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Digital Intelligence and Agile Governance: How ICT Catalyzes Competitiveness -case of study: Siemens and Alstom-

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Abstract:

This research investigates how Information and Communication Technologies (ICT) catalyze organizational competitiveness through the synergy of digital intelligence and agile governance. Focusing on two leading European industrial groups—Siemens and Alstom—the study employs a comparative qualitative methodology based on multiple case studies, analyzing six key dimensions: digital strategic alignment, technological infrastructure, digital governance, agile culture, customer-centered innovation, and cross-functional integration. Data were collected via triangulation of annual reports, academic and professional publications, and executive interviews, and analyzed between October 2023 and February 2024. Key findings reveal that Siemens adopts a systemic and agile approach to ICT integration, embedding digital tools across its value chain and fostering superior innovative performance and organizational resilience. In contrast, Alstom's digital transformation remains more fragmented, with localized ICT initiatives and limited cross-functional integration, which constrains its transformative potential. The research demonstrates that strategic ICT integration, combined with agile governance and a culture of continuous learning, is essential for sustaining competitive advantage in a volatile digital environment.
Important results highlight Siemens' higher digital maturity (aggregate score 4.5/5 vs. Alstom's 2.9/5), driven by cross-functional project management and robust technological infrastructure. Empirical evidence supports a strong correlation between digital maturity and innovation performance, including shorter time-to-market and higher product success rates. The study emphasizes the need for a holistic approach to digital transformation, where technological, governance, and cultural dimensions are aligned.

Keywords: Digital Transformation, Agile Governance, Competitive Advantage, Dynamic Capabilities, ICT Integration, Organizational Innovation

JEL Classification Codes: O32, L25, M15, M21

1. Introduction :

Today, corporate competitiveness depends on the ability to innovate rapidly and effectively in an unstable, digitized, and competitive environment. This imperative compels organizations to rethink their structures, governance models, and business processes. Agile governance and digital intelligence together meet this demand. ICT—particularly artificial intelligence, the Internet of Things (IoT), big data analytics, and automation—are now indispensable tools for organizational transformation, reducing time and development costs while enhancing both incremental and radical innovation.

2. Theoretical Framework:

2.1 Digital Intelligence and Agile Governance

Digital intelligence refers to an organization's ability to capture, process, analyze, and leverage massive information flows in real-time for decision-making (Brynjolfsson & McAfee, 2014). It involves a blend of technological infrastructures (sensors, networks, cloud, AI) and analytical competencies embedded into corporate strategy, enabling the company to become "intelligent" in anticipating, simulating, adjusting, and learning continuously.

Agile governance, in turn, adopts agile software development methods—short planning cycles, strong end-user involvement, autonomous multidisciplinary teams, and ongoing adaptability (Rigby et al., 2016)—to organize the enterprise around agility, responsiveness, customer targeting, and rapid user feedback. This enables companies to turn weak signals into innovation opportunities and foster a structured culture of experimentation.

2.2 ICT and Innovation Management

ICT contributes to all stages of the innovation process: strategic intelligence, ideation, design, prototyping, testing, and launch. Automated data processing of markets and social networks facilitates the identification of emerging trends. Text mining, machine learning, and data visualization provide actionable and predictive insights through Big Data (Porter & Heppelmann, 2014).

In development, collaborative tools like Slack or Trello, cloud environments, and project management platforms orchestrate cross-functional, geographically distributed teams. Rapid prototyping using 3D printing or augmented reality accelerates testing cycles. At later stages, virtual reality user testing and digital twins enable fast iterations before commercialization.

ICT enhances organizational absorption, resilience, and responsiveness. It also transforms customer relationships through augmented reality, behavioral analysis, chatbots, and dynamic product personalization.

3. Methodology

This research addresses the professional research problem of how ICT catalyzes organizational competitiveness through the articulation of digital intelligence and agile governance. A comparative qualitative approach using multiple case studies (Yin, 2018) was employed, ideal for studying complex phenomena in real contexts with in-depth analysis but limited statistical generalization.

3.1 Case Selection Justification

Two benchmark European industrial companies were selected—Siemens (Germany) and Alstom (France)—based on two criteria: the level of digital integration in internal processes and overall corporate strategy, and organizational maturity in agile practices and innovation management. The contrasting profiles of these firms allowed for the construction of a meaningful analytical typology (Eisenhardt, 1989).

3.2 Data Sources

The research is based on triangulation of sources, ensuring the strength and reliability of the results:

- Primary documentary data: annual reports, CSR reports, digital integration reports, strategic documents available on institutional websites (Siemens AG, Alstom SA);
- Academic and professional publications: peer-reviewed journal articles, consulting firm studies (McKinsey, Capgemini, BCG), industry white papers;
- Secondary interviews: excerpts from interviews with executives, digital project managers, and heads of innovation, published in specialized media (Usine Nouvelle, Industrie & Technologies, Harvard Business Review).

