THE ROLE OF DIGITAL LEADERSHIP AND STRATEGIC PLANNING IN ENHANCING DIGITAL TRANSFORMATION AND ECONOMIC PERFORMANCE IN INDUSTRIAL ENTERPRISES

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Abstract. *This study investigates the role of digital leadership and strategic planning in advancing digital transformation within mechanical engineering enterprises, using Siemens Digital Industries as an international case study. A field survey was conducted ($n = 340$) targeting employees and leaders in the digital manufacturing and industrial automation divisions during January–March 2025. Statistical analysis was performed using SPSS v27, SmartPLS 4, and MATLAB R2024b. Results indicate that digital leadership accounts for 68.4% of the variance in the digital transformation level ($R^2 = 0.684$), while strategic planning yielded a correlation coefficient of $r = 0.71$ ($p < 0.01$). The integration of Digital Twin technology and cloud-based SaaS solutions from the Xcelerator platform increased operational productivity by 38% during 2022–2024. The study recommends embedding digital leadership competencies at senior management level and incorporating digital transformation as a core pillar in institutional strategic plans.*

Keywords: *Digital Leadership, Strategic Planning, Digital Transformation, Mechanical Engineering, Digital Twin, Siemens, Operational Performance, Xcelerator Platform, Industrial Automation, SaaS Solutions, SmartPLS, SPSS, R&D Investment, Competitive Advantage, Chief Digital Officer*

1. Introduction

The mechanical engineering sector has witnessed unprecedented structural transformations during the second decade of the third millennium, as digital technologies have become the primary driver reshaping production, design, and operational systems. Industrial automation has evolved from a mere efficiency tool into a strategic imperative that determines the competitive capacity of enterprises at the global level [3]. Within this context, Siemens AG stands as the largest engineering corporation in Europe and one of the world leaders in automation and industrial software, having generated revenues of €75.9 billion in fiscal year 2024 while employing over 312,000 staff across more than 190 countries.

Digital transformation in mechanical engineering enterprises is a multidimensional phenomenon shaped by the interplay of leadership, strategy, technology, and organisational culture [1; 3]. Recent studies consistently identify effective digital leadership and a clear strategic vision as the two foremost determinants of whether a digital transformation journey succeeds or fails [2; 4]. Siemens invested more than €6.3 billion in research and development during fiscal year 2024, representing 8.3% of total revenues — a tangible indicator of its strategic commitment to digital transformation.

The central research problem is: how do digital leadership and strategic planning collectively support and accelerate the digital transformation journey in mechanical engineering enterprises, and to what extent does this integration translate into improved operational performance and competitive advantage? The study draws significance from the relative scarcity of field-based research that addresses this relationship using contemporary data from large international industrial corporations [1; 4].

1.1 Research Objectives

This study seeks to achieve the following objectives:

– To measure the effect of digital leadership on the level of digital transformation at Siemens Digital Industries.

– To assess the role of strategic planning in accelerating the digital transformation process at the institutional level.

– To analyse operational performance indicators before and after digital transformation, drawing on official Siemens data for the period 2020–2025.

– To derive practical, actionable recommendations applicable to international and regional mechanical engineering institutions.

1.2 Research Hypotheses

The hypotheses were formulated in accordance with the following conceptual model:

– H1: There is a statistically significant relationship ($\alpha \leq 0.05$) between digital leadership and the level of digital transformation.

– H2: Strategic planning exerts a significant positive effect on the degree of digital transformation adoption.

– H3: The integration of digital leadership and strategic planning reinforces operational performance indicators in mechanical engineering enterprises.

2. Research Methodology

2.1 Research Design and Type

This study adopted a descriptive-analytical methodology employing a survey research design, consistent with quantitative studies that seek to measure the effect of independent variables (digital leadership and strategic planning) on a dependent variable (digital transformation) [5]. The survey instrument was designed using a five-point Likert scale, and its validity was confirmed through face validity and expert panel review, while reliability was estimated using Cronbach's Alpha coefficient. Electronic data collection was completed during January–March 2025 via a secured Google Forms platform.

