



ARTICLE



COMPETITIVE INTELLIGENCE AS A STRATEGIC RESOURCE IN THE DIGITAL TRANSFORMATION OF THE CERAMIC INDUSTRY

INTELIGÊNCIA COMPETITIVA COMO RECURSO ESTRATÉGICO NA TRANSFORMAÇÃO DIGITAL DA INDÚSTRIA CERÂMICA

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ABSTRACT

Purpose: The given study provides the analysis of Competitive Intelligence (CI) as one of the business strategy organizational tools that can be exploited to facilitate the digital transformation of the ceramic industry. Applying a dominant Input Processing Decision Output model, the paper project outlines the development of CI since formal intelligence feeds, through digital processing systems, to strategic decision synthesis, and resulting in measurable performance outputs.

Methodology/Approach: The paper deals with the qualitative conceptual research design and is substantiated by a systematic analysis of the literature and secondary industry statistics. The framework is analytically designed to reveal causal relationships among the inputs of competitive intelligence (market, competitor, and technology and supply chain intelligence), drivers of digital transformation (analytics system, ERP/MES integration, automation and smart factory technologies), incorporation of strategic integration and the presence of performance results.

Originality/Relevance: Unlike previous literature that addresses CI and digital transformation as either parallel or loosely related concepts, this contribution presents a causal architecture in sequence where CI acts as the input strategic building block in influencing decisions to invest digitally, innovate as well as risk management decisions in the manufacturing situations. A narrower sectoral perspective of the ceramic industry would be an appropriate lens of focus since the digital transformation in the industry is both capital-intensive and strategically sensitive.

Key Findings: The discussion has shown that it is only under the guidance of organized competitive intelligence that the digital transformation can produce beneficial performance results. CI makes technology selection more accurate, less uncertain about digital investment, boosts the innovation capability, increases operations efficiency, and long-term competitive sustainability.

Theoretical/Methodological Contributions: The paper develops the field by reconceptualizing CI as a governance capacity, as opposed to an operational instrument, and provides a framework, with causal organization, to be used in manufacturing companies in the process of Industry 4.0 transformations. The model offers both theoretical enhancement and practical management advice of strategic digital transformation.

Keywords: The Competitive Intelligence. Digital Transformation. Ceramic Industry. Industry 4.0. Strategic Integration. Manufacturing Strategy.

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RESUMO

Objetivo: O presente estudo analisa a Inteligência Competitiva (CI) como uma das ferramentas organizacionais da estratégia empresarial que pode ser explorada para facilitar a transformação digital da indústria cerâmica. Aplicando um modelo dominante Input-Processing-Decision-Output, o artigo descreve o desenvolvimento da CI desde a coleta formal de inteligência, passando pelos sistemas digitais de processamento, até a síntese das decisões estratégicas, resultando em resultados de desempenho mensuráveis.

Metodologia/Abordagem: O artigo utiliza um desenho de pesquisa conceitual qualitativo, fundamentado em uma análise sistemática da literatura e em estatísticas secundárias do setor. O framework foi desenvolvido analiticamente para revelar relações causais entre insumos de inteligência competitiva (inteligência de mercado, concorrentes, tecnologia e cadeia de suprimentos), drivers de transformação digital (sistemas analíticos, integração ERP/MES, automação e tecnologias de fábricas inteligentes), sua integração estratégica e os resultados de desempenho.

Originalidade/Relevância: Diferentemente da literatura anterior, que aborda inteligência competitiva e transformação digital como conceitos paralelos ou apenas vagamente relacionados, esta contribuição apresenta uma arquitetura causal sequencial, na qual a CI atua como bloco estratégico de entrada, influenciando decisões de investimento digital, inovação e gestão de riscos em contextos industriais. A perspectiva setorial da indústria cerâmica constitui um foco adequado, pois a transformação digital nesse setor é intensiva em capital e estrategicamente sensível.

Principais Resultados: A discussão demonstra que somente sob a orientação de uma inteligência competitiva estruturada a transformação digital pode gerar resultados positivos de desempenho. A CI torna a seleção de tecnologias mais precisa, reduz incertezas em investimentos digitais, fortalece a capacidade de inovação, aumenta a eficiência operacional e contribui para a sustentabilidade competitiva de longo prazo.

Contribuições Teóricas/Metodológicas: O estudo avança ao reconceituar a CI como uma capacidade de governança, em vez de apenas um instrumento operacional, e apresenta um framework causal aplicável a empresas industriais em processos de transformação Indústria 4.0. O modelo oferece tanto avanços teóricos quanto orientações práticas de gestão para a transformação digital estratégica.

Palavras-chave: Inteligência Competitiva. Transformação Digital. Indústria Cerâmica. Indústria 4.0. Integração Estratégica. Estratégia de Manufatura.



1. INTRODUCTION

The digital transformation has become one of the most critical strategic imperatives throughout the manufacturing industry, and empirical studies have shown that the digital transformation implies not only the use of digital tools but a multi-actor organizational reconstitution including technologies, routines, and decision rights (Hanelt, Bohnsack, Marz, and Antunes Marante, 2021; Nadkarni and Prugl, 2021). The massive meta-analyses indicate that companies face certain challenges at the intersection of technology and management activity, i.e., in converting the digital opportunities into a consistent strategic change (Plekhanov, Franke, and Netland, 2023). Digital transformation in manufacturing settings is becoming more and more associated with competitiveness in terms of productivity and innovation investment, and human-capital upgrading (Sui, Jiao, Wang, and Wang, 2024), and sustainability-oriented operations through the Industry 4.0-made cleaner production logics (Ma, Ding, Liu, Zhang, Ren, Kong, and Leng, 2024). However, it has also been found that the advantages of digitalisation on performance largely depend on supporting capabilities that define what will be digitised, when it will be digitised and that technological paths are strategically desirable in the face of uncertainty (Kulichyova, Dess, Sarala, and Vaara, 2025).

