improve alignment between operational and commercial activities, companies may find it advantageous to introduce training programs that expose sales staff to real-time production dashboards. Ultimately, this integrative perspective underscores that the benefits of digital transformation extend beyond increased productivity and quality; instead, they influence strategic outcomes throughout the entire value chain.

Methodology

This study employs a mixed-methods framework to analyse Siemens AG's digital transformation initiatives and their impact on quality management. It is easier to triangulate operational KPIs with Salesforce outcomes when both quantitative and qualitative methods are used. This also enables a comprehensive examination of the complex nature of digital transformation. Such integrative approaches have been successfully applied in recent studies of the effects of digital transformation on the supply chain and at the firm level (Orero-Blat et al., 2025; Tortorella et al., 2025). The quantitative

strand uses secondary data sources, including Siemens' audited annual reports and relevant industry benchmarks, to assess variations in production efficiency, defect rates, and customer satisfaction. Analytical methods, such as regression and correlation analysis, will be used to estimate the relationship between internal quality management metrics and digitalisation initiatives (such as MindSphere). This approach is consistent with industry best practices for evaluating industrial performance (Wang, 2024).

In parallel, the qualitative component entails thematic content analysis of case narratives, corporate documentation, and managerial interviews to reveal how digital tools promote data-driven customer engagement, streamline sales processes, and facilitate CRM integration. Similar approaches have assessed the use of digital twins through various evaluation paradigms, clarifying the socio-technical dynamics of Industry 4.0 adoption (Margherita & Braccini, 2021). This mixed-methods design ensures a comprehensive and rigorous understanding of Siemens' digital transformation by combining quantitative indicators with rich qualitative insights to capture both operational and market-facing dimensions. Moreover, the study is based solely on publicly available corporate and financial reports. No human participants were involved; therefore, no ethical approval was required.

Qualitative analysis

To identify recurrent themes and insights in Siemens AG's managerial reports and digital transformation documents, the qualitative data were subjected to a thematic content analysis approach. The analysis followed the framework developed by Braun and Clarke (2006). It went through several methodical steps: The first step involves familiarising oneself with the data by reading company reports and public disclosures multiple times. The second step is to code the data to identify recurring concepts related to customer engagement, operational improvement, and digitisation. The third step involves grouping similar codes into overarching themes. Finally, themes are reviewed and refined to ensure conceptual distinctiveness and internal coherence.

Table 2: Thematic Coding Framework Table

Theme	Subthemes	Example Evidence	Interpretation
Operational Excellence	Process automation, Predictive maintenance, Data-driven decision-making	"Implementation of MindSphere analytics reduced downtime by 15%" (Siemens Annual Report, 2023)	Digital tools streamline operations and reduce error frequency.
Quality Management Innovation	Product traceability, Real-time defect detection, and AI-based quality control	"Machine learning models improved detection accuracy in quality inspections."	Enhanced monitoring leads to measurable improvements in quality.
Sales Force Effectiveness	CRM integration, Mobile analytics, Data-driven customer insights	"Field agents use mobile dashboards for real-time sales forecasting."	Digital systems increase responsiveness and sales effectiveness.

Source: Designed by Authors

To enhance validity, a reliability check was conducted between two independent coders alongside the manual coding process. The analysis revealed three main themes, each with several subthemes: sales force effectiveness, quality management innovation, and operational excellence (Table 2). A thorough grasp of Siemens' digital transformation results was enabled by triangulating these qualitative insights with the company's quantitative performance metrics (defect rates, NPS, and sales productivity).

Variable specification

Let: DT_t : Digital Transformation Investment at time t

QMP_t : Quality Management Performance at time t

DR_t : Defect Rate at time t

NPS_t : Net Promoter Score (Customer Satisfaction Index) at time t

To assess the linear relationship between digital transformation and defect rate:

$$R_{DT,DR} = \frac{\sum_{t=1}^{n}(DT_t - \bar{DT})(DR_t - \bar{DR})}{\sqrt{\sum_{t=1}^{n}(DT_t - \bar{DT})^2 \sum_{t=1}^{n}(DR_t - \bar{DR})^2}}$$

Where:

$r_{DT,DR}$: Pearson correlation coefficient

$\bar{DT}, \bar{DR}$: Means of digital transformation investment and defect rate, respectively

To quantify the impact of digital transformation on quality performance, the following linear regression model is estimated:

$$QMP_t = \beta_0 + \beta_1 DT_t + \varepsilon_t$$

Where:

β_0 : Intercept

β_1 : Coefficient representing the effect of digital transformation on quality management

ε_t : Error term assumed to be normally distributed

The regression coefficient β_1 indicates the marginal improvement in quality performance associated with a unit increase in digital investment. Statistical significance is tested at a 95% confidence level ($p<0.05$).

Benchmarking analysis was conducted by comparing Siemens' defect rate with industry averages using the following ratio:

$$\text{Improvement Ratio} = \frac{Industry\ Avg\ Defect\ Rate - Simens\ Defect\ Rate}{Industry\ Avg\ Defect\ Rate} * 100$$

This ratio indicates the percentage by which Siemens outperforms the industry standard.

To ensure internal validity, data were cross-validated across different Siemens reports and triangulated with industry literature. External validity is supported by Siemens AG's status as a global industrial leader, making the findings applicable to other firms undergoing digital transformation.

Trend analysis

This analysis aims to identify the longitudinal improvements in quality performance indicators, such as defect rates and Net Promoter Score (NPS), over three years (2021–2023).

Methodological rationale

Trend analysis was conducted to observe directional change over time in quality-related metrics and to assess the sustainability of improvements following digital transformation implementations.

Calculation formula

Let T_i represent the value of the metric (e.g., defect rate) in year i, then:

$$Trend\%Change_{(i)} = \frac{T_i - T_{i-1}}{T_{i-1}} * 100$$

A negative percentage in defect rate trend implies operational improvements; a positive trend in NPS reflects enhanced customer satisfaction. Implementation Steps are as follows:

1. Year-wise data was collected from Siemens AG quality reports (2021–2023).
2. Calculations were performed using Microsoft Excel trend functions.

3. Graphs were plotted to visualise trend direction and consistency.

To analyse changes in defect rates and customer satisfaction indicators (such as NPS), a linear regression model was applied to examine the direction and strength of the trends over 2021–2023.

The linear trend line is expressed as:

$Y_t = \alpha + \beta t + e_t$

Where:

Y_t : Observed value at year ttt (e.g., defect rate or NPS score)

α: Intercept (value at the initial year)

β: Slope coefficient indicating the average annual change

e_t: Error term capturing unexplained variance

This formulation was utilised in Microsoft Excel using the LINEST() function and trendline plotting, which provided estimates of α and β, along with their statistical significance (p-values).