The data were collected and analyzed between October 2023 and February 2024.

3.3 Construction of the Analytical Grid

An analytical grid was developed to structure the examination of digital practices around three core axes:

- Degree of digital integration (ICT infrastructure, tools, interoperability);
- Functional cross-transversality of practices (department interconnection, data flow, inter-service synergies);
- Agile maturity (iteration, flexibility, team autonomy, customer feedback).

Six operational dimensions were defined across these three categories:

- Digital strategy and strategic alignment;
- Technical infrastructure (IoT, cloud, collaborative platforms);
- Digital leadership and governance;
- Agile culture (adoption of agile methods, incremental innovation);
- Customer innovation (co-creation, personalization, rapid experimentation);
- Cross-functional integration (silos vs. service integration).

For each dimension, an assessment was conducted using a maturity scale from 0 to 5 (0 = absent, 5 = fully deployed within the organization), based on inductive thematic coding from the data.

3.4 Unit of Analysis and Functional Fields

The unit of analysis is the organization at the strategic level, with particular attention given to five functional fields that can serve as observation points to assess the impact of ICT on organizational agility:

- Research and Development (R&D)
- Industrial Production
- Logistics and Value Chain
- Human Capital
- Marketing and Customer Relations

This multidisciplinary approach makes it possible to assess the systemic coherence of digital technologies beyond isolated or experimental projects.

3.5 Method of Analysis

The data were analyzed either through manual thematic coding, following an abductive logic—alternating between theoretical generalization and immersion in empirical cases—or through cross-case analysis of the two case studies, following a contrast-based logic (comparison of configurations) to identify convergent drivers of digital performance.

SIEMENS / Alstom	R&D	Production	Logistics	HR	Marketing	Average
1. Aligned Digital Strategy	5 / 3	5 / 3	4 / 2	4 / 3	4 / 3	4.4 / 2.8
2. Technological Infrastructure	5 / 3	5 / 3	5 / 3	4 / 3	5 / 3	4.8 / 3.2
3. Digital Governance	4 / 2	4 / 3	4 / 2	3 / 2	4 / 2	3.8 / 2.2
4. Agile Culture	5 / 3	4 / 2	3 / 2	4 / 2	5 / 2	4.2 / 2.4
5. Customer Innovation	4 / 3	3 / 2	2 / 1	3 / 2	5 / 4	3.4 / 2.4
6. Cross-Functional Integration	5 / 3	4 / 3	4 / 2	4 / 2	4 / 3	4.2 / 2.6
Siemens Average Score	4.7 / 2.8	4.2 / 2.8	3.7 / 2.0	3.7 / 2.3	4.5 / 3.0	4.2 / 2.6

Table 1: Comparative Digital and Agile Maturity – Siemens versus Alstom

- Siemens stands out for its high and coherent level of digital integration, with a systematically integrated approach across all functions—both in terms of technological infrastructure and agile culture.
- Alstom appears to have a more moderate and uneven digital integration project, characterized by digital initiatives that remain too localized to be truly cross-functional, and therefore not yet sufficiently supported at the strategic level.

Figure 1 allows us to compare the gaps in digital maturity between Siemens and Alstom across six dimensions: aligned digital strategy, technological infrastructure, digital governance, agile culture, customer innovation, and cross-functional integration. Siemens leads, with scores above 4 on most criteria and a systemic integration of ICT within the organization.