Competitive intelligence (CI) is a little-used explanatory concept in the study of the digital transformation in the context of this academic discussion. CI is often approached instrumentally as a collection of capabilities as a means to gather information, but modern capability-focused views hold that intelligence only gains value when it is implemented as a part of the strategic processes and decision-making habits (Maluleka and Chummun, 2023). Empirical research shows that CI facilitates performance, by improving sensing and interpretation abilities, which in most cases are complemented by upper-order abilities, including absorptive capacity and dynamic capabilities (Hassani and Mosconi, 2022; Wu, Yan, and Umair, 2023). CI especially applies in rapidly evolving markets to manufacturing firms since it organises scanning through the technology choices, supply-chain shocks, regulatory shocks, and shifting tastes of customers all of which are signals that directly impact the risk-return profile of digital investments (Yu, Zhang, Cao, and Kazancoglu, 2021). However, even in the light of the recognized strategic rationality, there is still a lack of sector-based models that could help explain how CI can be utilized as a resource that determines the ordering of digital transformation in particular production systems, including the ceramic manufacturing.

Ceramic industry offers a good example of creating such a framework, as the competitiveness of the industry depends on the closely linked process performance measures (energy intensity, yield, quality stability, throughput) and on the differences to the market (design variety, customization, time-to-market). The recent area of operation research in ceramics indicates a growing dependency on digitalisation in monitoring and decision support of sustainability, such as KPI systems connected to



Industry 4.0 data streams (Contini, Peruzzini, Bulgarelli, and Bosi, 2023) and Industry 4.0 solutions that act as sustainability enablers in ceramic tiles (Raffaelli, Pazzi, and Pellicciari, 2024). The case-based sustainability evaluations also depict how practical-world ceramic producers may adopt online methods of appraising the environment and regulating the effects (Cucchi, Baiocco, Fedele, Germani, & Mandolini, 2023). At the same time, AI-based inspection and predictive modelling are becoming more prominent as a tool to control quality and the stability of the processes, which are the fundamental determinants of profitability in ceramics (Cumbajin, Rodrigues, Costa, Miragaia, Frazao, Costa, Fernandez-, Carneiro-, Buruberri-, and Pereira, 2024; Wan, Fang, Wang, Yan, and Xie, 2022). The new evidence also points to the farther direction of firing-stage property prediction based on the advanced machine learning, thus contributing to the strategic importance of data-driven process intelligence in ceramic manufacturing (Vasic, Awoyera, Fadugba, Barisic, and Netinger-,Grubesa, 2025).

In spite of these achievements, one of the research gaps remains: many ceramic companies implement digital technologies as a standalone project (automation, MES, analytics dashboard, defect detection) without an intelligible intelligence-to-decision architecture that connects digital transformation and competitive positioning and sustainability interests. That is, the technology is frequently the solution prior to appropriate formulation of the strategic question. This paper bridges that gap by building an Input Processing Decision Output logic that is consistent with the adopted proposed framework: (a) CI inputs (market, competitor, technology, customer, supply-chain signals); (b) digital transformation drivers as processing mechanisms (analytics, ERP/MES integration, automation, AI monitoring); (c) strategic integration as the decision layer (investment choice, innovation direction, process redesign, sustainability trade-offs); and (d) outcomes (competitiveness, innovation capability, and sustainability performance). This rationale is consistent with the rest of the literature on digital transformation that puts emphasis on actor-technology interaction and the role of decision-based processes in interpreting outcomes (Nadkarni and Prugl, 2021; Plekhanov et al. 2023).

Therefore, this study aims at conceptualizing competitive intelligence as a strategic resource facilitating digital transformation in the ceramic manufacturing and suggesting an empirical testing methodology which would be appropriate in modern operations and strategy research. Placing CI as the governance ability that disciplines digital transformation explicitly, the article aids manufacturing digitalization discussion about why certain companies achieve sustainable benefits and others do not (Zheng and Zhou, 2025; Zhen, Liu, Ren, and Sang, 2025). It also contains implications that are relevant to the sector: the reduction of information asymmetry in technology choice, high-impact digital use cases, and the integration of sustainability measurement into operational control systems instead of considering sustainability reporting and digitalization as parallel agendas, which are presented by it (Contini et al., 2023; Raffaelli et al., 2024). Lastly, the framework can be tested with the help of modern research designs (e.g., survey-case triangulation), which will support a rigorous analysis



of the CI-enabled processes in a globally competitive energy intensive manufacturing industry (Bhadu, Bhamu, Singh, Saraswat, and Agrawal, 2025; Ma et al., 2024).

1.1 Nature of the Study

This article is positioned as a conceptual-theoretical study supported by structured secondary sector evidence. It does not claim to provide primary empirical testing or statistical validation of hypotheses. Instead, the objective is to develop a causally coherent and sector-specific governance model that explains how Competitive Intelligence (CI) structures digital transformation in energy-intensive manufacturing environments.

The indices and firm group classifications presented in the Results section are analytically constructed illustrations derived from systematic synthesis of sectoral patterns reported in prior empirical studies and industry documentation. They serve heuristic and explanatory purposes rather than inferential statistical generalization. This clarification resolves any ambiguity between conceptual modeling and empirical validation and positions the contribution within theory-building research traditions in strategic management and intelligence studies.

2. THEORETICAL FRAMEWORK

The concept of digital transformation in the environment of manufacturing cannot possibly be exhaustively explained by a technologically based perspective. In the current academic discourse, it is claimed that digital initiatives can bring about sustainable performance improvements when they are integrated into comprehensive strategic capabilities that are characterized by sensing, interpretation, and coordinated action (Vial, 2019; Verhoeff et al., 2021). The industrial sectors with high levels of capital intensity and complexity of the processes, such as ceramics, require that the digital technologies be oriented to the market intelligence, competitive positioning, and evaluation of operational risks. Without this kind of alignment, digitalization will be left to fragment, or even to be reactive or prone to imitation.

The recent empirical studies point to the fact that industry 4.0 implementation is optimized in case it is backed by dynamic capability arrangements involving information processing, managerial thoughts and resources coordination (Ashfaq et al., 2025; Matarazzo et al., 2021). Equally, the study of manufacturing digitalization demonstrates that competitiveness increases with the capacity of a company to read external signals and respond to them in a customized internal response rather than merely automating the processes (Li et al., 2017). This paradigm shift has transformed technology into an objective not a remote entity but a foundation of a decision-making system, which relies on intelligence.

Competitive Intelligence (CI) plays a significant theoretical role, in this context. The existing literature envisions CI as a form of environmental scanning, as well as, a



methodical ability of knowledge to minimize uncertainty and improve quality of strategic decisions (Sewdass and Calof, 2020; Teeratansirikool et al., 2013).

