Enhancing Digital Technology Capabilities to Improve Competitive Advantage in the Steel Production Industry: A Case Study of Baosteel in China

Chen Nan[1], Tachakorn Wongkumchai[2*], Uswin Chaiwiwat[3], and Chulalux Soprakan[4]

[1]MBA, Faculty of Management Science, Dhonburi Rajabhat University, Bangkok, Thailand.

[2-4]Faculty of Management Science, Dhonburi Rajabhat University, Bangkok, Thailand.

*Corresponding Author; e-mail : tachakorn.w@dru.ac.th

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Abstract

The steel industry, a cornerstone of global industrialization and economic development, stood at the precipice of a digital revolution. Traditional production methods, while having served the industry well for centuries, were increasingly challenged by the demands of a rapidly evolving market and the advent of the digital age, marked by the proliferation of technologies in the steel industry. Digital transformation was not merely a technological upgrade; it was a strategic imperative for steel manufacturers seeking to maintain their competitive edge in the 21st century. The objective of the research was to study the approaches to enhance the capabilities of digital technology to improve the competitive advantage in the steel industry, focusing on the case study of Baosteel. The research methodology employed qualitative research techniques. The sample consisted of 100 Baosteel employees using a purposive sampling method. The data collection instrument utilized an interview questionnaire, and the data analysis method was content analysis. The results of the research revealed that the approaches to enhance the capabilities of digital technology to improve the competitive advantage in the steel industry included: Legacy systems (18%), which meant upgrading existing systems, modifying new systems, or integrating old systems with new systems to make the organization ready to support new technologies; Skills gap (16%), which meant the organization needed to continuously invest in developing the skills of employees to cope with changes and fully utilize new technologies; Data management (16%), which required organizations to have an effective data management system for data collection, storage, analysis, data security, and protection against cyberattacks; Resistance to change (14%) was also recognized as a continuing

challenge, requiring clear communication and employee engagement. Opportunities related to digital transformation included increased efficiency (12%), improved product quality (9%), and cost reduction (8%). These were identified as key goals for organizations to focus on to enhance their competitiveness. The increasing importance of customer experience (5%) and new business models (3%) were also recognized, highlighting the need for differentiation and innovation. In summary, organizations involved in this type of industry could apply the research results and create opportunities to utilize technology to create competitive advantages, such as improving old systems with modern technology, developing employees' technological skills, and increasing the efficiency of the organization's information management to create efficiency in generating differences and innovations in seeking future organizational competitiveness.

Keywords: Competitive Advantage, Digital Transformation, Steel Production

Introduction

The steel industry, a cornerstone of global industrialization and economic development, stands at the precipice of a digital revolution. Traditional production methods, while having served the industry well for centuries, are increasingly challenged by the demands of a rapidly evolving market. This market is characterized by heightened competition, fluctuating demand, and escalating environmental concerns. The advent of the digital age, marked by the proliferation of technologies such as big data analytics, cloud computing, artificial intelligence, and the Internet of Things (IoT), presents a transformative opportunity for the steel industry. These technologies have the potential to revolutionize every facet of steel production, from resource allocation and process optimization to quality control and supply chain management. As Leng et al. (2020) highlight, "Digital transformation is not merely a technological upgrade; it is a strategic imperative for steel manufacturers seeking to maintain their competitive edge in the 21st century." The integration of digital technologies can lead to significant improvements in operational efficiency, cost reduction, and product quality, enabling steel producers to navigate the complexities of the modern market and meet the evolving needs of their customers. The global steel industry is fiercely competitive, with players vying for market share in an environment characterized by price volatility, shifting demand patterns, and stringent environmental regulations. To thrive in this landscape, steel manufacturers must constantly seek ways to enhance their efficiency,