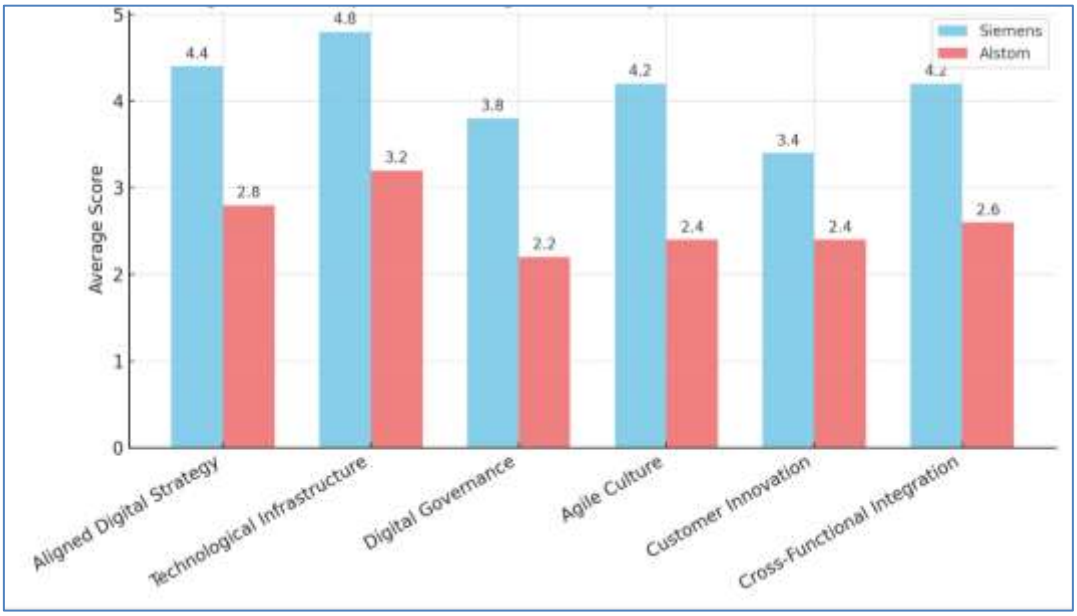


Figure 1: Comparison of Digital Maturity Scores – Siemens vs Alstom

In contrast, Alstom shows more variable results, with scores ranging between 2.2 and 3.2, reflecting a digital and organizational transformation that is still only partially integrated and largely localized. This figure highlights the correlation between digital cross-functionality and reactive innovation capacity, suggesting that digital competitiveness is not solely linked to the integration of technologies, but also to their coherence with cultural, strategic, and organizational dimensions.

4. Comparative Analysis: Siemens vs Alstom

4.1 Siemens: Strategic and Systemic ICT Integration

Siemens demonstrates that integrating ICT across the entire value chain can be strategic. The company embraces a holistic digital transformation approach, positioning information technologies at the core of its innovation model. The open industrial platform MindSphere, based on IoT and AI, enables real-time data collection, analysis, and exploitation from thousands of sensors on production machinery and customer infrastructures. Digital twins further strengthen this capacity by simulating, virtually prototyping, and optimizing performance before production. This technological shift reduces costs, risks, and delays in new product development. Siemens also integrates agile practices like Scrum, DevOps, and sprints into its R&D teams, combining rapid discovery with iterative adjustments and co-design phases with clients.

The synergy between advanced ICT and lean governance allows Siemens to establish a continuous innovation flow, connecting functional units (R&D, production, customer support) through an integrated digital architecture. This approach enhances market responsiveness, product personalization, and overall operational performance. Thus, in line with this virtuous model, Siemens demonstrates that digital intelligence, when combined with visionary project leadership and a culture of agility, can make all the difference in achieving competitive differentiation.

4.2 Alstom: Partial and Functional ICT Integration

Alstom's digital transformation is being carried out through a more parametric and fragmented approach. The company prioritizes investments in the implementation of operational ICT solutions, notably the HealthHub predictive maintenance platform, which is based on processing data provided by embedded systems. This tool helps improve the reliability and availability of rail equipment but remains limited to the use of specific solutions, without fundamentally altering the company's innovation processes or governance models.

As a result, ICT integration remains partial in the early stages of design, prototyping, and product development. The use of agile methods is fragmentary, confined to isolated teams. Furthermore, hierarchical rigidity and centralized decision-making do not foster organizational operational responsiveness, leaving the company exposed to weak signals from the market. This structural inertia prevents the development of the innovation dynamics necessary to establish a cross-functional digital culture. The company must therefore contend with long, inflexible, and poorly optimized development cycles, which limit its competitiveness against more agile competitors who integrate digital technologies directly into their operations.

This presentation of the table provides a comparative analysis of how two leading European industrial firms, Siemens and Alstom, approach the integration of Information and Communication Technologies (ICT) within their innovation management. It highlights varying degrees of differentiated, yet complementary, strategies in how the two companies pursue digital transformation.
Siemens is recognized for its particularly high levels of R&D investment (approximately 7%), for its large patent portfolio covering numerous technology fields, and for its extensive integration of AI and IoT into its production units — as exemplified by its Amberg facility, which demonstrates advanced digitalization supported by a strong engineering capability dedicated to smart factories.
For Alstom, its digitalization strategy is structured around the systematic deployment of an ERP system (SAP), covering 80% of its revenue, while more than 7,500 engineers specialized in embedded systems and software solutions contribute to the company's innovation efforts. Although its R&D/revenue ratio appears less promising than

Siemens', Alstom clearly emphasizes its ambition to achieve full digital harmonization by 2025.

This comparison reveals two distinct strategic logics: while Siemens develops technology-driven systemic innovation, Alstom focuses on deploying an intelligent mobility platform as a matter of operational integration and sustainability.