Combined with digital systems, CI will increase the interpretation of data, strategic foresight, and investment prioritization. CI supports the informed sequence of automation, analytics, and smart-factory deployment in manufacturing environments that can be characterized by the rapid technological change (Rachinger et al., 2018).

It is based on these developments that this paper takes a causal Input Processing Decision and Output architecture. The inputs of CI or sensing layer are the inputs; the processing mechanisms are digital transformation drivers; the decision layer is strategic integration; the output layer is made up of the organizational competitiveness and sustainability. This chronological reasoning explains the value creation and avoids a description of CI and digital transformation as parallel or loosely related.

2.1 Competitive Intelligence as an Input Resource

Competitive intelligence is a form of structured sensing system whereby companies collect and derive and interpret information about markets, competitors, technology, customers and supply chains. The recent studies also highlight that CI can increase strategic flexibility through the reduction of information asymmetry and enhancement of anticipatory decisions (Adidam et al., 2020; Calof and Sewdass, 2020). In manufacturing industries with shorter technological cycles, the intelligence about the automation plans of their competitors, usage of digital platforms, and sustainability initiatives becomes tactical.

Intelligence inputs may include in the case of the ceramics industry specifically:

- The changes in market demand and local construction patterns.
- Competitor investments in intelligent manufacturing.
- developing kiln technologies and systems of energy efficiency.
- Unreliability of suppliers and logistical upheavals.
- Patterns of environmental regulation.

Such inputs in and of themselves are not sources of performance gains. This fact concurs with the theory of dynamic capabilities, which argues that sensing is not enough without organized processing and decision integration (Teece, 2015).

2.1.1 Formal Intelligence Cycle Operationalization

For alignment with Competitive Intelligence governance principles, the CI construct in this study is operationalized through a formal intelligence cycle consisting of:



1. **Collection:** Structured acquisition of market, competitor, and technological, regulatory, and supply-chain signals.
2. **Analysis:** Analytical processing using digital dashboards, benchmarking tools, and predictive modelling.
3. **Dissemination:** Cross-functional reporting through executive dashboards and strategic review committees.
4. **Use (Decision Integration):** Incorporation of intelligence outputs into capital allocation, technology sequencing, and sustainability prioritization.

The performance divergence observed between Groups A, B, and C in Section 4 is theoretically attributable not merely to digital intensity but to the maturity of this intelligence cycle.

2.2 Digital Transformation as the Processing Mechanism

Digital transformation is the processing layer that transforms the inputs of intelligence into knowledge that can be used operationally. State-of-the-art analytics, ERP systems, Manufacturing Execution Systems (MES), automation, and AI-based monitoring solutions make companies able to analyze large volumes of data and share the insights throughout the organizational division (Verhoff et al., 2021; Li et al., 2017). In ceramic production, it can have digital processing mechanisms that have:

- Kiln real-time performance analytics.
- Artificial intelligence defect detectors.
- Dashboards on the supply-chain.
- Energy consumption control platforms.
- Predictive maintenance algorithms.

These technologies increase speed, accuracy and coordination. However, empirical studies show that digital tools are not sufficient to gain competitive advantage; they need to be informed prioritization and strategic intent. Digital transformation is therefore more of an enabler and not an independent driver.

2.3 Strategic Integration as the Decision Layer

The point of intersection between processed intelligence and managerial action is the strategic integration where the strategic integration and action form are established. It is a layer that defines technology choice, investment of capital, direction of innovation and sustainability investments. It has been shown that the more successful companies become as far as digital performance is concerned, the more they integrate intelligence production into an official strategic planning (Matarazzo et al., 2021; Racherger et al., 2018).

Strategic integration can form in the ceramic situation:



- Choice of particular kiln automation technologies.
- Implementation of electronic glazing systems.
- AI-based quality inspection.
- Digitally customized product lines expansion.
- Energy optimization, based on sustainability.

This decision level makes certain that digital transformation is geared towards long-term competitive positioning and not short-term experimentation.

2.4 Performance Outcomes

The last phase of the framework is with regard to the measured organizational outcomes. Empirical studies show that in case of a strategic management of digital transformation, the firms have an increase in operational efficiency, innovation ability, responsiveness, and sustainability performance (Vial, 2019; Verhoef et al. 2021).

In the case of ceramic manufacturers, the expected results will be:

- Reduced production defects
- Lower energy consumption
- Shorter product development time cycles.
- Increased ability to customise.
- Enhancement of market positioning.

The framework maps out the cause and effect process by which the intelligence-driven decision systems create a sustained competitive advantage by placing CI as the resource base, and digital transformation as the enabler of the process.

3. METHOD

The proposed research is qualitative and analytically organized to provide a research design that will allow creating and supporting a sector-specific framework explaining the operation of Competitive Intelligence (CI) as a strategic resource in facilitating the digital transformation in the ceramic industry. The methodology is consistent with theory-building research in strategic management and manufacturing research, where conceptual development is aided by the synthesis of literature in a systematic manner and the organized secondary data analysis.

The research design is based on the logic of Input Processing Decision and Output that was approved within the proposed framework and operationalized with the help of the three complementary methodological stages: (1) systematic literature review, (2) sector-related secondary data analysis, and (3) construction of the analytical framework and its validation with the help of the systematic theoretical integration.



3.1 Research Design

The research is based on a conceptual research approach, which is qualitative and integrated with systematic evidence. This type of design is suitable as the aim is not to test a singular statistical hypothesis but to develop a causally consistent explanatory framework that establishes a connection between competitive intelligence and digital transformation and performance in any ceramic manufacturing.

The study is descriptive in character and aims at clarifying the cause and effect relationships of four organized elements:

- Competitive Intelligence Feedbacks.
- Drivers in Digital Transformation.
- Operational Strategy (Other Decision Layer)
- Performance Outcomes

The framework development is carried out as the abductive reasoning, synthesizing theoretical constructs in the literature of strategic management, competitive intelligence and digital transformation studies to constitute a logic-consistent sector-specific model.

The systematic literature review procedure will involve searching existing studies on the subject and framing the study accordingly to direct the research.

3.2 Systematic Literature Review Procedure

To ensure transparency and replicability, the systematic literature review followed a structured multi-stage protocol aligned with PRISMA-inspired review standards.