reduce costs, and improve product quality. Digital technologies offer a powerful means to achieve these objectives. By leveraging data-driven insights, automation, and intelligent systems, steel producers can optimize their operations, streamline their supply chains, and deliver superior products that meet the evolving needs of their customers. The importance of digital prowess in the steel industry is underscored by Chi et al. (2022), who argue that "digital transformation is the key to enhancing the core competitiveness of enterprises in the industry." The ability to harness the power of digital technologies is no longer a luxury but a necessity for steel manufacturers seeking to remain relevant and competitive in the global market. Baosteel Group, a leading player in the Chinese steel industry, has recognized the transformative potential of digital technologies and embarked on a journey of digital transformation. The company has strategically invested in a range of digital solutions, including big data analytics, cloud computing, IIoT, MPC, and DLN algorithms. These technologies have been integrated into various aspects of Baosteel's operations, from production planning and process control to quality assurance and customer relationship management. The company's digital transformation efforts have yielded impressive results, including significant improvements in production efficiency, product quality, and cost reduction. As notes in his case study, "Baosteel's digital path follows an upgrading logic from informatization to digitization and then to intelligence." This strategic approach has enabled the company to leverage digital technologies to optimize its operations, enhance its product offerings, and strengthen its market position.

The pressing problem facing enterprises in the steel industry was the rapid development of artificial intelligence and technology, which made it undoubtedly urgent to formulate enterprise strategies such as improving work systems and developing 21st-century talents. At the same time, effectively integrating the upstream and downstream industrial chains and building an industrial ecosystem was also a problem faced in the digital transformation process. Digital transformation was not just a single enterprise's technology transformation, but a major transformation involving the upstream and downstream supply chains, the industries between enterprises and even society as a whole. In other words, the digital transformation of the steel industry was at a critical moment to overcome such challenges and accelerate the pace of enterprise transformation.

Due to the significance and challenges identified, the research team was motivated to investigate approaches to enhance digital technology capabilities to improve competitive

advantage in the steel manufacturing industry. The aim was to utilize the findings to inform future strategy formulation and organizational development.

Research Objective

1. To study approaches to enhancing digital technology capabilities to improve competitive advantage in the steel production industry

Literature Review

Enhancing Digital Technology Capabilities to Improve Competitive Advantage

In today's digital age, businesses are recognizing the critical role of digital technology in achieving a competitive edge. Digital technologies have transformed industries, creating both opportunities and challenges for organizations. Digital technology capabilities, encompassing technical expertise, data management skills, robust infrastructure, a culture of innovation, and effective leadership, are crucial for success. These capabilities lead to improved efficiency, enhanced innovation, better customer experiences, data-driven decision-making, and increased agility. Organizations can strengthen these capabilities by investing in talent, fostering a digital culture, building robust infrastructure, embracing data-driven decisions, partnering with technology providers, and focusing on customer needs. However, the adoption of digital technologies also presents challenges. Implementation and maintenance can be costly and complex, and the demand for digital skills often exceeds the supply. Furthermore, the increased reliance on digital technologies raises concerns about cybersecurity threats and data breaches, necessitating robust security measures. Additionally, successful digital transformation requires effective change management to address employee resistance and ensure smooth adoption. Finally, the ethical implications of digital technologies, such as algorithmic bias and data privacy, must be carefully considered and managed. In conclusion, while challenges exist, the potential benefits of digital transformation are significant. Organizations that proactively address these challenges and effectively leverage digital technologies will be well-positioned to thrive in the digital age ((Bharadwaj et al., 2020; Mikalef et al., 2020)

Baosteel Group: A Pillar of China’s Steel Industry

Baosteel Group, now a part of China Baowu Steel Group, has been integral to China's industrial growth since its inception in 1978. It spearheaded the modernization of China's

steel industry through large-scale production and technological advancements, supported by government aid and foreign collaboration. In its early years, Baosteel experienced rapid growth and adopted cutting-edge steelmaking technologies. Subsequently, it pursued an expansion strategy, acquiring domestic companies and venturing into international markets through joint ventures and overseas subsidiaries. The company also focused on vertical integration and research and development to enhance its product offerings. Despite facing challenges such as the global financial crisis, Baosteel transformed itself by focusing on innovation, efficiency, and sustainability. In 2016, Baosteel merged with Wuhan Iron and Steel Corporation to form China Baowu Steel Group, the world's largest steel producer. Baosteel's legacy is marked by technological innovation, strategic expansion, and sustainable development, contributing significantly to China's economic growth. As part of China Baowu, Baosteel's future looks promising, leveraging its strengths to navigate the global steel market (Liu & Bai, 2020; Chen et al., 2021; Wang et al., 2022; Li & Zhang, 2023; Zhang & Li, 2022; Xu et al., 2020; Ma & Wang, 2021).

