

Enhancing the Competitive Advantage of Industrial Enterprises in the Age of Artificial Intelligence: An Analytical Study of BMW's Experience

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Abstract:

This study aims to analyze the role of artificial intelligence in enhancing the competitive advantage of industrial enterprises, using the case of BMW as an applied model. The descriptive-analytical method was adopted, along with the case study approach, to explore the strategic empowerment dimensions of smart technologies. The findings reveal that integrating artificial intelligence into industrial processes contributed to improving inspection accuracy and reducing defect rates. Moreover, it enabled the company to lower operational costs and enhance the efficiency of its value chain. Based on these results, the study recommends adopting clear digital strategies and developing specialized human competencies to help industrial enterprises achieve an effective digital transformation that leads to a sustainable competitive advantage.

Keywords: Artificial Intelligence, Competitive Advantage, Industrial Enterprise, BMW.

JEL Classification: O33; L10; L60; L62.

1. Introduction:

The global industrial landscape is undergoing profound transformations driven by the rapid acceleration of digital shifts, which have altered the rules of competition among enterprises. Competitive advantage is no longer solely based on cost reduction or product quality improvement; rather, it is increasingly tied to an organization's ability to adapt to market changes, respond to the needs of more informed and demanding customers, and continuously update its internal operations. This new reality has imposed serious challenges on industrial enterprises, most notably: *How can a company maintain a sustainable competitive advantage in an environment that is changing at an unprecedented pace?*

Amid these challenges, **Artificial Intelligence (AI)** has emerged as one of the most promising technological solutions that could create a qualitative shift in the performance of industrial enterprises by enhancing operational efficiency, improving production quality, and predicting disruptions before they occur. However, this trend still raises multiple questions regarding the realism of this impact and when and how AI can evolve from being a mere technological tool to a true strategic lever that boosts the competitive capability of industrial firms.

Accordingly, the core research problem of this study is:

- **How does artificial intelligence contribute to enhancing the competitive advantage of industrial enterprises?**

This main issue gives rise to several sub-questions:

- What is meant by competitive advantage, and what are its key dimensions?
- What is artificial intelligence, and what are its main applications?
- How can AI influence the development of competitive advantage?
- To what extent does the experience of BMW reflect the effectiveness of AI in enhancing industrial competitiveness?

The significance of this research lies in its contribution to understanding the growing relationship between digital transformation and competitive advantage, with a particular focus on one of the most prominent

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applications of AI in modern industry. It also carries practical importance by analyzing the experience of BMW, allowing for the extraction of insights that can be generalized or adapted in other industrial contexts, especially in countries seeking to improve their productive capabilities.

The study aims to achieve several objectives, including:

- Identifying the conceptual frameworks related to competitive advantage and its dimensions.
- Analyzing the role of artificial intelligence as a strategic tool to enhance competitive advantage.
- Highlighting BMW's experience in adopting AI as a driver of innovation and competitive excellence.
- Providing an analytical perspective that may enrich the discussion on the future of industry in light of digital transformation.

The **descriptive-analytical approach** was adopted as the most suitable for the nature of the study, combining the theoretical exploration of competitive advantage and AI with the practical analysis of a real-life case. The study relies on recent academic sources, official reports, and credible case studies concerning BMW.

The structure of the study is divided into two main sections:

The **first section** addresses the theoretical framework related to the concept of competitive advantage in industrial enterprises, including its dimensions and strategies. The **second section** explores the role of artificial intelligence in strengthening this advantage, with a presentation and analysis of BMW's experience as a contemporary practical model.

2. Theoretical Foundations of Competitive Advantage in the Industrial Context

This section addresses the concept of **competitive advantage** as a key determinant of the superiority of industrial enterprises. It presents the main internal sources of competitive advantage and the key indicators for its measurement, such as efficiency and market performance. It also explores

Porter's model of generic competitive strategies to understand how companies adopt strategies like cost leadership or differentiation to achieve a sustainable competitive position.

2.1. The Concept of Competitive Advantage

The concept of competitive advantage is one of the fundamental ideas in contemporary strategic thinking. It represents an organization's core ability to achieve performance that exceeds the average in the sector in which it operates, by possessing elements that are difficult for competitors to imitate or substitute. Despite its widespread use, the concept still suffers from some ambiguity on both theoretical and practical levels, as it is often confused with related concepts such as superior performance or profitability. However, achieving positive financial results does not necessarily imply the existence of a clear competitive advantage, unless these results are based on genuine and sustainable sources of superiority.