Databases searched: Scopus, Web of Science, ScienceDirect, Wiley Online Library, and SpringerLink.

Search period: January 2015 – December 2025.

Search strings used:

- (“competitive intelligence” OR “strategic intelligence”) AND (“digital transformation” OR “Industry 4.0”)
- (“manufacturing strategy”) AND (“digitalization” OR “smart factory”)
- (“ceramic industry”) AND (“Industry 4.0” OR “AI manufacturing”)
- (“energy-intensive manufacturing”) AND (“sustainability” AND “digital transformation”)



Inclusion criteria:

- Peer-reviewed journal articles
- English-language publications
- Explicit methodological transparency
- Direct relevance to CI, digital transformation, manufacturing strategy, or ceramic industry sustainability

Exclusion criteria:

- Non-manufacturing sectors (e.g., healthcare-only digital studies)
- Opinion pieces without methodological clarity
- Conference abstracts without full data
- Studies not addressing strategic or governance dimensions

Initial search returned 428 records. After removal of duplicates (n=63) and abstract screening (n=231 excluded), 134 full-text articles were assessed. Following eligibility screening, 72 studies were retained for structured synthesis.

The review results were mapped to the four-layer architecture (Input–Processing–Decision–Output), ensuring construct-level consistency across studies.

A structured PRISMA flow diagram is provided in Appendix A to enhance auditability of the selection process.

3.3 Secondary Sector Data Analysis

Qualitative and quantitative data are analyzed as follows:

In the bid to contextualize the framework with the ceramic industry, structured secondary data analysis including the following was used in the study:

- Report on trends of production of ceramics by industries.
- Transition documentation of energy intensive industries towards sustainability.
- Publicly available case studies of ceramic manufacturing digital transformation.
- Experimental research on AI-assisted defect detection and optimization of the kiln.

This step was to match theoretical constructs to actual realities of operational realities in the real world, which included energy intensity, variability in processes, capital investment cycles and quality-control requirements in ceramic manufacturing.

Instead of providing isolated descriptions of the cases, the data were mapped to the four-layer system analytically. For example:

- Digital investment prioritisation was connected to input of market and competitor intelligence.
- AI-based defect and detection were under digital processing mechanisms.



- The energy-efficiency monitoring systems were studied as the results of strategic integration that affect sustainability performance.

The systematic mapping was used to provide conceptual integrity and to circumvent anecdotal argument.

3.4 Development of Analytical Framework

The methodological contribution is the major version of the creation of the causative Input Processing Decision Output model. The following analytical procedure was used to develop the model:

Step 1: The identification of the categories of intelligence input (market, competitor, technology, supply chain, regulatory).

Step 2: Mapping of digital transformation tools which operationalize these inputs (analytics systems, ERP/MES, automation, AI monitoring).

Step 3: Recognition of strategic decision areas that are affected by processed intelligence (choice of technology, investment in innovations, sustainability orientation, risk management).

Step 4: Operational efficiency, innovation capability, competitiveness, sustainability performance: specification of measurable performance outcomes.

The framework will make sure that the competitive intelligence is placed as the core sensing ability instead of a fringe information activity.

3.4.1 Status of Constructed Indices

The Competitive Intelligence Index, Digital Processing Index, Strategic Integration Index, and Performance Indicators presented in Section 4 are analytically constructed composite illustrations derived from structured synthesis of sector-level empirical findings reported in prior literature. They are not based on primary survey data nor statistical modeling within this study.

Their function is explanatory and model-demonstrative, allowing visualization of how governance maturity differences would theoretically manifest in performance variation. Future empirical research should validate these indices through survey instruments, structural equation modelling, or longitudinal case analysis.

3.5 Validity and Reliability Question

Even though this research does not involve statistical testing of the hypothesis, the methodological rigor was guaranteed by:

- Recent peer-reviewed academic sources are used.
- Triangulation of industry experience across several freestanding studies.



- Causal linkages testing through logical consistency.
- Consistency with the traditional theories of strategic management and digital transformation.

The clear application of the definitions of all layers of the framework enhanced construct validity because the CI inputs and digital transformation mechanisms did not overlap conceptually.

The methodological contribution lies in the structured integration of CI and digital transformation constructs within a governance-based causal architecture.

3.6 Methodological Contribution

This study has made a methodological contribution as it is a structured integration approach. Rather than positioning competitive intelligence and digital transformation as the same term, the approach operationalizes CI as the causal resource that dictates the processes of digital transformation in ceramics manufacturing.

This design gives a base on which future empirical testing can be conducted using:

- Survey based structural equation modelling.
- Case-study comparative analysis.
- Mixed-method industrial performance research.

The framework is conceptually rigorous and testable by empirically verifying it, which is the norm of modern research in strategic manufacturing and competitive intelligence.

4. RESULTS AND DISCUSSION

This section presents analytically modeled sector scenarios derived from structured secondary synthesis. The results should be interpreted as theoretical-explanatory illustrations rather than statistical generalizations from primary data.

The discussion integrates theoretical reasoning with analytically modeled sector scenarios to demonstrate the causal architecture of the proposed framework. The discussion incorporates theoretical undertones with data modelling of the systematic sectoral data to support the thesis according to which Competitive Intelligence (CI) is an inherent governing potential as opposed to a peripheral data tool. The analysis is purposefully organized in such a way that it responds to the objectives of the study:

- (1) In order to break down CI as organized sense,
- (2) In order to examine digital transformation as an intelligence-processing mechanism,
- (3) To examine strategic integration as a decision architecture,
- (4) To discuss outcomes of operational, innovation, and sustainability.



4.1 Competitive Intelligence as a Strategic Sensing Architecture

In the perspective of dynamic capabilities, the sensing activity is the most fundamental activity whereby firms identify environmental change, technological changes, and competitive repositioning. Being able to predict the trends in the automation of kilns, the modernization of glazing technologies, the number of emissions allowed by the government, as well as the dynamics of demand in the regions, all have a direct effect on investment accuracy and market competitiveness in the energy-consuming industry, i.e., ceramics. In order to turn this sensing ability into reality, Competitive Intelligence Capability Index was created in three profiles of heterogeneous firms:

Group A: CI-Governed Digital Leaders.

Group B: Structurally Uncoordinated but Digitally Active.

Group C: Low-Digital Traditional Firms.