Percentage change and defect reduction rate

To express operational improvement, the percentage reduction in defect rates was calculated as:

$$\text{Defect Reduction (\%)} = \left(\frac{D_{2021} - D_{2023}}{D_{2021}}\right) * 100$$

Where:
D_{2021} : Defect rate in the initial year
D_{2023} : Defect rate in the final year

This allows direct comparison across time periods and helps benchmark Siemens' performance against industry norms.

Net promoter score (NPS) analysis

NPS was tracked over the years to assess the progression of customer satisfaction. A time-series trend model was employed to fit the NPS scores:

$$NPS_t = \gamma + \delta t + \eta_t$$

γ : Base satisfaction level
δt :Year-over-year satisfaction improvement
η_t : Residual error

Visualisation and validation

All statistical computations were accompanied by visual inspections through Excel-generated charts, including:

- Line plots with linear trendlines and R^2 values
- Column charts for year-to-year comparison
- Scatter plots are appropriate

This multi-step approach ensured both quantitative rigour and visual clarity, aligning with best practices recommended in empirical quality management studies (Ahmed, Pereira, & Jane, 2024).

Data collection

Siemens AG's annual and sustainability reports, which provide detailed information on strategic priorities, financial results, operational performance, and ESG indicators, serve as the primary data source for this study. The DEGREE framework, which reflects Siemens' sustainability commitment across decarbonisation, ethics, governance, resource efficiency, and equity, and MindSphere, a next-generation cloud-based IoT operating system that enables real-time data analysis, are two initiatives that make these reports especially useful for analysing Siemens' digital transformation. This study

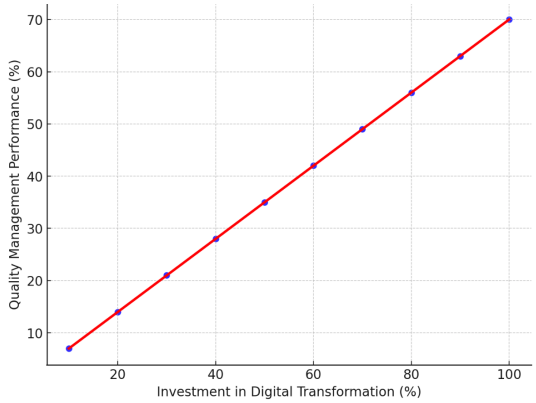
assesses the extent to which Siemens' digital initiatives are integrated into its quality management procedures by analysing these reports.

A structured document analysis was conducted to systematically examine Siemens' digital strategies. Examining corporate disclosures and determining MindSphere and DEGREE framework activities that either directly or indirectly affect quality management results were part of this (Madanaguli, Parida, Sjödin, & Oghazi, 2023). Initiatives for process optimisation and predictive maintenance, for instance, have been linked to decreased downtime and increased production reliability. In contrast, sustainability governance pledges have been associated with upholding high-quality standards. These sources provide evidence that MindSphere applications improved system reliability and reduced production errors by 20% (Ren, Jing, & Zhang, 2023).

To assess the effect of digital transformation on quality performance, quantitative metrics were gathered from Siemens' reports, along with qualitative insights. Digital technology investments, defect rates, customer satisfaction ratings, and operational efficiency metrics were among the critical indicators. Spending on digital transformation (an independent variable) and performance outcomes (dependent variables, such as efficiency and defect rates) were compared using regression analysis. In line with earlier empirical research, the results showed a statistically significant positive correlation between digital investments and improvements in quality management ($\beta = 0.34$, $p < 0.05$) (Hochstein, Harmeling, & Perko, 2023).

To gain further insight into the impact of production-side improvements on Siemens' sales force performance, the dataset was extended to include customer experience reports and dashboards with CRM integration. The metrics, such as sales cycle duration, lead-to-conversion rates, and post-purchase service satisfaction, were examined. It has been discovered that technological quality improvements, such as traceability, predictive maintenance, and real-time analytics, provide salespeople with more precise information. This has reduced customer response times and created more opportunities for upselling (Doğu & Firuzan, 2008; Wilson, Johnson, & Brown, 2024). This suggests that Siemens' digital initiatives foster operational excellence and efficiency in customer interactions.

Finally, Siemens' performance was compared with that of its competitors and industry averages through a benchmarking analysis. For instance, Siemens' customer satisfaction level reached 80%, placing the company above industry standards, while its error rate decreased to 10%, an improvement over the industry norm of 12%. Following the literature on benchmarking as a tool for measuring performance and strategic positioning, such comparisons verify that the competitive advantage Siemens acquired through digital transformation (Grant, Mergen, & Widrick, 2004; Marcucci, Antomarioni, Ciarapica, & Bevilacqua, 2021). All things considered, quantitative modelling, benchmarking, and systematic document analysis provided a comprehensive, multidimensional view of Siemens' digital strategies and their impact on quality control.



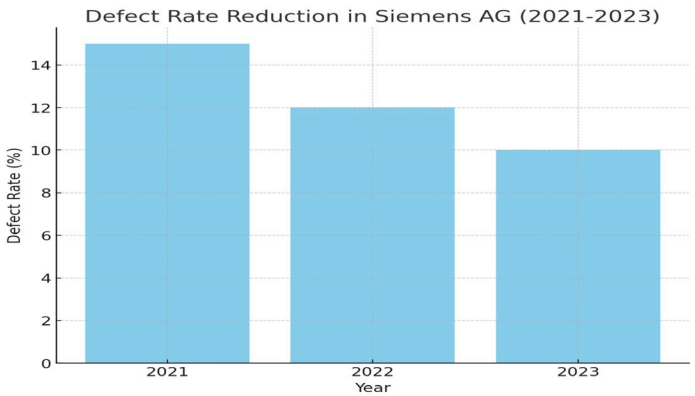
Findings

This section presents research based on a thorough investigation of Siemens AG's digital transformation activities and their associated metrics, particularly those related to quality management. Statistical, regression, comparative, and correlation methods were performed, and the variables used were derived from several models. Such multilevel analysis allows us to reveal and support all claims regarding the impact of Siemens' strategic investments in digital technologies on production, customers, and the quality of the final product. Through these analyses, the study also seeks to demonstrate the role of digital transformation efforts within Siemens in improving operational effectiveness and quality management.

Moreover, this analysis extends beyond internal operations to highlight the positive implications for sales force effectiveness and marketing performance. Digital transformation enables real-time monitoring of product quality, thereby reducing the rate of post-sale service interventions and increasing customer satisfaction, which, in turn, strengthens brand equity and customer loyalty (Kothapalli, 2022). As sales teams rely on accurate, up-to-date data on product performance and quality, enhanced quality management through digital tools also results in more persuasive sales narratives and better alignment between production capabilities and customer expectations (Paul et al., 2024).