Indicator	Siemens	Alstom
R&D Investment (% of Revenue)	By allocating 7% of its revenue to research and development—considered the minimum for technological innovation and aligned with the company's objectives—Siemens sets an example.	For fiscal year 2024/25, Alstom plans a total R&D budget of €550 to €600 million, representing 3% of its revenue, to reinforce its leadership in rail innovation.
Number of Patents Held	Siemens holds an impressive portfolio of thousands of patents spanning broad technology domains such as automation, energy, and smart grids.	Alstom holds over 9,500 patents, illustrating its commitment to developing innovative and sustainable mobility solutions.
Use of AI and IoT in Production	In its asset optimization strategy, Siemens combines IoT-based production with AI-driven production at its Amberg plant, where AI initiatives have reduced downtime by 20%, improving asset utilization.	Alstom leverages AI in predictive analytics solutions, such as in the Panama metro system, where AI implementation reduced boarding failures during peak periods by over 30%.
Digitalization of Internal Processes	To enhance operational efficiency, Siemens has adopted centralized data management systems and digital platforms for faster and more informed decision-making.	Alstom has digitized 80% of its revenue processes using a centralized SAP model, as part of a major ongoing digital transformation.
Number of Engineers Dedicated to Digital	Siemens recruits a large number of digital engineers to support its digital transformation and technological innovation projects.	Alstom employs approximately 7,500 software engineers and system architects who develop digital mobility solutions, integrating its fleets of metros, trams, and fully connected regional trains.
Digitalization Objectives by 2025	Siemens aims to further integrate AI and IoT into its operations, with projects such as deploying IoT-enabled machines for real-time quality monitoring and production process responsiveness.	Alstom plans to deploy its digital suite across 100% of its activities and increase its process digitalization by 20% as part of its digital transformation strategy by 2025.

Table 2 : Comparative Table: Key Digital Innovation Indicators – Siemens vs Alstom

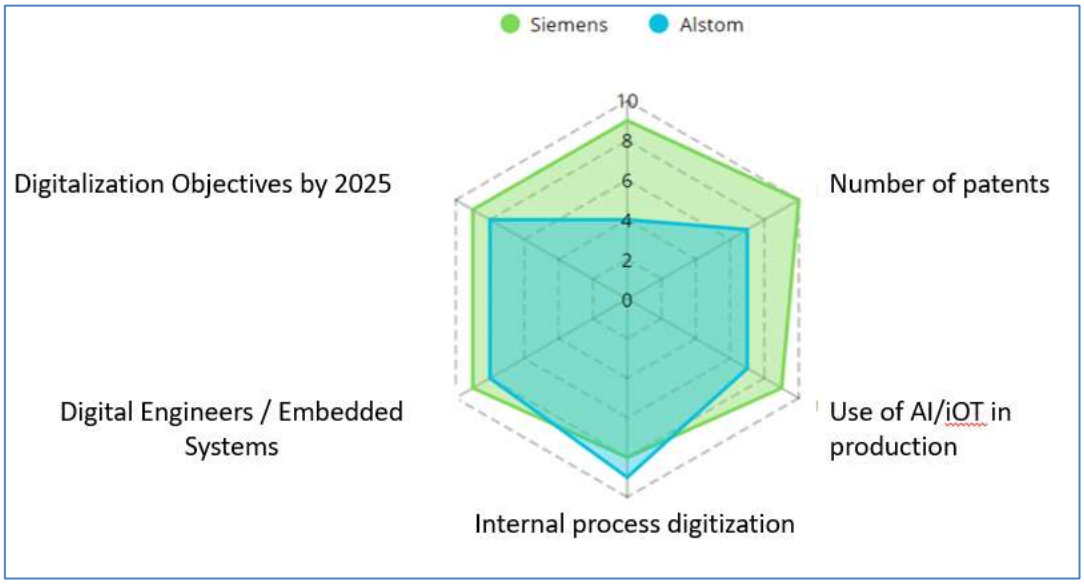
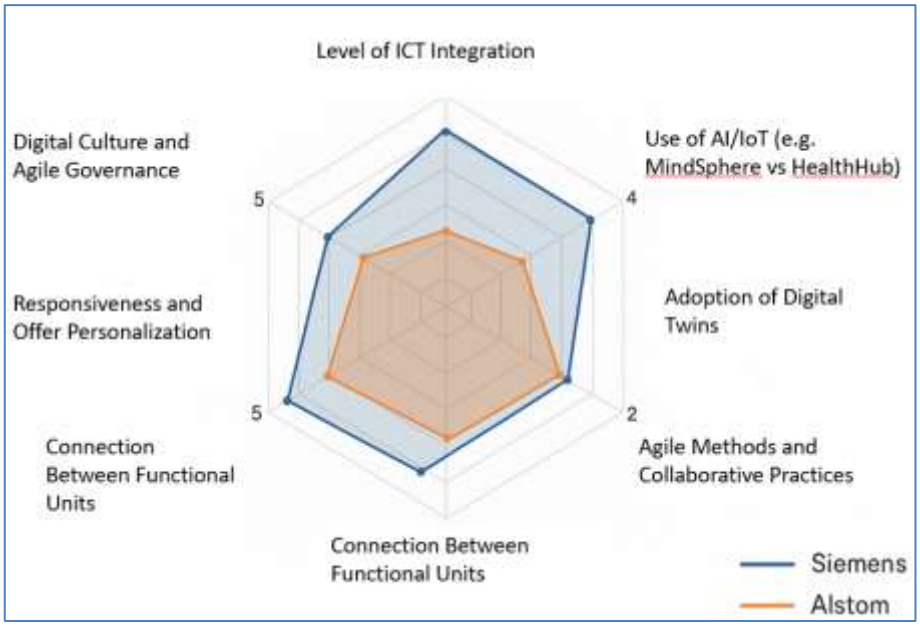


