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The Path and Effect of Digital Transformation in Chemical Enterprises: A Case Study of Wanhua Chemical

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Abstract. Driven by the Digital China Strategy, process industries represented by the chemical industry are currently facing core propositions of safety and controllability, green and low-carbon development, and high-end breakthroughs. Through new-generation information technologies such as the industrial internet and artificial intelligence (AI), digital transformation reconstructs the entire R&D-production-service chain, serving as a key path to address the "bottleneck" dilemma. Taking Wanhua Chemical as a case study, this paper explores the specific path of its digital transformation and evaluates the transformation effect from both financial and non-financial dimensions, aiming to provide practical experience for the digital transformation of chemical enterprises. The study finds that Wanhua Chemical has carried out digital transformation at three levels—foundation, application, and ecology—achieving improvements in financial performance such as operational capacity and growth capacity, while also benefiting from non-financial aspects including organizational structure, R&D innovation, and green and low-carbon development.

Keywords: Digital Transformation, Chemical Enterprises, Wanhua Chemical

1. Introduction

Digital transformation is not only a key strategy to promote the high-quality development of enterprises but also a major driving force to strengthen the construction of a modern industrial system and advance the development of new-quality productive forces. Due to the characteristics of long and complex industrial chains, intensive technology and capital requirements, and strict safety and environmental protection standards, the chemical industry is facing unprecedented challenges. Issues such as bottlenecks in production efficiency, instability in product quality, and low production efficiency have become increasingly prominent [1]. Traditional chemical enterprises urgently need to reconstruct business processes, optimize resource allocation, and improve management efficiency through digital means to achieve a shift from "scale expansion" to "quality leapforward".

Although digital transformation has become a global consensus and industrial trend, the application mechanisms of existing research in different industries still vary significantly, and a theoretical framework with industry characteristics has not yet been formed. On the one hand, research on the path of enterprise digital transformation is relatively scattered, mostly focusing on organizational model digitalization [2,3], production method digitalization [4], and business model

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digitalization [5,6], which makes it difficult to provide effective guidance for enterprises to address complex issues in transformation. On the other hand, regarding the effect of digital transformation, although some studies have confirmed that digital transformation can promote the growth of enterprise value [7,8], most studies only focus on a single research perspective, lacking comprehensive and in-depth analysis of the process and mechanism. Additionally, research targeting specific industries is insufficient, making it difficult to meet the precise needs of different industries in transformation practice. Based on this, this paper takes Wanhua Chemical as the research object, analyzes the practical application path and multi-dimensional effects of its digital transformation, aiming to provide theoretical support and reference for subsequent academic research, and help the academic and industrial circles understand and promote digital transformation practice more deeply.

2. Case introduction

2.1. Enterprise overview

Wanhua Chemical Group Co., Ltd. was founded in 1998 and listed in 2001. It has now become a national strategic scientific and technological force in China's chemical new material field and a global leader in the polyurethane industry. Relying on the core technology of the phosgene-based polyurethane full industrial chain, Wanhua Chemical has built the world's largest Methylene Diphenyl Diisocyanate (MDI) production system, breaking the over 40-year technological monopoly of international enterprises. Its patent quality index has ranked first in China's chemical industry for five consecutive years. In the process of digital transformation, the company has formed a new dual-wheel synergy paradigm of "independent technological innovation and digital intelligence-driven". Its benchmarking practice in independent innovation and digital transformation provides a typical sample for exploring the upgrading path of China's high-end manufacturing enterprises.

2.2. Enterprise digital transformation process

(1). Informatization Foundation Period (2008–2018): In 2008, the SAP ERP system was launched, marking the start of Wanhua Chemical's informatization construction. During this stage, Wanhua Chemical aimed to build a basic information system to support the large-scale development of its business. It expanded from a single production base to a global layout, laying a data foundation for reaching the 100-billion-yuan scale. (2). Standardization and Automation Period (2019–2022): Since 2019, Wanhua Chemical has prepared for the S4 HANA project, benchmarking against world-class standards to build a global standardized process system. In 2021, the S4 HANA project was officially launched. In the same year, Wanhua Chemical's revenue exceeded 100 billion yuan, ranking among the top 20 global chemical enterprises. At the same time, it completed the standardization of core business processes, paving the way for the next stage of transformation and upgrading. (3). Digitalization and Intelligentization Period (2023–2025): Since the implementation of the 2025 Strategy, Wanhua Chemical has continued to deepen its efforts, ultimately achieving comprehensive digitalization and partial intelligentization, and building a data-driven ecosystem. In the future, Wanhua Chemical will gradually build a digital ecosystem featuring the "integration of the four chains", leading the industry's green transformation and supporting its goal of entering the Fortune Global 500.

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3. Drivers of Wanhua Chemical's digital transformation

3.1. Policy promotion

In October 2022, the 20th National Congress of the Communist Party of China clearly stated that accelerating the construction of Digital China is a key strategic focus of national development. In 2023, the Ministry of Industry and Information Technology (MIIT) issued the Work Plan for the Digital Transformation of the Raw Material Industry (2024–2026), which clearly requires chemical enterprises to build industrial internet platforms, realize platform-based safety production supervision, intelligent park management, and industrial chain collaborative optimization. In 2024, the Third Plenary Session of the 20th Central Committee of the Communist Party of China also made specific arrangements for "building a high-level socialist market economic system". The meeting pointed out that it is necessary to give full play to the decisive role of the market in resource allocation while giving better play to the role of the government, with scientific and technological innovation as the guide to promote industrial upgrading and economic structure optimization.