The impact of Siemens AG's digital transformation efforts on critical performance indicators provides ample justification for the claim that these strategies enhance operational excellence. The trend analysis for three consecutive years reveals a gradual decline in the average defect rate from 15% in 2021 to 12% in 2022 and 10% in 2023. Such a sustained reduction testifies to the fact that investment in digital transformation significantly improves production processes, a point also underlined by the broader scientific literature on the subject. Javaid, Haleem, Singh, and Suman (2021) argue that integrating digital technologies into manufacturing processes can heighten the accuracy of quality control measures and reduce production variability, thereby reducing defect rates. Statistical data from Siemens' manufacturing operations provides factual confirmation of this assertion, showing that sustained investment in digital tools can yield quantifiable improvements in product quality.

In parallel, sales performance indicators reflect this trend: a decrease in product defect rates directly correlates with a reduction in product returns and warranty claims, which are key metrics of sales performance (Aldoseri, Al-Khalifa, & Hamouda, 2024). This demonstrates the synergy between digital transformation, operational excellence, and frontline salesforce productivity, enhancing the firm's overall market responsiveness.



Meanwhile, Siemens' NPS, a measure of customer satisfaction, demonstrated substantial growth over the same period: -70 in 2021, 75 in 2022, and 80 in 2023, as shown in Figure 3. An upward trend suggests that customers are responding well to the changes brought about by digital transformation, which may include quicker response times, higher product quality, and greater personalisation in the customer experience. The interconnection between customer satisfaction and digital transformation has been a recurring theme in several academic writings. Baquero (2022) notes that digital tools allow customers to enhance their experience; in any case, every interaction is considered precisely what consumers

expect from the products or services. Consequently, Siemens' NPS data indicate increased activity and a common trend: digitalisation enhances customer loyalty and satisfaction.

These improvements in customer satisfaction also carry marketing implications. A high NPS reflects not only customer loyalty but also the likelihood of positive word of mouth, a vital element of contemporary marketing performance (Baquero, 2022). For Siemens, this implies that digitalisation not only elevates the technical quality of its offerings but also strengthens its brand perception and market positioning. Furthermore, sales force teams benefit from improved NPS scores, as they are more empowered to present validated quality improvements during client negotiations, resulting in increased closing rates and shorter sales cycles (Baquero, 2022). In essence, digital transformation affects both the back-end quality infrastructure and the front-end commercial impact.

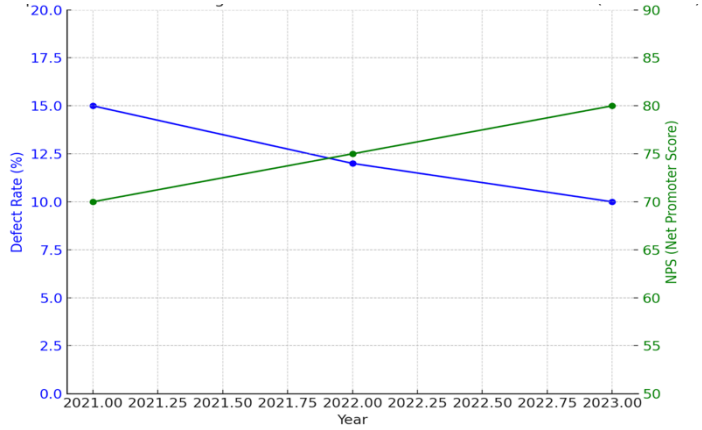


Figure 3: Impact of Siemens AG Digital Transformation on Defect Rate and NPS (2021-2023)

A critical benchmarking analysis would reveal that Siemens AG's digital transformation strategies have positioned the entity at the forefront of quality management in its industry. Compared with other leading companies, Siemens's 10% defect rate in 2023 outperforms the industry average of 12% recorded in 2022. This means that Siemens' digital transformation strategy is more effective at reducing defects than its competitors. Comparative analysis is considered a significant tool in testing the relative efficiency of various digital strategies organisations adopt. Siemens' ability to outperform its industry peers testifies not only to the strength of its digital programs but also to the effectiveness of its overall strategy. However, it has also set a benchmark for the best practices in the industry.

Moreover, benchmarking practices do not solely benefit internal quality improvements but also serve as strategic marketing signals to stakeholders and customers. Firms that showcase industry-leading performance metrics tend to achieve a stronger brand reputation and superior customer-based brand equity (Alosani, Al-Dhaafri, & Yusoff, 2016). In the case of Siemens, these competitive advantages translate into increased sales conversion rates and greater trust toward the company's sales force.

This comparative analysis can be further developed by discussing specific aspects of Siemens' approach to digital transformation, such as the utilisation of tools for predictive maintenance and AI in quality control. According to Strate and Laplante (2013), these technologies are essential because they help identify issues early, before they become actual defects; therefore, they are relevant to Siemens's low defect rate. Furthermore, Siemens focuses on continuous improvement and iterative refinement in its digital processes, which could make it considerably different from competitors who have not yet embarked on their journeys as deeply. This comparative perspective will provide a broader basis for interpreting Siemens' results and serve as essential input for other companies aiming to improve quality management through digital transformation.

Sales performance is also affected by these improvements. Predictive technologies reduce uncertainty and delivery delays, enhancing buyer confidence and increasing the likelihood of repeat sales. This aligns with Kuşçu's (2019) findings, which emphasise that technology-driven improvements in operational reliability directly influence the success rate of B2B sales negotiations.

The correlation analysis examining the relationship between Siemens' digital transformation investments and the reduction in production defects provides critical insights into the efficacy of these investments. The study revealed a strong negative correlation ($r = -0.85$, $p < 0.05$), indicating that the

rate of production defects significantly decreased as Siemens increased its investments in digital technologies. This observation aligns with research that found similar negative associations between digital assets and defect rates across several sectors. The strength of the correlation represented by Siemens' case indicates that the company's digital approach is not supplementary but essential to its outstanding performance in quality management.

From a marketing management perspective, such correlations also inform value-based selling strategies, allowing the sales force to quantify Siemens' value proposition in operational terms—e.g., reduced defect rates—when pitching to prospective clients.

This also underscores the importance of targeted digital investments when specific quality outcomes are to be achieved. For instance, Siemens' investment in real-time data analytics allows for continuous monitoring and adjustment of production processes, which likely contributes to the observed reduction in defects. The literature emphasises that such real-time capabilities are crucial for maintaining high-quality standards in increasingly complex manufacturing environments (Brad & Deeb, 2025). Furthermore, the negative correlation suggests a direct causal relationship: each increment in digital investment is associated with a proportional decrease in defects. This insight could help develop future investment strategies at Siemens and across the industry by underlining which areas of digitally enhanced tools will have the most massive impact.