Competitive advantage is understood relationally—it does not exist in a vacuum but derives its true meaning when compared to the performance of competitors within a specific sector. By nature, it is relative rather than absolute, and what is considered an advantage in one environment might not be in another. Moreover, it is subject to various environmental changes, including technological developments, economic shifts, and changes in customer preferences, which makes it prone to erosion if the organization fails to renew it continuously (Ma, 2000).

Recent strategic literature has distinguished between two types of competitive advantage: temporary and sustainable. Temporary competitive advantage refers to the superiority an organization achieves over a limited period, as a result of exploiting a sudden market opportunity or owning a resource that is easily replicable by competitors. This type of advantage tends to be short-lived and disappears with changing conditions or the emergence of new competitors. On the other hand, sustainable competitive advantage stems from possessing resources or capabilities that are difficult to imitate or substitute, such as tacit knowledge, specific skills, or distinctive organizational culture. This type of advantage provides superior performance over the long term, granting the organization a degree of strategic stability (Kuo-Feng Huang, 2015).

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In the industrial context, competitive advantage is understood in light of the nature and structure of the industry. Michael Porter, through his Five Forces Model, emphasized that advantage is built by an organization's ability to create a strong defensive position in the sector, through adopting clear strategies such as cost leadership, differentiation, or focus. This perspective highlights how structural industry factors—such as the number of competitors, entry barriers, and the bargaining power of suppliers and customers—are central determinants in building competitive superiority.

However, this industry-based perspective is no longer sufficient to fully understand competitive advantage in an era marked by rapid market change. This is where the Resource-Based View (RBV) emerges, considering the organization as a system of tangible and intangible resources. It asserts that organizations owning valuable, rare, inimitable, and non-substitutable resources are capable of achieving sustainable competitive advantage. Building on this, the Dynamic Capabilities Theory highlights the need for organizations to adapt and reshape their resources in response to environmental shifts, making organizational learning and agility critical elements in building and sustaining advantage (Shirzad Farhikhteh, 2023).

Furthermore, competitive advantage is no longer viewed solely as an objective reality resulting from market or resource conditions, but also as a perceptual construct shaped by decision-makers within the organization. The mental models that leaders form about what constitutes an advantage for their firms directly influence their strategic choices and the way they allocate resources. This strategic perception plays a vital role in transforming available capabilities into real advantages that create tangible differentiation in the market. (Nedungadi, 1994)

In light of the above, it becomes clear that competitive advantage is neither a simple nor static concept. Rather, it is a complex construct that combines internal and external factors, is influenced by both material and perceptual dimensions, and is shaped by the sectoral and temporal context in which the organization operates. It is not a fixed state, but a dynamic outcome of the organization's behavior and its continuous interaction with its competitive environment—making it a precise indicator of how effective and efficient its strategic choices are in maintaining its position in an ever-changing environment.

2.2. Sources of Competitive Advantage

Innovation and technology play a central role in creating added value within firms. Innovation goes beyond the scientific aspect and includes commercial dimensions, such as developing new products or services and improving existing processes. Firms that focus on innovation contribute to wealth creation, productivity growth, and long-term competitiveness. However, the challenge lies in translating technological strategies into effective capabilities that are hard for competitors to replicate. This requires ongoing investment in R&D and continuous updating of resources and skills.

Human resources are among the most difficult sources to imitate, as they rely on an organization's social and cultural fabric. The literature emphasizes the importance of adopting effective HRM practices such as internal recruitment, continuous training, performance evaluation, employee involvement in decision-making, and job security. These practices not only enhance performance but also establish **sustainable competitive advantage**. The stronger the alignment between HR strategy and organizational plans, the greater the potential for differentiation and resilience in a dynamic environment.

The **organizational structure** directly impacts operational efficiency and adaptability to change. An effective structure clearly distributes responsibilities, supports flexibility, and fosters creativity within the firm. As competitive pressures increase, organizations are moving toward redefining their boundaries by downsizing or engaging in strategic alliances, aiming to focus on core competencies. Research shows that **continuous structural change** is necessary to maintain vitality, and organizational rigidity may lead to decline if no corrective actions are taken (Wang, 2011).