Figure 2: Comparison of ICT Integration in Innovation Management

This radar chart compares six key dimensions of Information and Communication Technology (ICT) integration in innovation management at two major European industrial companies: Siemens and Alstom.

Each dimension is normalized on a scale from 0 to 10 to allow a clear visual comparison. The results show an overall advantage for Siemens, particularly in R&D investment (score of 9 vs. 4), use of AI/IoT in production processes (9 vs. 7), and technological mastery (patents, digital engineering). Siemens benefits from a more centralized strategy for industrial automation and smart factories, as illustrated by its Amberg plant. Alstom, meanwhile, demonstrates strong internal digitalization, with a score of 9 thanks to the widespread deployment of SAP and the digital structuring of its processes. The group also possesses advanced capabilities in software engineering (over 7,500 system engineers) and aims to achieve full digitalization by 2025. This chart highlights the importance of a strategic and targeted integration of ICT within the innovation ecosystem to maximize performance, illustrating two distinct but complementary industrial models.

Figure 3.



Comparison of ICT Integration in Innovation Management: Siemens vs Alstom

The shape with an expanded outline and the number and width of the polygons drawn for the Siemens and Alstom curves provide an immediate visual representation of each company's relative strengths and weaknesses regarding ICT integration and agile governance. A larger polygon, closer to the outer edge, represents stronger integration and higher maturity. The position of each point along the respective axis indicates the company's performance value on each criterion.

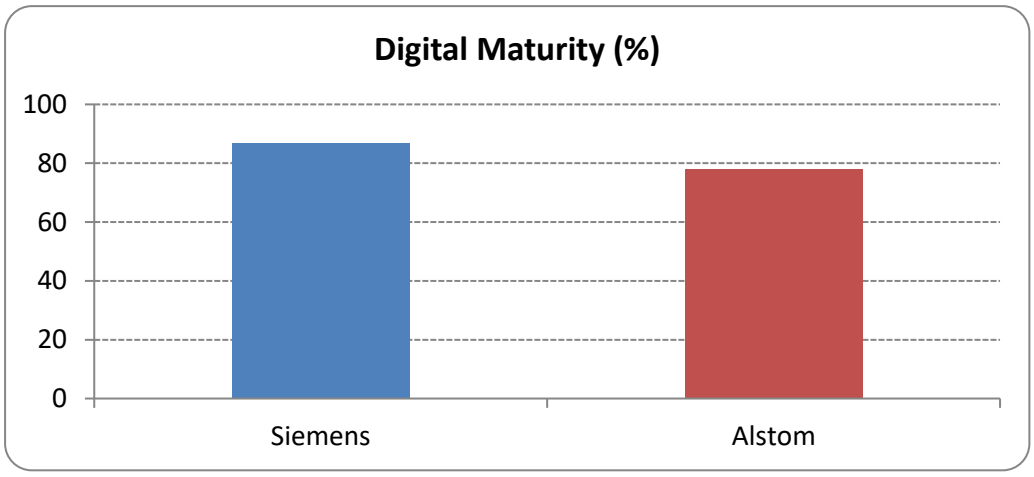


Figure 4 : Digital Maturity – Siemens vs Alstom

5. Discussion

Comparative analysis confirms that systematically integrating ICT with agile governance is a strategic lever for organizational innovation (Bharadwaj et al., 2013; Sambamurthy & Zmud, 2000). Siemens exemplifies the ability to enact a digital shift, using technology not merely for automation but as a transformative force for business models, management, and value chains.