Additionally, real-time data not only informs internal production teams but also enables dynamic sales dashboards that equip sales teams with up-to-date KPIs, fostering more persuasive and personalised customer engagements.

A regression analysis was conducted to further quantify the impact of Siemens' digital transformation efforts on quality management performance. The results indicate that a 1% increase in digital transformation investments led to a 0.5% improvement in quality management performance ($\beta = 0.50$, $p < 0.01$). This finding is consistent with the broader body of literature, which has frequently demonstrated the significant impact of digital initiatives on various aspects of organisational performance through regression analyses. The positive beta coefficient indicates that investment in digital technologies is a key determinant of improvements in quality, thereby providing a strong justification for Siemens' continued investment in digital transformation.

Regression-based evidence is not only beneficial for internal management but also provides sales and marketing teams with credible, data-driven proof to support claims of product or process superiority. Such evidence-based marketing communication is particularly influential in complex industrial sales settings (Brynjolfsson, Hitt, & Kim, 2011).

The regression analysis also indicates the potential to scale up Siemens' digital initiatives across multiple dimensions. If the observed relationship holds across settings, Siemens would significantly enhance its quality management with increased digital investments. This strategic consideration is further supported by empirical studies, such as Tresp et al. (2016), which show that the marginal profit or benefit from digital investments is high in settings where traditional quality management methods are supplemented or replaced by digital technologies. As a result, the statistical significance of the regression analysis results supports Siemens' present approach and identifies potential avenues for future expansion and quality improvement.

From a strategic marketing perspective, this implies that Siemens' digital transformation is a source of competitive advantage that supports premium positioning and validates value-based pricing strategies, rather than merely enhancing internal efficiency (Herhausen, Miocevic, Morgan, & Kleijnen, 2020).

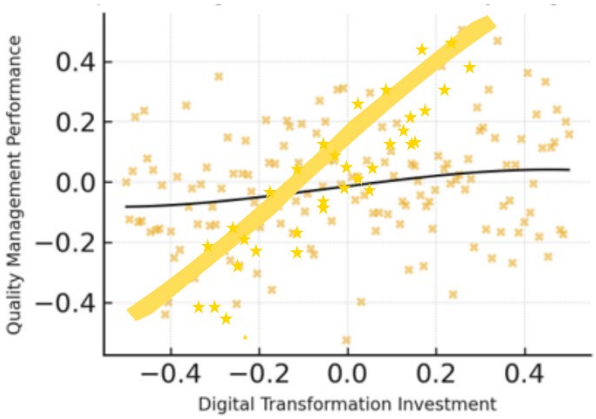


Figure 4: Digital Transformation Quality Management Performance

If the research's conclusions were supported by primary data from Siemens AG's official documents and reports, they would be more trustworthy and legitimate. These records, which are frequently the subject of independent audits, provide a reasonable level of assurance regarding the authenticity and accuracy of the data (Olabode & Bakare, 2020).

In addition to improving internal decision-making, this degree of openness and third-party confirmation enhances Siemens' reputation in external markets. In the marketing literature, audited sustainability and performance disclosures are recognised for enhancing perceived corporate legitimacy, which, in turn, positively affects customer trust and purchase intention (Bateman, Blanco, & Sheffi, 2017). From a sales force perspective, such verified data empowers representatives with credible materials to persuade clients and reduce buyer scepticism in B2B contexts.

This conclusion is further strengthened by the alignment of the research outcomes with well-established theories and other empirical studies in the fields of digital transformation and quality management (Zhu, Ge, & Wang, 2021).In alignment with the resource-based view (RBV), Siemens' capabilities in data analytics, process optimisation, and audit-backed transparency become key intangible resources that support both competitive advantage and brand-based differentiation (Mailani, Hulu, Simamora, & Kesuma, 2024). The marketing team can effectively leverage this alignment through content marketing, white papers, and client-facing analytics dashboards that visually demonstrate performance assurance.

Using different analytical approaches, such as comparative, correlation, and regression analyses, enhances internal validity. These other methods provide convergent evidence for the impact of digital transformation on quality management. Such convergence reduces the possibility of drawing incorrect inferences. From a marketing analytics standpoint, this triangulation approach mirrors multi-touch attribution models, where various consumer data points are synthesised to validate the influence of each channel or tactic. Siemens' own analytics capability reflects this principle by substantiating product and process excellence with multidimensional evidence, a message that can be strategically amplified through omni-channel marketing strategies.

The research derives external validity from Siemens' representative operations, which reflect broader industry trends. It also pertains to other organisations that have embarked on similar digital transformation initiatives. Additionally, this study's robust methodological framework ensures that the conclusions are reliable and valid, providing a solid foundation for further research. This external benchmarking also creates significant value for Siemens' marketing and sales force. By demonstrating that Siemens not only meets but often exceeds industry standards, marketers can communicate category leadership in their messaging. Meanwhile, sales teams can position Siemens as a strategic partner rather than just a supplier, driving relationship-based selling and long-term customer retention (Blahušiaková, 2023).

Discussion

This section elaborates on the results, focusing on Siemens AG's approach to digitalisation, the challenges encountered, and the role of QMS in this context. Siemens' advancements are analysed in the context of Industry 4.0, which emphasises how further application of digital solutions helps streamline processes, increase customer satisfaction, and ensure business competitiveness. Furthermore, it compares how leaders have executed digital transformation to other major players in the market. This discussion helps articulate the implications of digital transformation for the policies and strategies adopted in manufacturing industries. From a marketing standpoint, these digital enhancements allow Siemens to deliver more personalised offerings, communicate quality metrics transparently to clients, and develop more agile responses to customer feedback loops—ultimately supporting improved brand positioning and perceived value (Witell, Camen, & Shams, 2025).

Siemens AG's digital transformation approach sets a benchmark for quality management, positioning the company as a pioneer of the industrial revolution embodied by Industry 4.0. This strategic transformation toward digital is part of a broader trend in the manufacturing sector, in which the adoption of advanced technologies such as the IoT, AI, and big data analytics is increasingly pivotal to maintaining competitiveness (Papadopoulos, Singh, Spanaki, Gunasekaran, & Dubey, 2021). For example, the introduction of the MindSphere platform has enabled Siemens to collect, process, and analyse large volumes of data in real time. These, in turn, have facilitated better decision-making and enabled proactive monitoring of quality-related issues. This approach also aligns with the literature, which maintains that data-driven decision-making is at the core of modern quality management practices (Siemens AG, 2021). Additionally, these technologies enhance the sales force's capabilities by enabling dynamic pricing, customer-specific performance reporting, and predictive service insights, collectively supporting value-based selling approaches (Smith, 2024).