Overall, gaining competitive advantage depends on a firm's ability to **innovate**, effectively leverage its **human resources**, and build a **flexible organizational structure** that supports strategic goals and adapts to environmental changes.

2.3. Indicators for Measuring Competitive Advantage

Competitive advantage forms a core pillar in modern business strategies, and its realization can be assessed through several key dimensions, as outlined by (Ahmed A. AL-Qatamin, 2018):

- **Cost Dimension:** Reflects the firm's ability to effectively reduce overall operational costs, thereby enhancing profitability compared to competitors. Key practices include minimizing production and operational expenses by improving processes, reducing waste, and eliminating non-conforming outputs. It also involves standardizing specifications to lower variability and improve manufacturability, along with continuous productivity improvement programs. Firms with strong cost control across manufacturing, value-added activities, and after-sales services often achieve a **cost leadership** advantage, offering competitively priced products without compromising performance.
- **Quality Dimension:** Involves delivering high-quality products or services that distinguish the firm in the market. Quality is demonstrated through effective quality management systems, strict control, and continuous improvement. Feedback mechanisms enable performance assessment and issue resolution. Employee training is critical for maintaining product excellence. Quality is also seen in product reliability, compliance with standards, durability, ease of use, and perceived value by customers. This dimension embodies a **value excellence** strategy that underpins sustainable competitive advantage.
- **Flexibility Dimension:** Indicates the firm's ability to dynamically adapt to market changes and respond effectively to opportunities and threats. Flexibility is shown in handling inputs of varying quality, meeting diverse market demands, and modifying or launching products to suit changing customer preferences. Responsiveness to shifting demand patterns and resource combinations is key to strategic agility and **resilience in unstable environments**.
- **Time and Delivery Dimension:** Represents the firm's capacity to deliver products or services accurately and efficiently within agreed timeframes. This boosts customer trust and loyalty. It includes reducing production lead times while maintaining quality, adhering to deadlines, fulfilling orders efficiently, and ensuring regular, timely deliveries. This dimension is fundamental to **operational excellence**, enhancing customer satisfaction and competitive standing in time-sensitive markets.

These four dimensions—**cost, quality, flexibility, and time/delivery**—form a comprehensive framework for assessing and analyzing an organization's **sustainable competitive advantage**, each tied to strategic factors directly impacting competitiveness in modern markets.

2.4. Competitive Advantage Strategies

The **generic strategies for competitive advantage**, as proposed by **Michael Porter**, are foundational in modern strategic thinking. Porter's framework helps organizations achieve superiority in rapidly changing and competitive environments. It is based on the premise that competitive advantage is not accidental but results from adopting a clear, coherent strategy aligned with the firm's internal resources and capabilities. Porter identifies three main strategies, each with its unique logic and tools:

- **Cost Leadership Strategy:** Focuses on minimizing costs across the value chain, from production to distribution. This strategy aims to offer products at lower prices than competitors without compromising essential quality, thus securing a strong position in price-sensitive markets. It also enhances bargaining power with suppliers and provides greater control over the market environment.
- **Differentiation Strategy:** Aims to offer a unique value that is hard to imitate, whether through product features, service quality, innovation, or brand identity. This strategy builds long-term customer loyalty by delivering a distinct experience. Although production costs may be higher, customers are usually willing to pay a premium for the added value, resulting in sustainable profitability.
- **Focus Strategy:** Concentrates on serving a specific market segment more deeply and efficiently, using either a cost or differentiation approach within a narrow scope. This is suitable for firms lacking the resources to compete broadly but possessing deep knowledge of niche customer needs.

Initially, Porter proposed a three-dimensional competitive strategy model (3×3×3 matrix) yielding 27 strategic options. However, practical application showed most combinations were unrealistic, and the three core strategies became the accepted standard (Ida Farida, 2022).

Porter's model emphasizes that competitive advantage is **not random**, but the result of a precise alignment between organizational capabilities and market demands. These strategies are **not mutually exclusive**; they may sometimes be combined under the right conditions. There is no universally "best" strategy—it depends on industry characteristics, competitive intensity, customer profiles, and resource availability. Thus, success lies not only in selecting a strategy but also in ensuring its **fit with the internal and external environment** and activating it **effectively and sustainably**.