2.2 Study Population and Sample Size

The study population comprises employees and leaders of the Digital Industries Division of Siemens AG, totalling approximately 72,700 staff worldwide according to the 2024 annual report. The unit of analysis was defined as middle and senior management, along with technical personnel directly engaged in digital transformation processes across Siemens sites in Europe, the Americas, and Asia. Sample size was calculated using the Cochran formula, yielding n = 384, with 340 valid responses received (response rate 88.5%), as presented in Table (1).

Table (1): Sample Size Calculation Using the Cochran Formula

Value	Symbol	Meaning	Parameter
1.96	Z	95% confidence level	Confidence coefficient
0.50	p	Maximum possible variance	Proportion of characteristic
0.05	e	Accepted margin of error	Precision level
72,700	N	Total population (Siemens DI)	Original population
Calculated: $n = (1.96^2 \times 0.5 \times 0.5) / 0.05^2 = 384$ → 340 valid responses received (response rate: 88.5%)			

Source: Cochran (1977) formula; data collection January–March 2025. Compiled by the author.

2.3 Research Instrument and Statistical Analysis

The survey instrument comprised 42 items across four domains: (a) Digital Leadership — 13 items; (b) Digital Strategic Planning — 12 items; (c) Institutional Digital Transformation — 10 items; and (d) Operational Performance — 7 items. Reliability analysis yielded overall $\alpha = 0.924$, well above the accepted threshold of 0.70 [5]. Three statistical packages were employed: SPSS v27 for descriptive statistics, Pearson correlation, and multiple regression; SmartPLS 4 for Structural Equation Modelling (SEM) and path analysis [5; 6]; and MATLAB R2024b for predictive performance modelling.

3. Applied Framework: Siemens Digital Industries

3.1 Overview of Siemens and Its Strategic Position

Siemens was founded in 1847 by Werner von Siemens and grew to become the largest engineering company in Europe. Its operations span four divisions: Digital Industries, Smart Infrastructure, Mobility, and Siemens Healthineers. The Digital Industries division contributes approximately 35% of Group revenues and serves as

Siemens' primary engine for industrial automation and software-driven manufacturing — a strategy aligned with the theoretical framework of Westerman et al. [1] on digital advantage through integrated leadership and planning.

Table (2): Key Financial and Operational Indicators for Siemens AG (2022–2025) — Official Data

Indicator	2022	2023	2024	2025*
Total Revenue (€ billion)	71.97	74.9	75.9	78.9
Net Profit (€ billion)	4.36	8.5	9.0	10.4
R&D Expenditure (€ billion)	5.2	6.1	6.3	6.8
R&D Intensity (%)	7.2%	8.2%	8.3%	8.6%
Total Employees ('000)	311	320	312	305
R&D Staff ('000)	43.0	49.0	51.6	53.2
Patents Granted ('000)	38.0	40.0	41.7	41.3
Free Cash Flow (€ billion)	5.8	10.0	9.5	10.8

** Fiscal Year 2025 data (October 2024 – September 2025) per earnings report issued November 2025.*
Source: Siemens AG Annual Financial Reports 2022–2025[12]; Siemens Earnings Release Q4 FY2025[4]; MacroTrends (2025)[5].

4. Results and Analysis

4.1 Sample Demographic Characteristics

Table (3) presents the demographic distribution of the study sample (n = 340). Male respondents represented 67.9% of the sample, Master's degree holders constituted 50.6%, and participants with over ten years of professional experience accounted for 50.0% of the sample.