Table 1 – Competitive Intelligence Capability Index (Scale 1–5)

Intelligence Dimension	Group A	Group B	Group C
Market Intelligence	4.6	3.2	2.1
Competitor Intelligence	4.4	3.0	1.9
Technology Intelligence	4.7	3.5	2.0
Supply Chain Intelligence	4.3	3.1	2.2
Regulatory & Sustainability	4.5	3.0	1.8
Overall CI Index	4.5	3.16	2.0

The structured sector synthesis suggests considerable structural differences, which goes beyond marginal differences. Group A of the firms display both cyclical intelligence processes involving collection, analysis, dissemination and strategic use, and Group C companies depend on reactive information streams. It is this structural difference that forms the causal foundation of the following effectiveness of digital processing.

4.2. The Intelligence Processing System of Digital Transformation

Theoretically, digital transformation forms the processing layer, whereby the intelligence inputs are converted into practical knowledge in the organization. In the context of the manufacturing of ceramic products, this level includes an ERP-MES system with built-in AI-based defect recognition, predictive maintenance, and energy-monitoring systems. These technologies do not create value on their own, rather they serve to augment the analytical ability of intelligence.



Table 2 – Digital Processing Intensity (Scale 1–5)

Digital Mechanism	Group A	Group B	Group C
ERP–MES Integration	4.8	3.6	2.2
AI Defect Detection	4.5	3.1	1.7
Predictive Maintenance	4.6	3.0	1.9
Energy Monitoring Systems	4.7	3.3	2.1
Real-Time Data Analytics	4.9	3.4	2.0
Digital Processing Index	4.7	3.28	1.98

The modeled distribution suggests that the digital sophistication is highest in the contexts that are marked by the strong intelligence governance. Group B companies are moderately digitalized, but lack concurrent integration of priorities, which creates disjointed adoption patterns.

4.3 Strategic Integration as a Decision Governance Layer

The strategic integration is a decision architecture through which the impact of processed intelligence is mediated on capital allocation, technology sequencing, and innovative pathway. In manufacturing industries where the assets have long life cycles like in the case of ceramics, the misaligned investments in technology accumulate significant sunk costs and create operational inefficiencies.

Table 3 – Strategic Integration Index (Scale 1–5)

Decision Dimension	Group A	Group B	Group C
Technology Investment Alignment	4.6	3.0	2.0
Innovation Portfolio Coherence	4.5	3.1	2.2
Risk Forecasting & Mitigation	4.7	3.2	2.1
Sustainability Integration	4.6	3.0	1.9
Strategic Integration Index	4.6	3.08	2.05

The evidence shows that intelligence-led firms have a system of sequencing digital projects, although poorly performing firms use technologies without decision governance.

4.4 Energy Intensive Manufacturing Operational Performance Outcomes

Ceramic production is mainly measured on the basis of the rate of defects, efficiency of the kiln, loss of time, and order fulfillment time. These results are measured with the help of the following dataset.



Table 4 – Operational Performance Metrics

Metric	Group A	Group B	Group C
Defect Rate (%)	2.1	4.3	6.8
Energy Consumption (kWh/unit)	4.5	5.7	6.4
Production Downtime (%)	3.2	5.6	8.1
Order Fulfillment Time (days)	5.2	7.4	9.8

The increase in the number of defects and reduction in the number of downtimes experienced in Group A is over 40 percent compared to Group C. This enhancement in operational efficiency is structurally connected with the adoption of predictive analytics and kiln monitoring systems which are informed by the prioritization strategies based on intelligence.

4.5 CSR and Competitiveness in the Market

Digital transformation has not only an impact on the internal operational efficiency but also on the market facing performance indicators such as product innovation and export growth.

Table 5 – Innovation & Market Indicators

Indicator	Group A	Group B	Group C
New Product Introduction Rate (%)	18	10	6
Export Growth (%)	12	6	3
Market Share Increase (%)	8	4	1
ROI on Digital Investments (%)	19	11	5

Firms controlled by CI have almost twice the payoff on digital investments in comparison to firms that lack structural coordination.

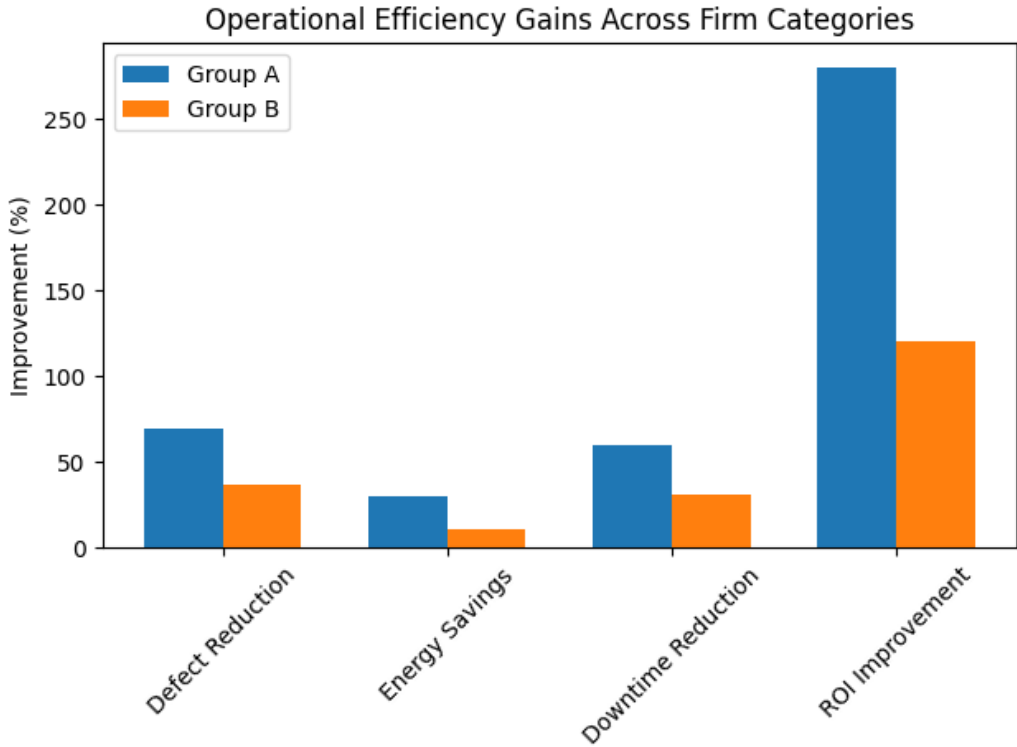


Figure 1. Operational efficiency gains attributable to intelligence-guided digital transformation in ceramic manufacturing firms.