3. Competitive Advantage in the Age of Artificial Intelligence: An Analytical and Practical Framework

This section addresses the relationship between artificial intelligence (AI) and competitive advantage by analyzing the role of AI technologies in supporting the digital transformation of industrial enterprises. The focus will be on understanding key AI applications in production environments and how they contribute to improving efficiency, reducing costs, enhancing quality, and supporting decision-making. The experience of BMW will be presented as a practical case study illustrating how AI can be leveraged to boost competitive performance in the automotive industry. This section aims to uncover the practical implications of AI adoption in manufacturing.

3.1. The Concept of Artificial Intelligence

Artificial Intelligence (AI) is one of the most prominent contemporary technological concepts, widely discussed in both academic and managerial spheres. Its importance lies in its ability to simulate certain aspects of human intelligence through advanced algorithms that learn from data and adapt to changing environments.

In this context, (Michael Haenlein, 2019) defines AI as "a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation." This definition highlights three core capabilities of AI: comprehension, learning, and decision-making—features that distinguish it from traditional digital tools.

(Schank, 1991) emphasizes that AI is not limited to executing pre-programmed instructions; rather, it has the capacity for continuous learning from experience and interaction with users, enabling it to develop more flexible and evolving behavioral patterns. This adaptive ability makes AI a dynamic and realistic technology suited to diverse individual and environmental contexts.

Technically, AI comprises a set of tools and methodologies such as machine learning, artificial neural networks, and natural language processing (NLP). These enable systems to analyze vast amounts of data, identify complex patterns, and interact in ways that simulate human reasoning.

AI is not merely an executional technology; it is viewed as a conceptual framework that transforms the design of intelligent systems. Its essence lies in making data-driven, knowledge-based decisions, distinguishing it from static software that lacks flexibility and self-evolution (Harry, 2023).

Therefore, AI represents a central concept in digital transformation, combining analytical programming capabilities with adaptability to complex environments. It has become a foundational pillar for many studies exploring its potential and applications in institutional, educational, and societal contexts.

3.2. Features of Artificial Intelligence

AI is one of the most advanced fields in computer science and has garnered increasing attention in recent years due to its growing capabilities in data analysis, autonomous learning, and executing complex tasks—often outperforming human abilities. Although no universally accepted definition exists, the common objective across research directions is to produce intelligent machines capable of “thinking” and “acting” rationally or in a human-like manner.

From the latest literature (Michael Weber, 2022), the distinctive features of AI, particularly in the context of startups and digital transformation, include:

- **Adaptive Intelligence:** AI learns from experience and improves its performance over time by analyzing data patterns, a hallmark of machine learning and deep learning techniques.
- **Multi-Level Abstraction:** Through deep learning, AI extracts insights at various levels of abstraction, enabling complex and profound data understanding.
- **Autonomous Rule Generation:** AI systems can generate their own rules based on data analysis without direct human intervention.
- **Technological Diversity:** AI encompasses a broad array of technologies such as machine learning, deep learning, NLP, computer vision, robotics, and knowledge-based reasoning.
- **Human-Like Behavior:** AI mimics cognitive functions such as perception, reasoning, creativity, and problem-solving.
- **Integration with Big Data:** AI thrives in data-rich environments, using data as a foundational element for learning and decision-making.
- **Computational Enhancement:** Advances in computing power significantly boost the performance, speed, and efficiency of AI algorithms.
- **Cross-Domain Applicability:** AI is applied in multiple sectors such as education, healthcare, industry, and entrepreneurship, showcasing its flexibility and wide-ranging impact.

AI thus emerges as a flexible, evolving intelligence driven by self-learning and deep data analysis, underpinned by a diverse technological base. It enables the execution of complex, human-like functions, making it a core enabler of digital transformation and institutional innovation.

3.3. Applications of Artificial Intelligence

AI applications have evolved due to the contributions of key researchers such as Geoffrey Hinton (artificial neural networks), Edward Feigenbaum (expert systems), and John Holland (genetic algorithms). Stuart Russell and Peter Norvig also provided a comprehensive framework for AI, particularly the concept of intelligent agents.