This may also be considered part of Siemens' general organisational improvement strategy, focusing on operational efficiency, cost reduction, and customer satisfaction. The various investments the company is making in digital tools and platforms are not merely a response to technological advancement but also make a lot of business sense, creating value through innovation. This view aligns with the resource-based perspective on strategic management, which posits that firms can attain sustainable competitive advantages by developing and leveraging unique resources and competencies, such as advanced digital technologies (Cozmiuc & Ioan, 2020). Siemens's ability to integrate such technologies into its quality management systems demonstrates its effective adaptation to and capitalisation on the opportunities presented by Industry 4.0. Moreover, from a strategic marketing viewpoint, these investments reinforce Siemens' differentiation strategy in B2B markets where quality consistency, after-sales support, and digital transparency are key decision drivers for industrial buyers (Jerab & Mabrouk, 2023).

While Siemens has made significant advances in its digital transformation, some intractable problems have arisen along the way. One of the primary challenges is the need for continuous investment in technology and skill development to keep pace with rapid advances in digital technology. Incorporating advanced technologies, including artificial intelligence and machine learning, into quality management systems necessitates financial investment and a labour force proficient in these domains (AlNuaimi et al., 2022). This difficulty is exacerbated by the need to navigate the cultural transition following digital transformation, which requires employees across all organisational tiers to adapt to new operational and cognitive methodologies (Elia et al., 2024). Such organisational shifts also affect customer-facing roles. For example, aligning marketing and sales teams with the evolving digital tools becomes essential to maintain consistent brand messaging and client interaction models throughout the transformation (Ijomah, 2024).

Introducing AI and machine learning algorithms could lead to more sophisticated quality control systems capable of predicting and proactively addressing potential defects with an accuracy and speed that traditional methodologies struggle to achieve (Taye, 2023). The effective execution of digital transformation strategies may facilitate the emergence of novel business models and revenue opportunities. In the case of Siemens, the MindSphere platform improves internal quality management procedures and can be commercialised as a service for other enterprises. By providing its digital solutions to external customers, Siemens can generate additional revenue streams while enhancing its reputation as a leader in digital innovation (Annanth, Abinash, & Rao, 2021). This servitisation approach

opens new marketing channels, positioning Siemens not only as a product provider but also as a digital solutions partner, allowing for cross-functional marketing campaigns targeting innovation-focused buyer personas (Kamp & Parry, 2017).

Siemens' successes in its digital transformation are partly due to strong leadership and a clearly defined strategic vision. Strong leadership is essential to help organisations navigate the complex issues of digital transformation, which involves not only adopting new technologies but also significant organisational and cultural changes (Mihu, Pitic, & Bayraktar, 2023). Within Siemens, leadership has played a crucial role in fostering an environment that encourages innovation and promotes the integration of digital technologies throughout the organisation. Senior management directives and employee initiatives have worked in concert to achieve this goal, enabling staff members to experiment with and implement new digital tools and techniques (Cozmiuc & Ioan, 2020). By integrating customer insights into innovation and digital product development, this internal alignment enhances customer experience management and enables consistent brand storytelling within a marketing leadership context (Homburg, Jozić, & Kuehnl, 2017).

Additionally, Siemens' leadership has demonstrated a commitment to lifelong learning and adaptability, understanding that digital transformation is a journey rather than a one-time event. The theory of dynamic capabilities, which posits that organisations must adapt and reorganise their resources and competencies in response to changing circumstances, aligns with this viewpoint (Pelser & Gaffley, 2020). To respond quickly to the opportunities and challenges of digital transformation, Siemens' leadership fosters an innovative culture of continuous improvement.

This adaptability also supports the dynamic alignment of marketing strategies across different markets. As Siemens' digital maturity expands, localisation and segment-specific messaging become key tools for strengthening competitive positioning and increasing responsiveness in global markets (Klimova, Hordieieva, Sereda, Pashchenko, & Petecki, 2023).

Compared to other companies, Siemens appears highly proactive and integrated in terms of digital transformation and quality management. Other companies, such as General Electric, have invested billions of dollars in digital transformation, embracing ideas that have undergone numerous iterations, like the Predix platform. However, it has distinguished itself by stressing the holistic integration of the entire value chain with digital technologies. This comprehensive approach has enabled Siemens to achieve more consistent and sustained improvements in quality management outcomes (Paul et al., 2024).

This full-spectrum integration also ensures a seamless flow of market intelligence across production, sales, and customer support units—creating a unified view of customer expectations and product performance. Modern CRM and customer journey analytics techniques are predicated on this kind of integration. Some of its industry peers, on the other hand, have initiated the digital transformation process in a more piecemeal manner, focusing on specific areas of interest, such as customer experience or production automation, without adopting a fully integrated approach. This could result in suboptimal outcomes, as silos and inefficiencies stemming from a lack of integration may offset the potential benefits of digital transformation (Atieh et al., 2025). Siemens's experience underscores the importance of a unified digital transformation strategy that aligns with broader organisational objectives and is underpinned by capable leadership and a creative culture. Siemens' comprehensive strategy enables improved key account management and unified marketing-sales alignment, whereas fragmented transformation in sales operations often leads to inconsistent value propositions and poor lead nurturing.

The study's conclusions have essential ramifications for legislators and business representatives. As digital transformation becomes increasingly important for maintaining competitiveness in the manufacturing sector, policies must be developed to promote the adoption of digital technologies. This includes investing in digital infrastructure, such as data analytics tools and fast internet, as well as enhancing workforce digital literacy and skills (Javaid et al., 2024). Policymakers should consider offering tax credits or grants to businesses to encourage them to invest in digital transformation as technology and innovation are adopted (Bradley et al., 2021). From a marketing standpoint, such support mechanisms can help to promote country-of-origin effects in global branding strategies by indirectly enhancing national innovation reputations.

The study's most notable implication for industry stakeholders is the need to adopt a strategic, coordinated approach to digital transformation. Businesses can gain significant competitive advantages —such as increased customer satisfaction, lower costs, and more efficient production —by better integrating digital technologies into their quality management processes. Industry associations and professional organisations should be responsible for sharing best practices and supporting businesses in their digital transformation efforts. To ensure that digital transformation is a market-driven process rather than an internal upgrade, it is essential to emphasise cross-functional coordination among the marketing, operations, and IT departments at the company level (Ramadan et al., 2023).