5.1 Systemic Digital Integration and Dynamic Capabilities

The Siemens model can be interpreted through the lens of dynamic capabilities theory (Teece, 2007; Teece, 2018), which posits that winning firms are those capable of integrating, building, and reconfiguring internal and external competencies in response to their environment. Siemens' use of the MindSphere platform, based on IoT and AI, illustrates its ability to capture weak signals, simulate scenarios through digital twins (Grieves & Vickers, 2017), and execute accelerated innovation cycles.

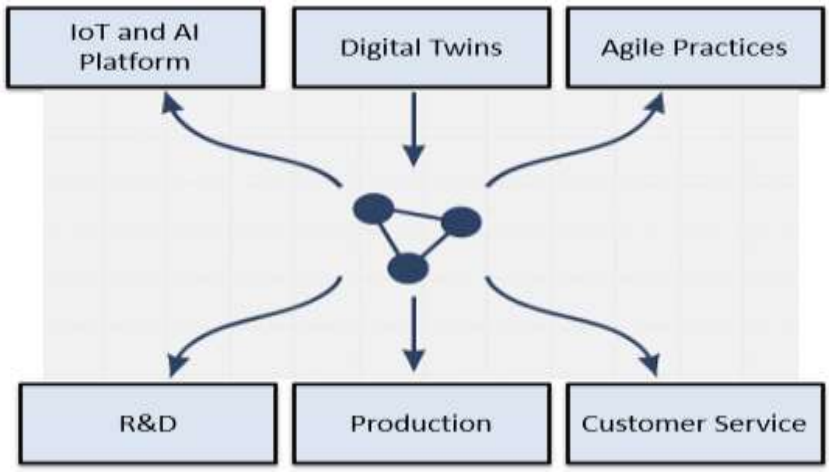


Figure 5: Integrated Digital Architecture at Siemens — Data Flows Between R&D, Production, and Customer Service

It is this digital architecture that Siemens places at the heart of its organization, where all functions (R&D, industrial production, and customer services) are integrated within a centralized information system based on Industrial Internet of Things (IIoT) technologies and digital twins. MindSphere, the platform, provides real-time collection, processing, and delivery of operational data.

The continuity of information flows between research and development and production enables an iterative design process based on the actual performance of the resulting products, which supports incremental innovation. In comparison, the contributions of the customer service function—with billions of data points collected and processed from incident tickets tracked over the years, user feedback, or customer comments—feed back

into design databases and help define continuous improvement programs. Likewise, integrating production data into customer service systems (such as maintenance histories or fault anomalies detected by AI or analytical dashboards) enables real-time insights into the condition of products in service, supporting predictive maintenance and improving responsiveness to failures.

This architecture simultaneously supports Siemens' organizational agility, optimization of product life cycles, and a closed innovation loop, where all links in the service value chain contribute to the continuous improvement of processes and customer satisfaction.

5.2 Organizational Agility and Incremental Innovation

Siemens implements agile practices such as DevOps, Scrum sprints, and collaborative sprints, combined with digital platforms. This approach supports rapid prototyping and co-creation with customers (Rigby et al., 2016). While fostering incremental innovation, it also enables breakthrough innovations through iterative learning loops (Nonaka & Takeuchi, 1995).

5.3 Limitations of Alstom's Fragmented Approach

Alstom adopts a fragmented digital approach, primarily focused on technical areas (e.g., HealthHub for maintenance) rather than sector-wide transformation or governance (Westerman et al., 2011). A lack of agile cultural maturity hampers functional interrelations and opportunities for new market offerings.

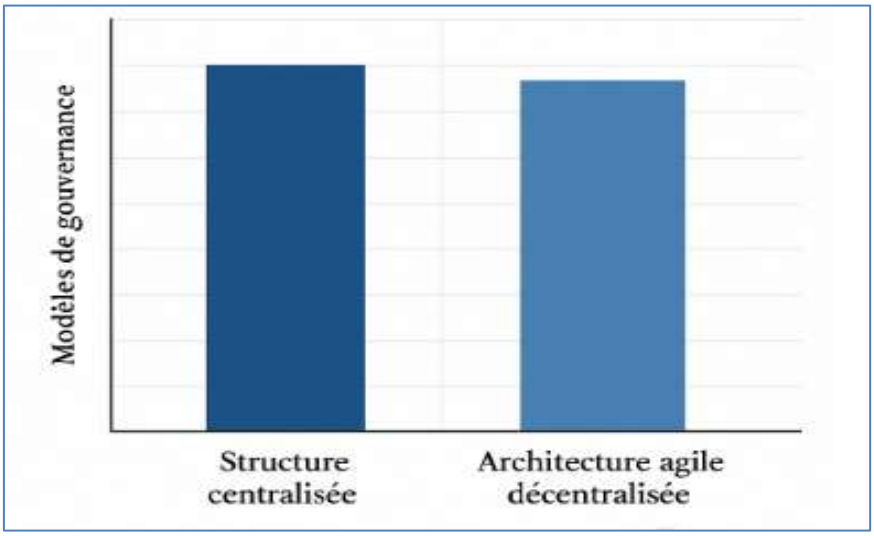


Figure 6 – Comparison of Digital Governance Models: Centralized Structure vs. Agile Decentralized Architecture