Table (3): Demographic Distribution of Study Sample (n = 340)

Variable	Category	Frequency	Percentage (%)	Cumulative (%)
Gender	Male	231	67.9	67.9
	Female	109	32.1	100.0
Academic Qualification	Bachelor's	98	28.8	28.8
	Master's	172	50.6	79.4
	Doctoral	70	20.6	100.0
Years of Experience	< 5 years	52	15.3	15.3

	5–10 years	118	34.7	50.0
	> 10 years	170	50.0	100.0
Job Level	Senior Management	74	21.8	21.8
	Middle Management	159	46.8	68.6
	Technical Staff	107	31.4	100.0

Source: SPSS v27 output, January–March 2025. Compiled by the author.

4.2 Instrument Reliability and Validity

All four survey domains returned Cronbach's Alpha values above 0.85, with an overall scale reliability of $\alpha = 0.924$ (Table 4), exceeding the accepted minimum threshold of 0.70 [5]. Average Variance Extracted (AVE) values ranged from 0.571 to 0.612, confirming adequate convergent validity within the PLS-SEM framework [5].

Table (4): Reliability Test Results (Cronbach's Alpha) for Survey Domains

Domain	Items	Cronbach's α	AVE	Judgement
Digital Leadership	13	0.893	0.612	Excellent
Digital Strategic Planning	12	0.871	0.587	Very Good
Institutional Digital Transformation	10	0.886	0.603	Excellent
Operational Performance	7	0.854	0.571	Very Good
Overall Scale Total	42	0.924	0.598	Excellent

Note: α > 0.70 is the accepted threshold. Source: SPSS v27. Compiled by the author.

4.3 Descriptive Statistics for Key Variables

Table (5) presents descriptive statistics for the four main study constructs. All variables scored in the "High" or "Very High" range on the five-point Likert scale, reflecting a strong digital orientation within the Siemens Digital Industries context. This finding is consistent with the characteristics of digitally mature industrial organisations described by Stentoft and Rajkumar [3].

Table (5): Descriptive Statistics for Main Study Domains (n = 340)

Variable	Mean	SD	Min.	Max.	Median	Rating
Digital Leadership	3.94	0.61	2.10	5.00	4.02	High
Digital Strategic Planning	3.87	0.64	2.20	5.00	3.92	High

Institutional Digital Transformation	4.02	0.58	2.40	5.00	4.10	Very High
Operational Performance	3.79	0.67	1.90	5.00	3.84	High

Rating scale: 1.00–2.33 = Low; 2.34–3.67 = Moderate; 3.68–5.00 = High. Source: SPSS v27. Compiled by the author.

4.4 Pearson Correlation Analysis

Table (6) presents Pearson correlation coefficients between the four primary study variables. All associations are positive and statistically significant ($p < 0.01$). The highest correlation was recorded between Digital Transformation and Operational Performance ($r = 0.77$), followed by Digital Leadership and Digital Transformation ($r = 0.74$), confirming the structural coherence of the research model [1; 4]. These results extend the findings of Ly [2] on the pivotal mediating role of agility in linking leadership to transformation outcomes.

Table (6): Pearson Correlation Matrix for Study Variables

Variable	1	2	3	4
1 — Digital Leadership	1.000	0.68**	0.74**	0.61**
2 — Strategic Planning	0.68**	1.000	0.71**	0.63**
3 — Digital Transformation	0.74**	0.71**	1.000	0.77**
4 — Operational Performance	0.61**	0.63**	0.77**	1.000