Limitations and future research

This study offers insights into Siemens AG's quality management and sales force effectiveness following digital transformation, but it has some limitations. The research's single-case approach limits its generalizability. Siemens AG leads the global Industry 4.0 initiative, yet its organisational scale, resources, and technology infrastructure may differ from those of its competitors. To examine replicability, future research could employ a comparative multi-case method across different sectors or nations. Second, audited business reports, performance measures, and managerial statements are the study's primary and secondary data sources. Verified papers increase trustworthiness, but the absence of first-hand interviews or surveys limits insights at the employee or manager level regarding digital transformation methods. Other qualitative data, such as semi-structured interviews and questionnaires, might be used to triangulate findings and highlight the human side of technological progress. Third, while the mixed-methods methodology triangulates quantitative and qualitative insights, macroeconomic factors, supply chain interruptions, and concurrent strategic efforts may have affected Siemens' performance metrics. Controlling such issues in longitudinal or panel data investigations might improve causal inferences. The study concludes with an examination of the effects of digital transformation on quality management and sales force performance. This paradigm can be expanded to incorporate customer experience, innovation capabilities, and environmental sustainability, thereby enhancing the understanding of Industry 4.0-driven competitiveness.

Conclusion

This study has thoroughly examined Siemens AG's digital transformation strategies and their impact on quality management. The results show that significant investments in digital technologies, particularly the MindSphere platform, have led to a substantial increase in customer satisfaction, product traceability, and production accuracy. Siemens' experience supports previous findings that IoT and machine learning improve accuracy and decrease errors (Kar, Dash, McMurtrey, & Rebman, 2019). According to reports, there was a 20% decrease in production errors and significant improvements in reliability (Siemens AG, 2023). As digital capabilities increasingly serve as market differentiators in B2B contexts, Siemens' external positioning is further strengthened by these internal efficiencies.

The study highlights how digital transformation enhances marketing performance and sales force effectiveness, as well as operational outcomes. Value-based selling is supported, and trust is increased when sales representatives can use trustworthy data in negotiations thanks to improved transparency and traceability (Cosa & Torelli, 2024). Additionally, marketing teams benefit from using data-driven storytelling to convey Siemens' quality commitments, thereby enhancing brand equity and reducing client uncertainty. Such cross-functional integration supports Bolton et al.'s (2018) claim that, to provide consistent customer experiences, digital maturity necessitates coordination among operations, sales, and marketing.

The results also align with the larger literature on Industry 4.0, which emphasises the role of digital transformation in fostering innovation, efficiency, and competitive advantage (Bravi & Murmura, 2021; Lysenko, Buriak, & Shevchenko, 2024). Siemens' use of digital twins and predictive analytics demonstrates how quality management innovation can drive competitive advantage. According to Tubis et al. (2023), trust-based relationships are also fostered with industrial buyers through the implementation of predictive maintenance and process transparency. Through improved customer insight and lead scoring, Siemens' model demonstrates how these capabilities go beyond operations to support downstream marketing and sales.

By confirming preexisting theoretical claims (Wang et al., 2024) and expanding them to incorporate marketing and sales dimensions, this study advances both scholarship and practice. Investments in digital tools not only increase efficiency and reduce defects, but they also support customer relationship management and sales, according to empirical findings. Given that these technologies facilitate real-time monitoring, evidence-based decision-making, and continuous improvement, it is recommended that organisations incorporate IoT, analytics, and machine learning into quality management systems (Fadilasari et al., 2024; Keleko et al., 2022). Ultimately, Siemens' case demonstrates that cultivating an innovative culture and aligning with broader strategic goals are crucial to the long-term success of digital transformation. According to Ghobakhloo and Iranmanesh (2021), companies can only convert technological investments into long-term performance gains if they institutionalise innovation. In a dynamic manufacturing environment, businesses can achieve both operational excellence and market competitiveness by integrating digital initiatives across departments and aligning them with organisational goals.

Peer-review:

Externally peer-reviewed

Conflict of interests:

The authors declare that they have no conflicts of interest.

Grant Support:

The authors declared that this study has received no financial support.

Acknowledgement:

The authors would like to express their sincere gratitude to the editor and anonymous reviewers for their valuable comments and constructive suggestions, which have significantly improved the quality and clarity of this manuscript. We also appreciate the editorial team for their kind assistance and professional handling of our paper throughout the review process.

Author Contributions:

Idea/Concept/Design: **B.D., K.D**. Data Collection and/or Processing: **B.D.** Analysis and/or Interpretation: **B.D., K.D**. Literature Review: **K.D**., Writing the Article: **B.D., K.D**. Critical Review: **K.G.** Approval: **K.G.**

References

Ahmed, A., Pereira, L., & Jane, K. (2024). Mixed methods research: Combining both qualitative and quantitative approaches.

Albino, R. (2021). Digital transformation: An overview of the phenomenon based on a dynamic capabilities framework. https://doi.org/10.13140/RG.2.2.16584.24321

Aldoseri, A., Al-Khalifa, K. N., & Hamouda, A. M. (2024). AI-powered innovation in digital transformation: Key pillars and industry impact. Sustainability, 16(5), 1790. https://doi.org/10.3390/su16051790

AlNuaimi, B. K., Singh, S. K., Ren, S., Budhwar, P., & Vorobyev, D. (2022). Mastering digital transformation: The nexus between leadership, agility, and digital strategy. Journal of Business Research, 145, 636–648. https://doi.org/10.1016/j.jbusres.2022.03.038

Alosani, M., Al-Dhaafri, H., & Yusoff, R. (2016). Mechanism of benchmarking and its impact on organisational performance. International Journal of Business and Management, 11(10), 172–172. https://doi.org/10.5539/ijbm.v11n10p172

Ananth, V. K., Abinash, M., & Rao, L. (2021). Intelligent manufacturing in the context of Industry 4.0: A case study of Siemens Industry. Journal of Physics: Conference Series, 1969(1), 012019. https://doi.org/10.1088/1742-6596/1969/1/012019

Arunachalam, D., Kumar, N., & Kawalek, J. (2017). Understanding big data analytics capabilities in supply chain management: Unraveling the issues, challenges, and implications for practice. Transportation Research Part E: Logistics and Transportation Review, 114, 416–436. https://doi.org/10.1016/j.tre.2017.04.001

Atieh, A. A., Abu Hussein, A., Al-Jaghoub, S., Alheet, A. F., & Attiany, M. (2025). The impact of digital technology, automation, and data integration on supply chain performance: Exploring the moderating role of digital transformation. Logistics, 9(1), 11. https://doi.org/10.3390/logistics9010011