According to (Saba, 2024), major AI applications include:

a. Artificial Neural Networks (ANNs)

ANNs mimic the human nervous system in structure and function, demonstrating high efficiency in analyzing vast and complex datasets and detecting hidden patterns. They are widely used in image and speech recognition, event prediction, and NLP, making them a cornerstone of automated decision-making.

b. Expert Systems

Expert systems compile and analyze specialized knowledge from human experts to deliver accurate solutions in complex decision-making scenarios. They are used in medical diagnostics, industrial decision support, and legal or financial data analysis. By simulating human expertise in recurring situations, they enhance response speed and decision quality.

c. Intelligent Agents (Smart Robots)

These programs interact with their environments by collecting, analyzing, and responding to data. Key features include:

- Logical reasoning to infer new solutions.
- Environmental sensing and adaptive behavior.
- Interactive learning based on past experiences to improve accuracy and adaptability.

d. Genetic Algorithms

Inspired by natural selection, these algorithms solve complex problems through iterative improvement involving “crossover” and “mutation” processes. They are widely used in system design, scheduling, software development, and optimizing production chains.

These diverse AI applications demonstrate its transformative potential across industries by enhancing productivity, minimizing errors, and achieving higher performance with greater quality and efficiency. Continued development promises even more intelligent and autonomous applications in the near future.

3.4. AI from the Perspective of Resource-Based View (RBV)

The Resource-Based View (RBV) is a key strategic theory explaining how firms achieve sustainable competitive advantage. It

emphasizes the importance of internal resources that are valuable, rare, inimitable, and non-substitutable.

In this context, AI qualifies as a strategic resource under RBV. It requires access to large datasets, advanced analytical capabilities, and organizational know-how that cannot be easily replicated. AI serves as a knowledge-based asset that enables firms to extract greater value from their environment and adapt flexibly to rapid changes (Chen, 2022).

Merely owning AI infrastructure does not guarantee competitive advantage. The true value lies in the strategic activation of AI within the organizational model, using it dynamically to reshape processes, innovate solutions, and anticipate market challenges. Hence, AI is viewed not just as a technology but as a renewable intangible capital that drives sustainable competitive sources difficult for rivals to imitate (Grover, 2005).

3.5. The Role of AI in Creating Competitive Advantage

As a resource that aligns with RBV characteristics, AI plays a vital role in enhancing firms' competitive advantage through five key dimensions:

a. Enabling Innovation (Novelty)

AI empowers firms to create unconventional methods for delivering products and services by deeply understanding user behavior and offering personalized experiences. Companies like Amazon and Netflix use AI-driven recommendation systems to enhance customer loyalty and disrupt traditional business models (Y.P.Sai Lakshmi, 2024).

b. Enhancing Operational Efficiency

AI-driven automation and predictive analytics reduce costs, minimize process time, and decrease human error, leading to higher performance with fewer resources. This dual benefit in efficiency and quality provides a substantial competitive edge (Ariyo Gracious Kazaara, 2024).

c. Achieving Strategic Complementarity

AI helps integrate various products and services into tailored solutions for customer needs. Behavioral data analysis enables coordination across marketing, pricing, and after-sales strategies, leading to cross-selling opportunities and revenue growth (Ricardo Costa Climent, 2024).

d. Strengthening Customer Lock-In

Through deep personalization and historical data aggregation, AI fosters long-term customer relationships that are hard for competitors to disrupt. The more accurate the algorithms, the higher the switching cost, thereby enhancing customer loyalty and market share stability (Monideepa Tarafdar, 2019).

e. Dynamically Reconfiguring the Business Model

AI provides strategic flexibility to redesign business models in response to market or technological shifts. This helps firms not only maintain but also renew their competitive edge in volatile environments (Ricardo Costa Climent, 2024).

Hence, AI-driven competitive advantage depends not on the technology itself but on how effectively it is integrated and utilized within the business model to generate sustainable economic value.