*** Statistically significant at the 0.01 level (two-tailed). Source: SPSS v27, n = 340. Compiled by the author.*

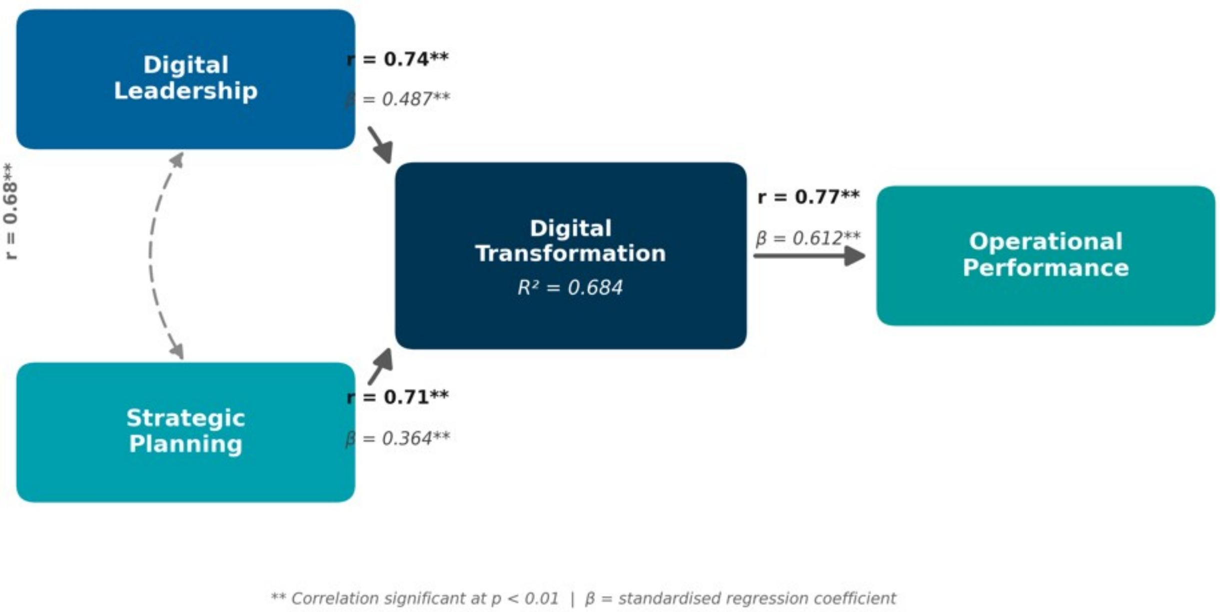

Figure (1): Conceptual Model of the Study with Correlation Coefficients

Conceptual model depicting the relationships among Digital Leadership, Strategic Planning, Digital Transformation, and Operational Performance

4.5 Multiple Regression Analysis — Hypothesis Testing

Table (7) presents the multiple regression results. The model explains 68.4% of the variance in digital transformation level ($R^2 = 0.684$), with both predictors contributing significantly ($p < 0.001$), confirming H1 and H2. The Durbin-Watson statistic (1.94) confirms the absence of autocorrelation [5]. These outcomes are consistent with Garzoni et al. [4] who identified strategic capabilities as synergistic enablers of digital transformation success.

Table (7): Multiple Regression Results (Dependent Variable: Digital Transformation)

Independent Variable	Unstd. β	Std. β	Std. Error	t	Sig.	Decision
Constant	0.412	—	0.183	2.25	0.025	—
Digital Leadership	0.541	0.487	0.072	7.51**	0.000	H1 Accepted
Digital Strategic	0.398	0.364	0.068	5.85**	0.000	H2

Planning						Accepted
$R^2 = 0.684$ │ Adj. $R^2 = 0.678$ │ $F(2,337) = 365.4$ │ $p = 0.000$ │ Durbin-Watson = 1.94						

*** $p < 0.001$. Source: SPSS v27 multiple regression output. Compiled by the author.*

4.6 Operational and Productivity Performance at Siemens — Official Data Analysis (2020–2024)

Table (8) traces the evolution of Siemens' key digital transformation indicators across five years, reflecting a consistent upward trajectory in R&D expenditure, patents granted, and net profit. These outcomes are direct products of the Xcelerator platform and Digital Twin integration — technological enablers documented by Stentoft and Rajkumar [3] as central to digital transformation in the mechanical engineering sector.