Strategic Management in China's Steel Industry: An Introduction and Review

China's steel industry, the world's largest, has achieved its dominance through strategic decisions and actions. Operating in a complex environment influenced by government policies and global market trends, the industry has employed various strategic management approaches. Traditionally, cost leadership, achieved through economies of scale, efficient processes, and low labor costs, has been a key focus, enabling Chinese steelmakers to offer competitive prices in the international market. Vertical integration, controlling the entire value chain, further enhances efficiency and reduces dependence on external suppliers. Additionally, technological innovation has become crucial, with companies adopting advanced manufacturing techniques and developing new, sustainable products. Government-encouraged mergers and acquisitions have consolidated the industry, creating larger and more resilient companies, while internationalization efforts have diversified markets and provided access to resources and technology. Strategic management's application in the Chinese steel industry is evident in several areas. Government policies aimed at capacity control address overcapacity concerns, while environmental regulations drive the adoption of cleaner production methods and renewable energy investments. Companies are diversifying their product portfolios to meet evolving market demands, and digital transformation is being embraced to enhance efficiency,

productivity, and decision-making. These strategies collectively demonstrate the industry's proactive adaptation to global challenges and changing market dynamics. While strategic management has played a pivotal role in the industry's success, new challenges have emerged. Rising trade protectionism and geopolitical tensions threaten China's steel exports, and stricter environmental regulations demand significant investments in cleaner technologies. Moreover, the maturing Chinese economy has led to a slowdown in domestic steel demand. These challenges highlight the necessity for the industry to continuously adapt its strategies to maintain its competitive edge. In conclusion, the Chinese steel industry's growth and resilience stem from its effective use of strategic management. As the industry navigates new challenges, the ability to adapt and innovate will be critical to ensuring its continued success in the global market (Li & Zhang, 2023; Xu et al., 2020; Ma & Wang, 2021; Chen et al., 2021; Wang et al., 2022; Li & Zhang, 2023).

The Challenges and Opportunities of Digital Transformation

Although digital transformation promises substantial benefits for the steel industry, the path to embracing these technologies is fraught with challenges. Legacy systems and outdated infrastructure present a major hurdle, as integrating new digital solutions with these can be both complex and expensive. Furthermore, the industry faces a skills gap, with many employees lacking the expertise to operate and maintain advanced digital systems. Data management and security also pose significant challenges, as steel manufacturers grapple with the collection, storage, and analysis of vast amounts of data while ensuring its integrity and confidentiality. Finally, overcoming resistance to change and fostering a culture of innovation can be a major obstacle in the traditionally conservative steel industry. Despite these challenges, the potential rewards of digital transformation are undeniable. Digital technologies can significantly enhance efficiency and productivity by optimizing production processes, reducing downtime, and improving resource utilization. Through advanced analytics and machine learning, real-time monitoring and control of production processes become possible, leading to improved product quality and reduced defects. Digitalization can also lead to significant cost savings through streamlined supply chains, optimized inventory management, and reduced energy consumption. Moreover, digital platforms and tools can facilitate personalized interactions with customers, enabling steel manufacturers to gain deeper insights into their needs and deliver customized solutions. Finally, digital technologies open new business models and revenue streams, such as data-driven services

and predictive maintenance solutions. In conclusion, while challenges exist, the potential benefits of digital transformation in the steel industry, from increased efficiency and improved product quality to new business opportunities, are compelling, making it a strategic imperative for steelmakers seeking to maintain competitiveness in the 21st century (He & Liu, 2019).