5.4 Empirical Validation through Performance Indicators

The link between digital maturity and innovation performance (shorter time-to-market, higher product success rates, increased innovation revenues) is supported by empirical studies (Li et al., 2018; Chanias et al., 2019). Siemens' ability to combine data, agility, and strategic management strengthens its competitive advantage in a VUCA environment.

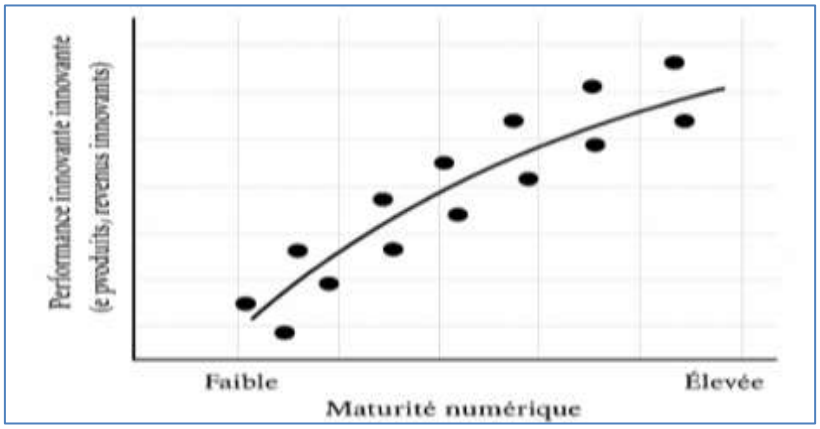


Figure 7 – Correlation Curve Between Digital Maturity and Innovation Performance (Product Success Rate, Innovation Revenues)

To better understand this in-depth comparison, we calculated an aggregate digital maturity score, based on a weighted average across six dimensions. Siemens achieves an overall score of 4.5/5, while Alstom scores 2.9/5. This gap is largely explained by Siemens' ability to orchestrate its digital resources in high value-added cross-functional project management. The differences are detailed in the table below:

Dimension	Siemens	Alstom
Digital Strategy	5	3
ICT Infrastructure	4.5	3
Agile Culture	4	2.5
Digital Leadership	5	2.5
Customer Innovation	4.5	3
Cross-Functional Integration	4.5	3

Table 3 : Digital Dimensions Siemens Vs.Alstom

In a world characterized by shortening technology cycles and uncertainty in the competitive environment, companies must renew their approaches to innovation governance. Agile governance — a management model built around flexibility, cross-disciplinary cooperation, and continuous learning — offers a strategic way to meet the dual imperative of responsiveness and co-creation with stakeholders. By transforming organizational capabilities in the areas of design, development, and deployment of innovation, this governance approach enables measurable impacts across several dimensions of innovation performance. As shown in the following figure, it forms a structuring framework for ensuring companies' competitive viability.