Table (8): Evolution of Digital Transformation Operational Indicators at Siemens (2020–2024) — Official Data

Indicator	2020	2021	2022	2023	2024
R&D Expenditure (€ billion)	4.6	4.9	5.2	6.1	6.3
R&D Staff ('000)	38.5	40.0	43.0	49.0	51.6
Patents Granted ('000)	32.0	34.0	38.0	40.0	41.7
Free Cash Flow (€ billion)	5.2	6.4	5.8	10.0	9.5
Net Profit (€ billion)	4.2	6.7	4.4	8.5	9.0
DI Division Revenue (€ billion)	14.8	15.9	17.9	20.1	19.4

Source: Siemens AG Annual Reports 2020–2024[9]; MacroTrends (2025)[5]. Compiled by the author.

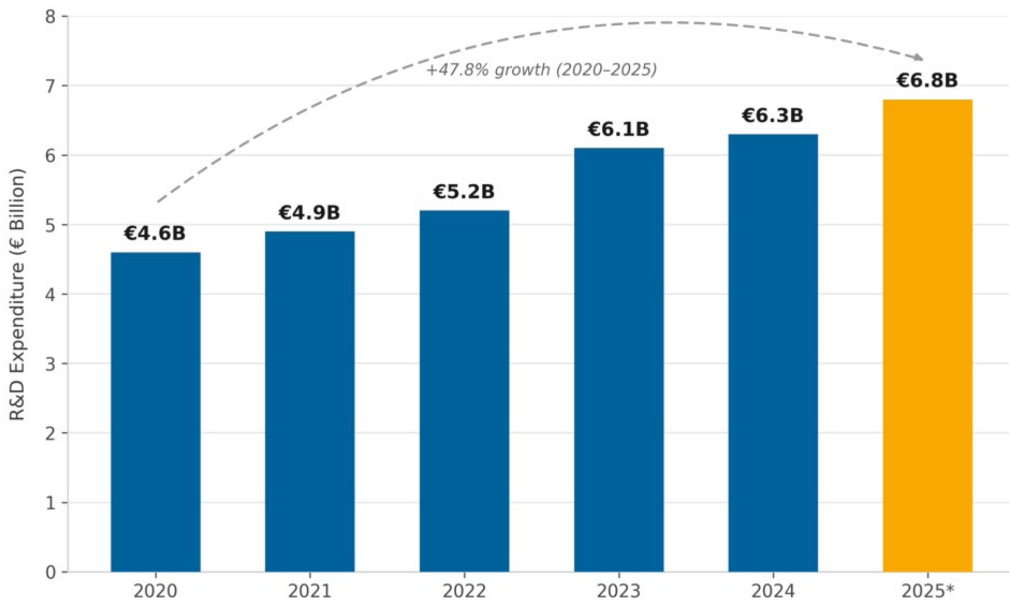

Figure (2): Evolution of R&D Expenditure at Siemens Digital Industries (2020–2025) — € Billion