Research Methods

This study employs a qualitative method. Data collection interviews with 100 employees at Baosteel, encompassing frontline workers and managers at all levels at more experience the 10 years. The research tools include questionnaires for interviews, and content analysis.

Research Results

Analysis of interview data from a sample of 100 respondents regarding the challenges and opportunities of leveraging technology for competitive advantage in the steel industry revealed the following:

1. Legacy Systems and Skills Gaps were the most frequently cited issues, highlighting the persistent challenges of adapting existing systems and developing employee skills.
2. Data Management was also considered highly important, as it serves as the foundation for decision-making and business operations in the digital age.
3. Resistance to Change remains an ongoing obstacle that requires continuous attention to ensure smooth transitions and employee buy-in.
4. Efficiency, Product Quality, and Cost Reduction were identified as key goals that organizations continue to prioritize in their digital transformation efforts to enhance their competitiveness.
5. Customer Experience and New Business Models, although mentioned less frequently, are gaining increasing recognition as crucial factors for differentiation and long-term growth.

These findings are summarized in Table 1.

Table 1 Challenges and Opportunities in Leveraging Technology for Competitive Advantage in the Steel Industry

No.	Issue	Percentage (%)
1	Legacy Systems	18%
	• Legacy systems continue to be a significant challenge in digital transformation due to their complexity and inflexibility. • Managing legacy systems can be approached in various ways, such as upgrading existing systems, replacing them with new ones, or integrating legacy and new systems. • Choosing the appropriate approach depends on several factors, including budget, business needs, and organizational readiness.	
2	Skills Gaps	16%
	• Skills gaps are a major obstacle in digital transformation, as new technologies require different skills than traditional ones. • Organizations need to invest in continuous employee skill development to cope with change and fully utilize new technologies. • Creating a culture of learning and development within the organization is crucial in bridging skills gaps.	
3	Data Management	16%
	• Data management has become increasingly important in the digital transformation era, as data is a valuable resource for business decision-making. • Organizations need effective data management systems to store, analyze, and utilize data appropriately. • Protecting data security is paramount, as data is vulnerable to cyberattacks.	
4	Resistance to Change	14%
	• Resistance to change is a common obstacle in digital transformation, as employees may feel insecure or unprepared for change. • Organizations need to communicate and educate employees clearly about the benefits of digital transformation. • Fostering understanding and employee engagement is crucial in mitigating resistance to change.	

5	Efficiency	12%
	• Increasing efficiency is one of the primary goals of digital transformation. • Digital technologies enable organizations to work more efficiently, reduce redundancy, and accelerate operations. • Measuring and monitoring performance regularly is essential for evaluating the success of digital transformation.	
6	Product Quality	9%
	• Digital transformation allows organizations to improve the quality of their products and services. • Utilizing digital technologies in product design, development, and manufacturing enhances precision and reduces errors. • Collecting and analyzing customer data helps organizations understand needs and develop products that better meet those needs.	
7	Cost Reduction	8%
	• Cost reduction is another key objective of digital transformation. • Digital technologies help reduce operational costs in various ways, such as reducing paper usage, increasing production efficiency, and minimizing travel expenses. • Thoroughly analyzing data and workflows enables organizations to identify cost reduction opportunities effectively.	
8	Customer Experience	5%
	• Enhancing customer experience is crucial for gaining a competitive advantage. • Digital technologies empower organizations to create positive experiences and respond to customer needs quickly and efficiently. • Utilizing customer data to improve products, services, and communication fosters customer satisfaction and loyalty.	
9	New Business Models	3%
	• Digital transformation opens opportunities for organizations to create new business models. • Organizations can leverage digital technologies to develop new products, services, or distribution channels. • Creativity and flexibility are essential for adapting and creating successful business models in the digital age.	

Undertaking digital transformation is challenging but can be highly beneficial for organizations if done successfully. Organizations need to understand the relevant issues and plan and execute carefully to fully utilize digital technologies and gain a competitive edge in this digital era.