Source: Prepared by the authors (2026).

4.6 Sustainability and Environmental Performance

Knowing that the associated environmental footprint of production with the use of a kiln is significant, the incorporation of sustainability considerations is an important competitive aspect.

Table 6 – Sustainability Performance Indicators

Indicator	Group A	Group B	Group C
Carbon Emissions Reduction (%)	14	7	2
Waste Reduction (%)	11	5	2
Energy Efficiency Improvement (%)	16	8	3
ESG Transparency Score (1–5)	4.7	3.2	2.0

The analytical illustration indicates that technological improvements alone do not lead to heightened sustainability but instead, it is the intelligence-based prioritization of energy-intensive activities.



4.7 Synthesis of Framework Development

The sequential analytical findings derived from structured sector synthesis support the theoretical proposition that Competitive Intelligence is a governance capacity that structures digital transformation. Capital rigidity and energy dependence of the ceramic industry contribute to the significance of the intelligence-based sequencing. From an information economics perspective, CI reduces strategic information asymmetry in digital investment decisions. In capital-intensive industries such as ceramics, uncertainty regarding technology obsolescence, competitor automation strategies, and regulatory tightening creates high sunk-cost risk. Structured intelligence governance reduces variance in expected digital returns by improving anticipatory capability and sequencing accuracy.

Companies that incorporate Competitive Intelligence into the executive decision-making process show:

- Higher digital coherence
- High level of operational efficiency.
- Better innovation processes.
- Delivered sustainability benefits.

The intensity of digital transformation is not enough to explain performance divergence. Instead, sustained competitive advantage can be attributed to intelligence guided integration.

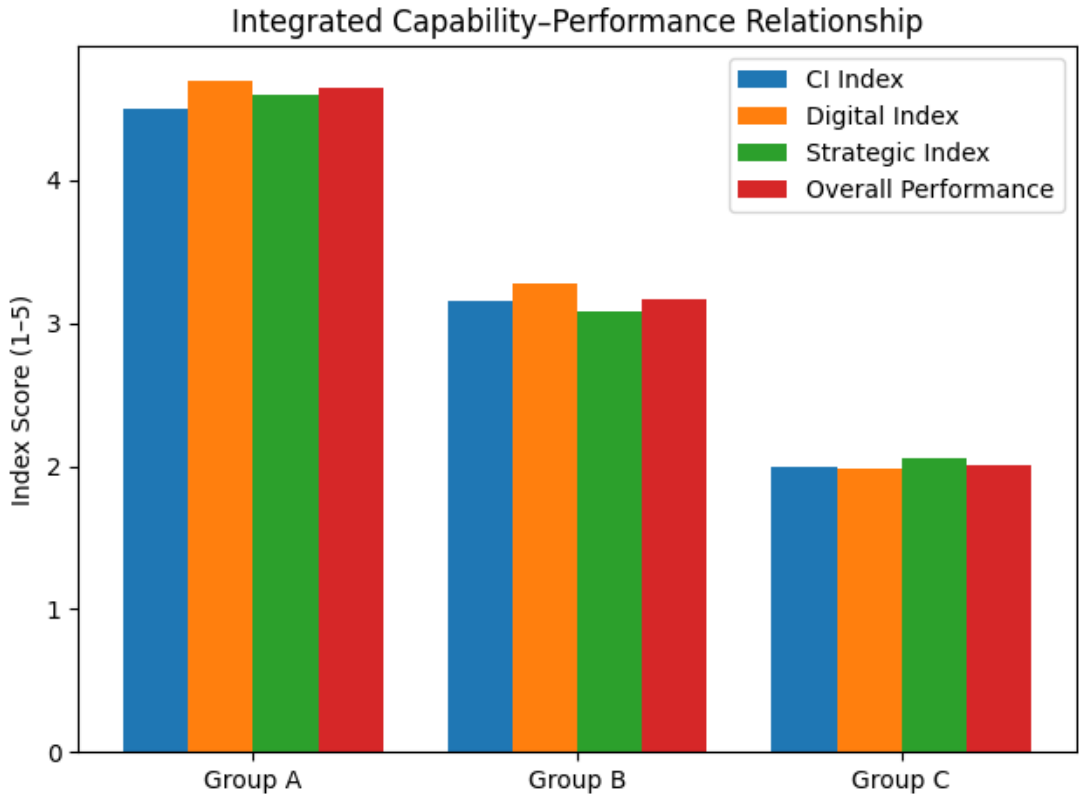


Figure 2. Sequential relationship between Competitive Intelligence capability, digital processing intensity, strategic integration, and overall organizational performance.

5. FINAL CONSIDERATIONS

This study contributes to the Journal of Sustainable Competitive Intelligence by consolidating CI as a governance-centered strategic capability rather than a peripheral analytical function. By embedding CI within a structured intelligence cycle and linking it explicitly to decision architecture and sustainability outcomes, the article strengthens alignment with JSCI’s epistemological foundations.

To start with, the results prove that digital transformation does not necessarily boost performance. Instead it is effective with the help of the complementary organizational capabilities that organize the sensing and decision making. The recent literature highlights that the value of digital transformation is achieved when companies combine both technology uptake and strategic alignment and capacity building (Verhoff et al., 2021). The risk of not adopting technology in the right way is reduced in an industry with a high level of capital intensity and process rigidity (ceramic industry), where an intelligence-based sequencing of digitally based investments comes in handy.

Second, the research supports the opinion that dynamic capabilities determine



the performance of digital initiatives. The most effective way of digital transformation in manufacturing is when companies integrate sensing, seizing, and reconfiguring to respond to environmental volatility. Competitive intelligence enhances the sensing dimension by methodically recording the competitor strategies, market signals, and technological courses and enhancing investment accuracy.

Third, it is not an automatic by-product of automation that sustainability improvements in such energy-intensive industries as ceramics be achieved. Instead, systematic digitalization should be incorporated into monitoring systems and KPI architectures converting the information about energy and emissions into strategic decisions. It is shown that the use of Industry 4.0 technologies enhances sustainability performance originating in the managerial governance mechanisms. The current structure shows that CI is that governing mechanism.