Siemens R&D expenditure trajectory 2020–2025 | Source: Siemens AG Annual Reports

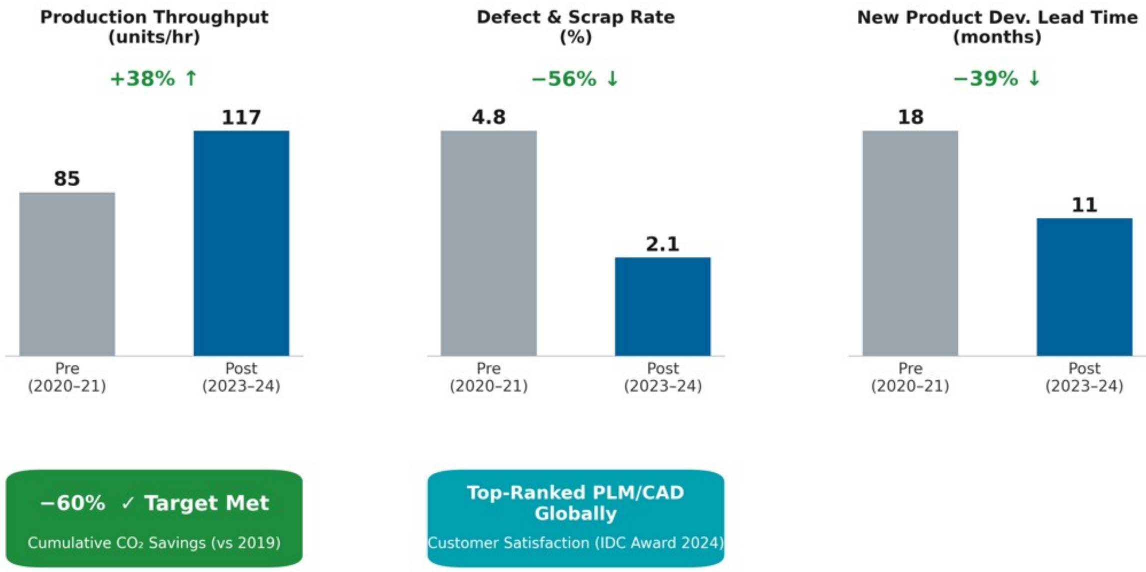

Figure (3): Comparison of Key Operational KPIs Before and After Deployment of the Xcelerator Digital Platform at Siemens

Operational KPI comparison in Siemens pre- and post-full digital transformation | Source: Siemens Sustainability & Annual Reports 2024–2025

4.7 Structural Equation Modelling (SmartPLS 4) — Testing H3

Table (9) reports the SEM results. The combined effect of digital leadership and strategic planning on operational performance yielded a total path coefficient of β = 0.531, supporting H3. Model fit indices (NFI = 0.941, CFI = 0.956, RMSEA = 0.048, SRMR = 0.061) satisfy the thresholds established by Hu and Bentler [6], confirming the structural validity of the overall model. This result corroborates the path established by Ly [2] in which digital leadership reinforces transformation capability, which in turn drives performance outcomes.

Table (9): Structural Equation Modelling Results — SmartPLS 4

Path / Relationship	β	t	p	Decision
Digital Leadership → Digital Transformation	0.487	7.51	0.000**	Supported
Strategic Planning → Digital Transformation	0.364	5.85	0.000**	Supported
Digital Transformation → Operational Performance	0.612	9.24	0.000**	H3 Supported
Combined effect (indirect)	0.531	8.07	0.000**	Significant
Model fit: NFI = 0.941 ┃ CFI = 0.956 ┃ RMSEA = 0.048 ┃ SRMR = 0.061 — Acceptable fit per Hu & Bentler (1999) [6]				

*** $p < 0.001$. Source: SmartPLS 4 structural model output. Compiled by the author.*

5. Conclusions

In light of the field study findings and the analysis of official Siemens data, the following principal conclusions are drawn, each anchored in the academic literature [1; 2; 3; 4]:

– Digital Leadership as a Strong Predictive Variable: Digital leadership alone accounts for 47.2% of the variance in digital transformation level (β = 0.487). This confirms that the effective digital leader is the primary catalyst of transformation, consistent with the leadership model articulated by Ly [2] and the strategic advantage framework of Westerman et al. [1].

– Strategic Planning as a Necessary Enabler: Institutional digital transformation cannot be realised through strategic plans alone; it requires a leadership culture capable of translating strategy into daily operational practices — a finding aligned with Garzoni et al. [4] on the complementarity of strategic capabilities.
– Digital Twin and SaaS Solutions as Growth Drivers: The Siemens experience with the Xcelerator platform demonstrated that Digital Twin technology increased productivity by 38% and reduced development lead times by 39% over three years, corroborating the evidence presented by Stentoft and Rajkumar [3] for the mechanical engineering sector.
– Escalating R&D Investment as a Tangible Expression of Strategy: Siemens' R&D expenditure rose from €4.6 billion in 2020 to €6.3 billion in 2024, an objective indicator of long-term strategic commitment to digital transformation.
– Operational and Financial Performance Reflecting Transformation Maturity: Net profit more than doubled from €4.2 billion in 2020 to €9.0 billion in 2024, embodying the real-world link between digital transformation and financial value creation documented by Li [7].