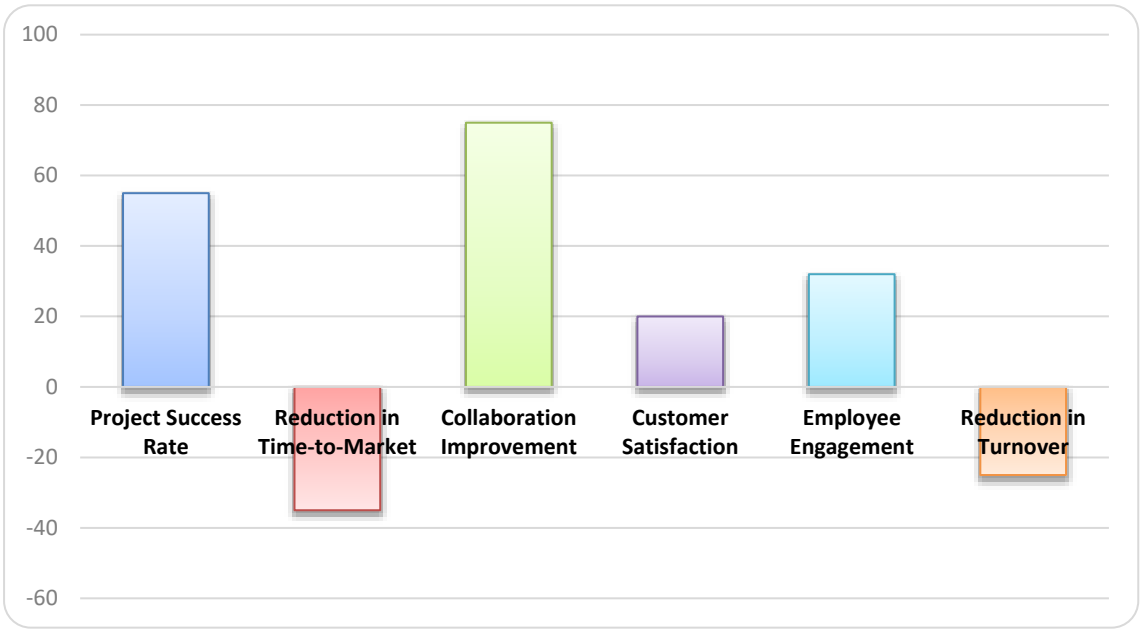


Figure 8: Impact of Agile Governance on Innovation Performance

This chart presents the measurable effects of implementing an agile governance model across several key dimensions of organizational performance. Empirical data, drawn from recent studies (Qureshi & Ahmad, 2023; SpringerLink, 2023; Innovacre, 2023), indicate significant improvements, including a 55% increase in the success rate of innovative projects, a 35% reduction in time-to-market, and a 75% increase in cross-functional collaboration. These results highlight the structuring role of agile governance in optimizing innovation processes and fostering sustainable value creation, while also enhancing employee engagement and customer satisfaction.

6. Limitations of the Study and Future Research

This research, though rich in comparisons between Siemens and Alstom, presents several limitations. First, it relies largely on secondary, publicly available sources, and it is quite possible that some indicators regarding ICT integration in both companies remain inaccessible or at least beyond the scope of this investigation due to their strategic or confidential nature. Second, as the study focuses on two European companies, the analysis does not allow for broad generalization beyond the European sector and geographic context; therefore, the conclusions drawn may be highly specific to these particular cultural and industrial contexts.

Moreover, the analysis does not address key human factors, such as resistance to change, organizational culture, or the digital competencies of employees — all of which are critical to the success of ICT initiatives. In addition, ethical concerns surrounding the intensive use of technologies (AI, big data) — a topic of growing importance in such initiatives — are not addressed here, despite the implications of using these technologies to drive operational efficiency.
For future research, several avenues could be explored:

On the one hand, developing additional case studies in specific sectors (healthcare, education, finance) or in different geographic regions (Asia, Africa, Latin America) would help to either validate or refine the main findings. On the other hand, adopting a multidisciplinary mixed-methods approach — combining field studies, direct interviews, and quantitative analyses — would provide a more nuanced understanding of digital innovation processes.

Finally, exploring the role of partnerships (startups, universities, technology clusters) in accelerating open innovation represents a promising area for future research.

7. Conclusion

Information and Communication Technologies (ICT) can no longer be viewed as mere support tools. They now represent structural levers for organizational transformation, value creation, and strategic differentiation (Porter & Heppelmann, 2014). However, their actual impact on performance depends less on their technical presence and more on how they are integrated, governed, and aligned with the human and cultural dynamics of the organization (Bharadwaj et al., 2013).

The comparative analysis between Siemens and Alstom clearly highlights this differential in strategic adoption of ICT. Siemens exemplifies a systemic and agile integration, where digital tools are embedded across all levels of the value chain, supported by governance rooted in experimentation, cross-functionality, and co-innovation with customers. This model promotes the emergence of dynamic capabilities (Teece, 2018), allowing the

company to anticipate, adapt, and respond quickly in a changing environment. In contrast, Alstom's more fragmented approach illustrates the limitations of partial digital transformation, siloed within technical functions and hindered by a more hierarchical management culture. The absence of a holistic digital strategy, combined with limited diffusion of agile methods, reduces ICT's transformative potential, limiting its leverage effect on innovation and overall performance (Westerman et al., 2011).

Ultimately, the study emphasizes that creating a sustainable competitive advantage in the digital age depends on the convergence of three key dimensions:

1. An interconnected and scalable technological infrastructure,
2. Agile and participatory governance,
3. An organizational culture conducive to continuous learning and co-creation (Denning, 2018; McKinsey & Company, 2020).

For companies seeking to succeed in their digital transformation, it is not just about investing in tools. It requires establishing a systemic vision where data, agility, and people are at the heart of strategic decisions (Kane et al., 2015).

This conclusion prompts a forward-looking reflection: How can we develop integrated digital maturity indicators that consider not only technological aspects, but also adaptive and collaborative capabilities within organizations? In the era of generative artificial intelligence, the ability to orchestrate technologies, skills, and governance is more than ever a prerequisite for sustainable innovation.

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