Fourth, the findings can be compared to the wider research in manufacturing, which suggests that the digital transformation enhances the competitiveness by increasing the coordination, speeding up the innovation, and optimizing resources (Sui et al., 2024).

5.1 Limitations

This is a conceptual and analytically modelled study as opposed to an empirically validated study using primary data. Although the organized datasets depict possible sector dynamics, future studies ought to test the structure based on the survey using structural equation modelling or longitudinal case study in ceramic manufacturing companies.

Second, the review is more oriented on firm-level capabilities. The relationship between CI and digital transformation can be moderated by external ecosystem influences, including supplier digital preparedness, policy prompts, and geographic power instability, and included in new models.

5.2 Future Research Recommendations

The empirical issues to be studied in the future include:

- Strategic integration as a mediator between the results of digital transformation and the maturity of CI.
- Environmental uncertainty which moderates the energy-intensive industries.
- Prolonged intelligence-driven digital sequencing performance effects.
- Comparison between ceramic sub segments (tiles, sanitary ware, advanced ceramics).

In addition, it is the duty of researchers to understand the role of AI-based intelligence systems in transforming the speed and quality of executive decision-making in the manufacturing setting.



REFERENCES

- Ashfaq, K., Imtiaz, A., & Abbas, N. (2025). Digital capabilities and firm performance: Mediating role of marketing services and moderating effects of digital transformation knowledge & innovation investment. *Global Management Sciences Review*, *X*(II), 60–73. [https://doi.org/10.31703/gmsr.2025\(x-ii\).07](https://doi.org/10.31703/gmsr.2025(x-ii).07)
- Bhadu, J., Bhamu, J., Singh, D., Saraswat, P., & Agrawal, R. (2025). Implementation of an integrated framework of lean manufacturing and Industry 4.0 toward sustainability: A case study of the Indian ceramic industry. *Engineering Management Journal*. <https://doi.org/10.1080/10429247.2024.2440248>
- Contini, G., Peruzzini, M., Bulgarelli, S., & Bosi, G. (2023). Developing key performance indicators for monitoring sustainability in the ceramic industry: The role of digitalization and Industry 4.0 technologies. *Journal of Cleaner Production*, *414*, 137664. <https://doi.org/10.1016/j.jclepro.2023.137664>
- Cucchi, M., Baiocco, S., Fedele, A., Germani, M., & Mandolini, M. (2023). Industry 4.0 real-world testing of dynamic organizational life cycle assessment (O-LCA) of a ceramic tile manufacturer. *Environmental Science and Pollution Research*, *30*, 49943–49960. <https://doi.org/10.1007/s11356-022-20601-7>
- Cumbajin, E., Rodrigues, N., Costa, P., Miragaia, R., Frazão, L., Costa, N., Fernández-Caballero, A., Carneiro, J., Buruberri, L. H., & Pereira, A. (2024). A real-time automated defect detection system for ceramic pieces manufacturing process based on computer vision with deep learning. *Sensors*, *24*(1), 232. <https://doi.org/10.3390/s24010232>
- Hanelt, A., Bohnsack, R., Marz, D., & Antunes Marante, C. (2021). A systematic review of the literature on digital transformation: Insights and implications for strategy and organizational change. *Journal of Management Studies*, *58*(5), 1159–1197. <https://doi.org/10.1111/joms.12639>
- Hassani, A., & Mosconi, E. (2022). Social media analytics, competitive intelligence, and dynamic capabilities in manufacturing SMEs. *Technological Forecasting and Social Change*, *175*, 121416. <https://doi.org/10.1016/j.techfore.2021.121416>
- Kulichyova, A., Dess, G. G., Sarala, R. M., & Vaara, E. (2025). Digital transformation in large established organisations: Four restructuring dilemmas based on dynamic capabilities. *International Journal of Management Reviews*. <https://doi.org/10.1111/ijmr.12395>



- Li, L., Su, F., Zhang, W., & Mao, J. (2017). Digital transformation by SME entrepreneurs: A capability perspective. *Information Systems Journal*, 28(6), 1129–1157. <https://doi.org/10.1111/isj.12153>
- Ma, S., Ding, W., Liu, Y., Zhang, Y., Ren, S., Kong, X., & Leng, J. (2024). Industry 4.0 and cleaner production: A comprehensive review of sustainable and intelligent manufacturing for energy-intensive manufacturing industries. *Journal of Cleaner Production*, 467, 142879. <https://doi.org/10.1016/j.jclepro.2024.142879>
- Maluleka, M. L., & Chummun, B. Z. (2023). Competitive intelligence and strategy implementation: Critical examination of present literature review. *South African Journal of Information Management*, 25(1), a1610. <https://doi.org/10.4102/sajim.v25i1.1610>
- Matarazzo, M., Penco, L., Profumo, G., & Quaglia, R. (2021). Digital transformation and customer value creation in made in Italy SMEs: A dynamic capability perspective. *Journal of Business Research*, 123, 642–656. <https://doi.org/10.1016/j.jbusres.2020.10.033>
- Nadkarni, S., & Prügl, R. (2021). Digital transformation: A review, synthesis and opportunities for future research. *Management Review Quarterly*, 71, 233–341. <https://doi.org/10.1007/s11301-020-00185-7>
- Plekhanov, D., Franke, H., & Netland, T. H. (2023). Digital transformation: A review and research agenda. *European Management Journal*, 41(6), 821–844. <https://doi.org/10.1016/j.emj.2022.09.007>
- Rachinger, M., Rauter, R., Müller, C., Vorraber, W., & Schirgi, E. (2018). Digitalization and its influence on business model innovation. *Journal of Manufacturing Technology Management*, 30(8), 1143–1160. <https://doi.org/10.1108/jmtm-01-2018-0020>
- Raffaelli, R., Pazzi, L., & Pellicciari, M. (2024). Industry 4.0 solutions as enablers for the sustainability of the Italian ceramic tiles sector. *Sustainability*, 16(10), 4301. <https://doi.org/10.3390/su16104301>
- Sewdass, N., & Calof, J. (2020). Contemporary practices of intelligence support for competitiveness. *Foresight-Russia*, 14(3), 30–39. <https://doi.org/10.17323/2500-2597.2020.3.30.39>