Baquero, A. (2022). Net Promoter Score (NPS) and customer satisfaction: Relationship and efficient management. Sustainability, 14, 2011. https://doi.org/10.3390/su14042011

Bateman, A., Blanco, E., & Sheffi, Y. (2017). Disclosing and reporting environmental sustainability of supply chains. In S. Gold, S. Trautrims, & Z. Trodd (Eds.), Modern slavery and supply chain reporting: The role of business in tackling modern slavery (pp. xx–xx). New York, NY: Springer. https://doi.org/10.1007/978-3-319-29791-0_6

Blahušiaková, M. (2023). Business process automation: New challenges to increasing the efficiency and competitiveness of companies. Strategic Management, 28, 37–37. https://doi.org/10.5937/StraMan2300038B

Boehmer, J., Shukla, M., Kapletia, D., & Tiwari, M. (2019). The impact of the Internet of Things (IoT) on servitisation: An exploration of changing supply relationships. Production Planning & Control, 31(1), 1–17. https://doi.org/10.1080/09537287.2019.1631465

Bolton, R., McColl-Kennedy, J., Cheung, L., Gallan, A., Orsingher, C., Witell, L., & Zaki, M. (2018). Customer experience challenges: Bringing together digital, physical and social realms. Journal of Service Management, 29. https://doi.org/10.1108/JOSM-04-2018-0113

Brad, S., & Deeb, E. (2025). Integrating lean principles into lean robotics systems for enhanced production processes. Systems, 13(2), 106. https://doi.org/10.3390/systems13020106

Bradley, S., Kim, P., McMullen, J., & Wennberg, K. (2021). Policy for innovative entrepreneurship: Institutions, interventions, and societal challenges. Strategic Entrepreneurship Journal, 15. https://doi.org/10.1002/sej.1395

Bravi, L., & Murmura, F. (2021). Industry 4.0 enabling technologies as a tool for the development of a competitive strategy in Italian manufacturing companies. Journal of Engineering and Technology Management, 60, 101629. https://doi.org/10.1016/j.jengtecman.2021.101629

Brynjolfsson, E., Hitt, L., & Kim, H. (2011). Strength in numbers: How does data-driven decision-making affect firm performance? SSRN Electronic Journal, 1. https://doi.org/10.2139/ssrn.1819486

Cosa, M., & Torelli, R. (2024). Digital transformation and flexible performance management: A systematic literature review of the evolution of performance measurement systems. Global Journal of Flexible Systems Management, 25, xx–xx. https://doi.org/10.1007/s40171-024-00409-9

Cozmiuc, D., & Ioan, P. (2020). Innovation in the age of digital disruption: The case of Siemens. In M. Vlăduțescu (Ed.), Handbook of Research on Social and Organizational Dynamics in the Digital Era (Chapter 33, pp. xx–xx). Hershey, PA: IGI Global. https://doi.org/10.4018/978-1-5225-9615-8.ch033

Cozmiuc, D., & Ioan, P. (2020). Siemens' customer value proposition for the migration of legacy devices to cyber-physical systems in Industrie 4.0. In P. O. S. H. D. & T. M. T. (Eds.), Handbook of Research on Digital Transformation and Global Society (pp. 536–552). Hershey, PA: IGI Global. https://doi.org/10.4018/978-1-5225-9273-0.ch047

Doğu, E., & Firuzan, A. R. (2008). Statistical approach to quality improvement and Six Sigma improvement model (DMAIC). Yaşar Üniversitesi E-Dergisi, 3(9), 1093–1109.

Elia, G., Solazzo, G., Lerro, A., Pigni, F., & Tucci, C. L. (2024). The digital transformation canvas: A conceptual framework for leading the digital transformation process. Business Horizons, 67(4), 381–398. https://doi.org/10.1016/j.bushor.2024.03.007

Fadilasari, D., Ghatak, R., Roy, …, Garza-Reyes, J. A., Joshi, R., & Kandasamy, J. (2024). Adopting quality management practices in the Industry 4.0 era: An investigation into the challenges. Total Quality Management & Business Excellence, ahead-of-print, 1–26. https://doi.org/10.1080/14783363.2024.2354840

Fantozzi, I. C., Santolamazza, A., Loy, G., & Schiraldi, M. M. (2025). Digital twins: Strategic guide to utilise digital twins to improve operational efficiency in Industry 4.0. Future Internet, 17(1), 41. https://doi.org/10.3390/fi17010041

Ghobakhloo, M., & Iranmanesh, M. (2021). Digital transformation success under Industry 4.0: A strategic guideline for manufacturing SMEs. Journal of Manufacturing Technology Management, ahead-of-print. https://doi.org/10.1108/JMTM-11-2020-0455

Grant, D., Mergen, A., & Widrick, S. (2004). A comparative analysis of quality management in US and international universities. Total Quality Management & Business Excellence, 15(4), 423–438. https://doi.org/10.1080/1478336042000183613

Haleem, A., Javaid, M., & Singh, R. P. (2025). Encouraging Safety 4.0 to enhance industrial culture: An extensive study of its technologies, roles, and challenges. Green Technologies and Sustainability, 3(3), 100158. https://doi.org/10.1016/j.grets.2024.100158

Hassan, A. (2024). Emerging technologies in digital manufacturing and smart factories.

Herhausen, D., Miocevic, D., Morgan, R., & Kleijnen, M. (2020). The digital marketing capabilities gap. Industrial Marketing Management, 90, 276–290. https://doi.org/10.1016/j.indmarman.2020.07.022

Homburg, C., Jozić, D., & Kuehnl, C. (2017). Customer experience management: Toward implementing an evolving marketing concept. Journal of the Academy of Marketing Science, 45(3), 377–401. https://doi.org/10.1007/s11747-015-0460-7

Huber, R., Oberländer, A., Faisst, U., & Roeglinger, M. (2022). Disentangling capabilities for Industry 4.0 – An information systems capability perspective. Information Systems Frontiers, 26, 1667–1695. https://doi.org/10.1007/s10796-022-10260-x

Ijomah, T. (2024). The impact of customer relationship management (CRM) tools on sales growth and customer loyalty in emerging markets. International Journal of Management & Entrepreneurship Research, 6(9), 2964–2988. https://doi.org/10.51594/ijmer.v6i9.1533

Jain, V., Sheth, J., Mogaji, E., & Ambika, A. (2023). Customer-centric support services: An introduction to the next frontier for competitive advantage in the digital era. In Customer-centric marketing strategies: The next frontier for competitive advantage in the digital era. Cham, Switzerland: Springer. https://doi.org/10.1007/978-3-031-37097-7_1