Research Discussion

The findings from the analysis of interview data resonate strongly with existing academic literature on the challenges and opportunities presented by digital transformation in the steel industry. Legacy Systems and Skills Gaps: The prominence of legacy systems as a challenge aligns with observations made by scholars such as Reis et al. (2020), who highlight the difficulties of integrating outdated systems with new digital technologies. Similarly, the skills gap, as emphasized in the interviews, has been widely recognized as a major hurdle in digital transformation efforts (Kane et al., 2020). Data Management: The importance of data management is underscored by the growing recognition of data as a strategic asset in the digital age (Hartmann et al., 2020). Effective data management enables informed decision-making, process optimization, and the development of new business models. Resistance to Change: The persistence of resistance to change, as noted in the interviews, echoes findings in the literature, which emphasize the importance of change management strategies in successful digital transformation initiatives (Wieder et al., 2020). Efficiency, Product Quality, and Cost Reduction: The prioritization of these goals is consistent with the broader objectives of digital transformation in the steel industry, which include improving operational efficiency, enhancing product quality, and reducing costs (Buyukozkan & Gocer, 2021). Customer Experience and New Business Models: Although mentioned less frequently, the growing recognition of customer experience and new business models aligns with the increasing emphasis on customer-centricity and innovation in the digital economy (Matt et al., 2020). The findings also highlight the interconnectedness of these challenges and opportunities. For instance, addressing legacy systems often requires upskilling employees, while effective data management is critical for achieving efficiency, product quality, and cost reduction goals. The study's results reinforce the importance of a holistic approach to digital transformation in the steel industry. Organizations need to invest in both technological and human capital, foster a culture of innovation and change, and leverage

data-driven insights to achieve sustainable competitive advantage in the digital age. The matrix relationships between context, strategic management, and challenges/opportunities were summarized in Table 2.

Table 2 Matrix Mapping: Context, Strategic Management, Challenges/Opportunities

Context	Strategic Management in China's Steel Industry	Challenges and Opportunities of Digital Transformation	Issue/ Result
Cost Leadership	Focus on achieving cost leadership through economies of scale, process optimization, and low-cost labor.	Digital technologies can streamline supply chains, optimize inventory management, and reduce energy consumption, leading to significant cost savings.	Cost Reduction (8%)
Vertical Integration	Pursuit of vertical integration to control various stages of the value chain.	Legacy systems and infrastructure can pose challenges in integrating new digital solutions.	Legacy Systems (18%)
Technological Innovation	Investment in technological innovation, including advanced manufacturing technologies and new steel products.	The successful implementation of digital technologies requires a workforce equipped with the necessary skills and knowledge, highlighting the skills gap challenge.	Skills Gaps (16%)
Mergers and Acquisitions	Consolidation through mergers and acquisitions to create larger, more competitive companies.	Resistance to change can be a major hurdle for steel manufacturers during digital transformation.	Resistance to Change (14%)
Internationalization	Expansion of global footprint through exports, investments, and partnerships.	Digital platforms and tools can facilitate personalized interactions with customers, enabling steel manufacturers to better understand their	Customer Experience (5%)

		needs and deliver tailored solutions.	
Capacity Control	Government policies to control steel production capacity and promote sustainability.	N/A	N/A
Environmental Sustainability	Adoption of cleaner production technologies and investment in renewable energy sources.	N/A	N/A
Product Diversification	Diversification of product portfolios to cater to evolving market demands.	Digital technologies can open new business models and revenue streams, such as data-driven services and predictive maintenance solutions.	New Business Models (3%)
Digital Transformation	Adoption of digital technologies to improve efficiency, productivity, and decision-making.	Data management and security are crucial aspects of digital transformation, requiring careful handling of vast amounts of data.	Data Management (16%)
Global Trade Tensions & Regulations	Challenges posed by rising trade protectionism and stricter environmental regulations.	N/A	N/A
Domestic Market Saturation	Slowing domestic steel demand growth due to China's maturing economy.	N/A	N/A
Enhanced Efficiency & Productivity	N/A	Digital technologies can optimize production processes, reduce downtime,	Efficiency (12%)

		and improve resource utilization.	
Improved Product Quality	N/A	Advanced analytics and machine learning can enable real-time monitoring and control of production processes.	Product Quality (9%)