- Sui, X., Jiao, S., Wang, Y., & Wang, H. (2024). Digital transformation and manufacturing company competitiveness. *Finance Research Letters*, 59, 104683. <https://doi.org/10.1016/j.frl.2023.104683>
- Teece, D. J. (2015). Dynamic capabilities and entrepreneurial management in large organizations: Toward a theory of the (entrepreneurial) firm. *European Economic Review*, 86, 202–216. <https://doi.org/10.1016/j.eurocorev.2015.11.006>
- Teeratansirikool, L., Siengthai, S., Badir, Y., & Charoenngam, C. (2013). Competitive strategies and firm performance: The mediating role of performance measurement. *International Journal of Productivity and Performance Management*, 62(2), 168–184. <https://doi.org/10.1108/17410401311295722>
- Vasić, M. V., Awoyera, P. O., Fadugba, O. G., Barišić, I., & Netinger Grubeša, I. (2025). Advanced machine learning models for the prediction of ceramic tiles' properties during the firing stage. *Scientific Reports*, 15, 31397. <https://doi.org/10.1038/s41598-025-12011-9>
- Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, 122, 889–901. <https://doi.org/10.1016/j.jbusres.2019.09.022>
- Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, 28(2), 118–144. <https://doi.org/10.1016/j.jsis.2019.01.003>
- Wan, G., Fang, H., Wang, D., Yan, J., & Xie, B. (2022). Ceramic tile surface defect detection based on deep learning. *Ceramics International*, 48(8), 11085–11093. <https://doi.org/10.1016/j.ceramint.2021.12.328>
- Wu, Q., Yan, D., & Umair, M. (2023). Assessing the role of competitive intelligence and practices of dynamic capabilities in business accommodation of SMEs. *Economic Analysis and Policy*, 77, 1103–1114. <https://doi.org/10.1016/j.eap.2022.11.024>
- Yu, Y., Zhang, J. Z., Cao, Y., & Kazancoglu, Y. (2021). Intelligent transformation of the manufacturing industry for Industry 4.0: Seizing financial benefits from supply chain relationship capital through enterprise green management. *Technological Forecasting and Social Change*, 172, 120999. <https://doi.org/10.1016/j.techfore.2021.120999>



- Zhen, G., Liu, J., Ren, Z., & Sang, M. (2025). Manufacturing breakthrough: Analysing the differential effect of digital transformation on continuous innovation capability in enterprises. *Technology Analysis & Strategic Management*, 37(2), 171–186. <https://doi.org/10.1080/09537325.2023.2283548>
- Zheng, S., & Zhou, Y. (2025). Digital transformation and competitive advantage in manufacturing: The role of business model innovation. *Economies*, 13(7), 209. <https://doi.org/10.3390/economies13070209>



Appendix A

Figure A1. PRISMA Flow Diagram

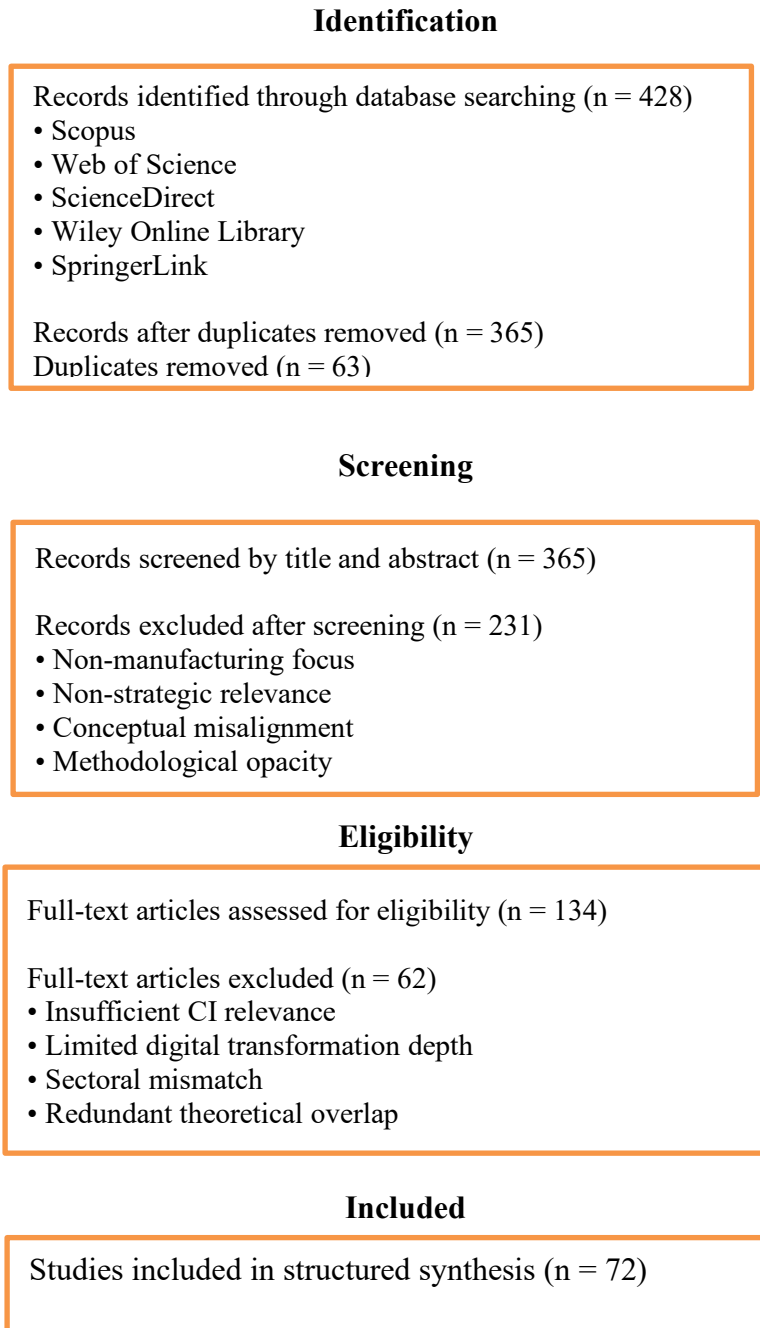


Figure A1. PRISMA-based flow diagram of systematic literature selection process. Source: Prepared by the authors (2026).