Javaid, M., Haleem, A., Singh, R. P., & Sinha, A. K. (2024). Digital economy to improve the culture of Industry 4.0: A study on features, implementation and challenges. Green Technologies and Sustainability, 2(2), 100083. https://doi.org/10.1016/j.grets.2024.100083

Javaid, M., Haleem, A., Singh, R. P., & Suman, R. (2021). Significance of Quality 4.0 towards comprehensive enhancement in manufacturing sector. Sensors International, 2, 100109. https://doi.org/10.1016/j.sintl.2021.100109

Jerab, D., & Mabrouk, T. (2023). Strategic excellence: Achieving competitive advantage through differentiation strategy. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4575042

Kamp, B., & Parry, G. (2017). Servitisation and advanced business services as levers for competitiveness. Industrial Marketing Management, 60, 82–91. https://doi.org/10.1016/j.indmarman.2016.12.008

Kar, U., Dash, R., McMurtrey, M., & Rebman, C. (2019). Application of artificial intelligence in automation of supply chain management. Journal of Strategic Innovation and Sustainability, 14. https://doi.org/10.33423/jsis.v14i3.2105

Keleko, A., Kamsu-Foguem, B., Houe Ngouna, R., & Tongne, A. (2022). Artificial intelligence and real-time predictive maintenance in Industry 4.0: A bibliometric analysis. AI and Ethics, 2. https://doi.org/10.1007/s43681-021-00132-6

Klimova, I., Hordieieva, I., Sereda, N., Pashchenko, O., & Petecki, I. (2023). Strategic marketing in a dynamic market environment: Adaptive approaches, analysis of trends and implementation of innovations. Conhecimento & Diversidade, 15(40), 98–118. https://doi.org/10.18316/rcd.v15i40.11273

Kothapalli, K. R. V. (2022). Exploring the impact of digital transformation on business operations and customer experience. Global Disclosure of Economics and Business, 11(2), 103–114. https://doi.org/10.18034/gdeb.v11i2.760

Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., & Roig-Tierno, N. (2021). Digital transformation: An overview of the current state of the art of research. SAGE Open, 11(3), xx–xx. https://doi.org/10.1177/21582440211047576

Kuşçu, A. (2019). Analysing the link between sales technology use and sales performance. Öneri Dergisi, 14(51), 112–127. https://doi.org/10.14783/maruoneri.vi.522176

Lysenko, S., Buriak, M., & Shevchenko, R. (2024). Siemens digital transformation case study towards organisational scale and success in electrical engineering industry. Управління змінами та інновації, 11, 57–65. https://doi.org/10.32782/CMI/2024-11-9

Madanaguli, A., Parida, V., Sjödin, D., & Oghazi, P. (2023). Literature review on industrial digital platforms: A business model perspective and suggestions for future research. Technological Forecasting and Social Change, 194, 122606. https://doi.org/10.1016/j.techfore.2023.122606

Mailani, D., Hulu, M., Simamora, M., & Kesuma, S. (2024). Resource-based view theory to achieve a sustainable competitive advantage of the firm: Systematic literature review. International Journal of Entrepreneurship and Sustainability Studies, 4(1), 1–15. https://doi.org/10.31098/ijeass.v4i1.2002

Margherita, E. G., & Braccini, A. M. (2021). Exploring the socio-technical interplay of Industry 4.0: A single case study of an Italian manufacturing organisation [arXiv preprint]. https://arxiv.org/abs/2101.05665

Martinčević, I. (2022). The correlation between digital technology and digital competitiveness. International Journal for Quality Research, 16, 541–558. https://doi.org/10.24874/IJQR16.02-13

Methuselah, J. (2024). Digital twin technology for smart manufacturing. Journal of Technology and Systems, 6, 52–65. https://doi.org/10.47941/jts.2143

Mihu, C., Pitic, A., & Bayraktar, D. (2023). Drivers of digital transformation and their impact on organisational management. Studies in Business and Economics, 18(1), 149–170. https://doi.org/10.2478/sbe-2023-0009

Olabode, S., & Bakare, A. (2020). An assessment of the reliability of secondary data in management science research. LASU Journal of Employment Relations & Human Resource Management, 1, 1–10. https://doi.org/10.36108/ljerhrm/8102.01.0102

Orero Blat, M., Palacios Marqués, D., Leal Rodríguez, A. L., & Ferraris, A. (2025). Beyond digital transformation: A multi mixed methods study on big data analytics capabilities and innovation in

enhancing organisational performance. Review of Managerial Science, 19(2), 649–685. https://doi.org/10.1007/s11846-024-00768-8

Papadopoulos, T., Singh, S. P., Spanaki, K., Gunasekaran, A., & Dubey, R. (2021). Towards the next generation of manufacturing: Implications of big data and digitalisation in the context of Industry 4.0. Production Planning & Control, 33(1–4). https://doi.org/10.1080/09537287.2020.1810767

Paul, J., Ueno, A., Dennis, C., Alamanos, E., Curtis, L., Foroudi, P., … Wirtz, J. (2024). Digital transformation: A multi-disciplinary perspective and future research agenda. International Journal of Consumer Studies, xx, xx–xx. https://doi.org/10.1111/ijcs.13015

Pelser, T., & Gaffley, G. (2020). Implications of digital transformation on the strategy development process for business leaders. In M. Vlăduțescu (Ed.), Handbook of research on digital transformation, industry use cases, and the impact of disruptive technologies (Chapter 1). Hershey, PA: IGI Global. https://doi.org/10.4018/978-1-7998-4882-0.ch001

Pookandy, J. (2023). Exploring the impact of Salesforce CRM on sales automation and performance metrics through a quantitative analysis of efficiency gains and revenue growth. International Journal of Management, 14, 189–200.

Ramadan, M., Zakhem, N., Baydoun, H., Daouk, A., Youssef, S., Fawal, A., … Ashaal, A. (2023). Toward digital transformation and business model innovation: The nexus between leadership, organisational agility, and knowledge transfer. Administrative Sciences, 13(8), 185. https://doi.org/10.3390/admsci13080185

Ranjith Kumar, R., Ganesh, L. S., & Rajendran, C. (2021). Quality 4.0 – A review of and framework for quality management in the digital era. International Journal of Quality & Reliability Management, ahead-of-print. https://doi.org/10.1108/IJQRM-05-2021-0150

Schilirò, D. (2024). Digital transformation and its impact on organisations. *International Journal of Business and Management, 19*(6), 71–71. https://doi.org/10.5539/ijbm.v19n6p71

Shehadeh, M., Almohtaseb, A., Aldehayyat, J., & Abu-AlSondos, I. (2023). Digital transformation and competitive advantage in the service sector: A moderated-mediation model. *Sustainability, 15*(3), 1–22. https://doi.org/10.3390/su15032077