From Table 2, This matrix illustrated the intricate connections between the context of China's steel industry, the strategic management approaches adopted, and the challenges and opportunities presented by digital transformation. It highlighted how strategic decisions intersected with the evolving digital landscape, and how these dynamics were reflected in the priorities and concerns of Baosteel employees. The analysis underscored that strategic management approaches in China's steel industry were closely intertwined with the challenges and opportunities of digital transformation. Legacy systems, skills gaps, and data management emerged as significant hurdles that needed to be overcome for successful digital adoption. The primary goals of digital transformation in this sector were identified as efficiency, product quality, and cost reduction. Moreover, the growing importance of customer experience and new business models signaled a shift towards a more customer-centric and innovative approach, even though these aspects were mentioned less frequently. Figure 1 provides a visual representation of these key concepts in the form of a mind map.

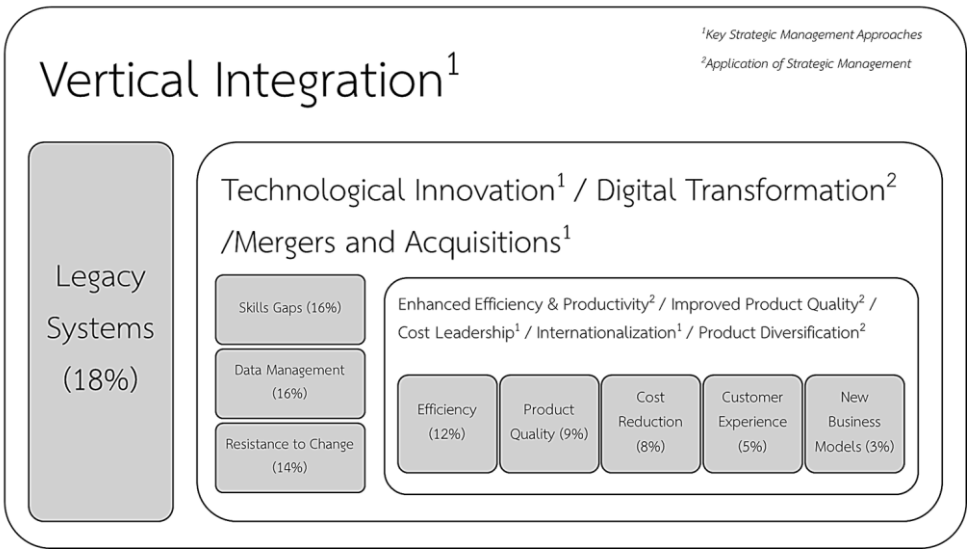

Figure 1. Strategic Management and Challenges/Opportunities.

Research Suggestions

The study concluded that Baosteel's digital transformation had been instrumental in enhancing its competitive advantage within the steel industry. The company's strategic approach, technological innovation, and organizational adaptation enabled it to successfully navigate the challenges and capitalize on the opportunities presented by digitalization. The research offered several recommendations for other steel manufacturers embarking on their own digital transformation journeys. These included developing a clear strategic vision, re-engineering business processes, selecting and integrating appropriate technologies, adjusting organizational culture, and prioritizing data security and compliance. The study also highlighted the importance of continuous iteration and improvement to ensure sustained success in the dynamic digital landscape. Furthermore, the study advised organizations to give balanced and integrated attention to all aspects of digital transformation. Investing in employee skill development and fostering a culture receptive to change were deemed crucial. Effective utilization of data and digital technologies was highlighted as essential for achieving business goals and creating a competitive advantage. Lastly, the study emphasized the importance of providing positive customer experience and developing new business models for long-term sustainability.

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