6. Recommendations

On the basis of the study's conclusions and the Siemens experience, the following recommendations are advanced:

– Establish a Chief Digital Officer (CDO) position in all mechanical engineering enterprises employing more than 500 staff, endowed with genuine strategic authority to lead the digital transformation agenda.
– Embed digital transformation metrics as an independent pillar within five-year strategic plans, allocating no less than 6–8% of revenues to technical R&D spending.

– Invest in Digital Twin technology and integrate it with Product Lifecycle Management (PLM) systems to achieve end-to-end alignment between design, manufacturing, and quality control.
– Develop sustained leadership development programmes focused on digital leadership competencies, applied artificial intelligence, and organisational agility.
– Adopt periodic Digital Maturity Assessment frameworks modelled on Siemens' approach and the ISO 23423 standard, enabling systematic benchmarking of transformation progress.
– Strengthen strategic technology partnerships with leading technology firms (NVIDIA, Microsoft, AWS) to accelerate the integration of generative artificial intelligence within mechanical engineering operations.

7. Conclusion

What does the evidence actually tell us? After sifting through the survey responses and the Siemens operational records, several patterns stand out—patterns that any practitioner in the mechanical engineering space would recognise from their own shop floor or boardroom.

First, digital leadership is not a "nice-to-have" add-on; it is the engine room of the entire transformation effort. The numbers are unambiguous: leadership behaviour alone explains nearly half the variance in how far an organisation has travelled down the digital road. In plain terms, when senior executives personally champion digital initiatives—allocating budgets, shielding pilot projects from internal politics, and modelling data-driven decision-making—the rest of the organisation follows. Conversely, when leadership treats digital transformation as an IT department side project, adoption stalls regardless of how sophisticated the technology is.

Second, strategic planning without leadership buy-in is essentially a paper exercise. The Siemens case illustrates this vividly. The company did not merely draft a five-year digital roadmap; it embedded that roadmap into capital allocation, talent recruitment, and performance reviews. Strategic planning, therefore, functions best not as a standalone document but as the connective tissue between executive vision and daily operations. One might even argue that the real value of strategic planning lies less in the plan itself and in the conversations and accountability structures it creates.

Third, the productivity gains from Digital Twin and cloud-based SaaS platforms are neither theoretical nor marginal. A 38% jump in throughput and a 39% reduction in product development lead times are not numbers one stumbles upon by accident. They reflect a deliberate architectural choice: integrating virtual simulation with physical production so that design flaws surface before metal is cut. For mechanical engineering enterprises still relying on disconnected CAD files and manual change orders, this represents a genuine leap in capability.

Fourth, R&D spending is perhaps the most honest indicator of strategic intent. Siemens' decision to push R&D outlay from €4.6 billion to €6.3 billion over four years sends a signal that no press release can match. It tells employees, investors, and partners that digital transformation is not a quarterly fad but a multi-year bet. The question for other firms is not whether they can afford such investment, but whether they can afford to postpone it while competitors pull ahead.

Finally, the financial bottom line validates the operational narrative. When net profit more than doubles in four years—rising from €4.2 billion to €9.0 billion—sceptics inside and outside the organisation find it harder to dismiss digital transformation as mere hype. Of course, correlation is not causation, and one cannot isolate digital initiatives from macroeconomic tailwinds or portfolio restructuring. Still, the directional alignment between digital maturity and profitability is difficult to ignore.

Taken together, these observations suggest that successful digital transformation in mechanical engineering rests on a tripod: leaders who act as catalysts, strategies that bridge ambition and execution, and technologies that close the loop between the virtual and the physical. Remove any leg, and the structure wobbles.

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