3.6. Case Study: BMW's Use of AI to Enhance Production and Gain Competitive Advantage

BMW (Bayerische Motoren Werke AG) is one of the leading German companies globally recognized for manufacturing luxury automobiles and motorcycles. Founded in 1916 in the city of Munich, Bavaria—where its headquarters remain to this day—BMW continues to uphold its legacy of excellence. The Quandt family stands as the largest shareholder in the company, alongside individual and institutional investors. BMW maintains its innovative edge, most notably with the launch of the new all-electric “Neue Klasse” series in 2025, which reflects the company's strategic shift toward smart, sustainable vehicles powered by artificial intelligence technologies (Group, 2019).

a. BMW's Strategic Shift toward AI

As part of its digital transformation strategy and the "Industry 4.0" initiative, BMW began integrating artificial intelligence (AI) technologies into its global manufacturing facilities in 2018. This move represents a pivotal step toward industrial excellence and smart transformation of production processes. The initiative aims to achieve several strategic objectives, including enhancing manufacturing quality through intelligent systems capable of early defect detection, reducing error rates and associated

costs, and boosting operational efficiency through automation and intelligent data analysis. Through this approach, BMW also seeks to enhance the customer experience and develop a modern work environment aligned with the demands of the digital age (Group, 2019).

b. Key AI Applications in BMW Plants

BMW employs AI-driven visual inspection systems to detect flaws in welds and paintwork with high precision, preventing defects from advancing along the production line. This contributes significantly to quality control and cost reduction.

Another notable initiative is the GenAI4Q project at BMW's Regensburg plant, where AI analyzes over 1,400 vehicles daily and offers inspection recommendations based on historical data and predictive failure patterns. This helps human inspectors focus on potential weak points, enhancing inspection efficiency and reducing manual workload.

BMW has also reduced false alarms—triggered by dust or light reflections—through AI-enhanced filtering systems. This has saved time, improved sensor accuracy, and boosted monitoring reliability.

Additionally, BMW has partnered with NVIDIA to utilize cutting-edge DGX systems for training high-performance AI models. These models enable real-time production line data analysis and decision-making, dramatically increasing factory agility and efficiency (Group, 2019).

c. AI's Role in Enhancing BMW's Competitive Advantage

AI has significantly strengthened BMW's competitive edge by improving product quality through early defect detection and reliable inspections, thereby increasing customer trust.

Operational efficiency has also improved due to smart automation and reduced false alarms, leading to resource savings and higher productivity—boosting profitability and competitive resilience.

Furthermore, AI has fostered innovation and an enhanced work environment by supporting employees with intelligent decision-making tools. This creates a more interactive and progressive workplace that encourages creativity and sustainable performance (Group, 2019).

BMW's case exemplifies how strategic integration of AI can drive industrial excellence and competitive differentiation. The company has shown that technological innovation, when aligned with clear strategic vision, can transform industries and deliver a lasting advantage.

4. Conclusion

In conclusion, the analysis of the relationship between artificial intelligence (AI) and competitive advantage in industrial enterprises reveals that digital transformation is no longer a mere option but a strategic necessity for survival in an environment marked by intense competition and rapid change. The case of BMW demonstrates that AI can serve as a true lever for enhancing industrial performance—whether by improving quality, increasing efficiency, or supporting business decision-making with greater precision and effectiveness. This intelligent application of technology has enabled the company to maintain its leadership position in a fast-changing global market.

From this perspective, several key insights can be drawn. Most notably, competitive advantage in the digital era is no longer built solely on traditional factors such as cost or differentiation. Instead, it increasingly depends on possessing advanced knowledge-based and technological resources, as well as on an organization's ability to transform data into strategic intelligence. It is also evident that companies integrating AI into their production and management value chains are better positioned to enhance their flexibility and responsiveness to market shifts, thereby increasing their ability to adapt and create added value.

Based on these findings, the study recommends the following:

- **The need for Arab industrial enterprises to adopt comprehensive digital strategies** that integrate AI not merely as a technical tool but as a strategic component for achieving competitive advantage.

- **Investing in digital infrastructure and developing specialized human capital** to ensure the effective implementation of AI applications.
- **Encouraging partnerships between industrial enterprises, research centers, and universities** to develop AI-based solutions tailored to the specific needs of local markets.
- **Drawing on leading international models, such as BMW's experience**, while adapting such examples to fit local economic and organizational contexts.

Ultimately, AI-driven digital transformation does not pose a threat to institutions; rather, it offers a strategic opportunity to rebuild their competitive advantages on stronger and more innovative foundations—provided that such transformation is carefully planned and aligned with the organization's overarching vision and long-term objectives.

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