3.2. Industry-driven pressure

Currently, with the in-depth adjustment of the global economic structure and the rapid advancement of the technological wave, the chemical industry is facing numerous challenges. On the one hand, market competition has become increasingly fierce, and product homogeneity is serious. To maintain their competitive advantages, enterprises must improve production efficiency, reduce operating costs, and accelerate the pace of innovation. On the other hand, the complexity and high risk of chemical production require enterprises to achieve more precise and efficient management to ensure safe production and compliant operation. Therefore, chemical enterprises need to change their traditional development models, accelerate the integration of their industries with the digital economy, and optimize various links such as finance, business, and management through the application of digital technologies to achieve all-round optimization and upgrading of chemical enterprises and adapt to the new development needs of the industry.

3.3. Enterprise internal needs

First, core products such as MDI have high process complexity, and pain points such as production energy consumption, material precision, and monitoring and scheduling urgently need to be addressed. The integration of a digital R&D platform helps accelerate innovation. Compared with other international giants, Wanhua Chemical also needs to maintain its global leadership in MDI technology through digital transformation. Second, flexible manufacturing and intelligent supply chain systems can achieve rapid responses to meet customized customer needs, thereby enhancing the recognition of international customers. Third, the traditional three-tier architecture of IT infrastructure will increasingly struggle to support various flexible emerging applications in the future; moreover, the traditional architecture also requires supporting disaster recovery and backup, which will also face many problems. Finally, from the perspective of sustainable development, digital technologies can support the enterprise's Environmental, Social, and Governance (ESG) work, which not only demonstrates the enterprise's environmental responsibility but also actively responds to national calls.

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4. Path of Wanhua Chemical's digital transformation

Digital transformation is a progressive process from building underlying capabilities to applying specific scenarios, and finally realizing business value and strategic goals. As a global leading chemical new material company, Wanhua Chemical's transformation path reflects high strategicity and systematicness. Therefore, this paper sorts out its digital transformation path from three levels: foundation, application, and ecology.

4.1. Foundation layer

At this level, Wanhua Chemical takes "building a global, highly flexible, and intelligent digital foundation" as its strategic goal, and solidifies the foundation for transformation from three aspects: infrastructure, data governance, and talent. In terms of infrastructure, it implements a dual-mode IT strategy, adopts hyper-converged architecture and cloud-native technology, builds a unified cloud management platform covering the globe, integrates multiple data centers and disaster recovery systems, and realizes unified scheduling of IT resources. In data governance, it integrates AI and 5G to build an intelligent prediction model to support business decision-making. Relying on an enterprise-level data lake and Master Data Governance (MDG) system, it promotes data standardization across all business domains. In terms of talent, it establishes an informational team with composite capabilities in IT, professional fields, industry, and management, and gains trust by solving business pain points.

4.2. Application layer

Adhering to the principle of "business-driven and value-oriented", Wanhua Chemical focuses on six platforms—intelligent manufacturing, operation and management, ecological collaboration, collaborative office, AI empowerment, and infrastructure—and reconstructs the entire business process to support global operations.Wanhua Chemical introduces "AI for Science" in R&D, accelerating molecular discovery and reaction optimization through AI;at the procurement end, it builds the industry's first internet procurement ecosystem, realizing "four-order matching" and real-time tracking to improve supply chain collaboration and reduce costs;in production, it gradually achieves the leap from mechanization and automation to intelligent unmanned operation, promoting independent factory operation and accurate early warning;in operation, it builds a global unified ERP system based on S/4 HANA, and improves operational efficiency and risk control level with the help of intelligent tools.

4.3. Ecology layer

Wanhua Chemical regards ecological transformation as a strategic commanding height, and achieves comprehensive transformation by building an open platform, empowering partners, conducting joint innovation, and sharing value. First, it builds an ecosystem collaboration platform, connects multiple types of entities to realize full-process digital collaboration, and establishes an end-to-end business network based on the S/4 HANA system to promote the "integration of the four chains" and form a new chemical e-commerce model. Second, it establishes a carbon footprint tracking system, provides digital prediction and carbon management tools for suppliers, and offers "product + digital service" to customers to reduce their R&D costs. Third, it joins hands with universities, research institutions, and enterprises to form technology alliances and cross-industry ecosystems, sharing transformation experience and innovation resources. At the same time, it builds an internal circular

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economy network, releases ESG reports externally, and realizes a multi-dimensional win-win situation in economy, environment, and industrial resilience through mechanisms such as patent licensing and joint profit sharing.

5. Effect of Wanhua Chemical's digital transformation

This paper selects profitability, operational capacity, and growth capacity as analysis indicators for the financial dimension, and analyzes the non-financial dimension from organizational structure, R&D innovation, and green and low-carbon development.

5.1. Financial dimension

5.1.1. Profitability

First, the net profit margin on sales is selected to analyze profitability, as shown in Table 1. Over the five years, Wanhua Chemical's sales revenue has continued to increase, but its net profit has not shown a continuous upward trend; thus, the net profit margin on sales peaked in 2021 and then declined. Although digital transformation has a positive effect on reducing costs, promoting production, and optimizing inventory, its overall impact on profitability is limited.

Table 1. Profitability indicators of Wanhua Chemical (2020–2024)

	2020	2021	2022	2023	2024
Net Profit (10,000 yuan)	1,041,491.89	2,503,943.07	1,704,190.69	1,829,980.52	1,479,131.37
Sales Revenue (10,000 yuan)	7,343,296.85	14,553,781.76	16,556,548.44	17,536,093.57	18,206,911.92
Net Profit Margin on Sales (%)	14.18	17.20	10.29	10.44	8.12
Net Cash Flow from Operating Activities (10,000 yuan)	1,684,970.60	2,792,229.22	3,633,682.49	2,679,675.26	3,005,343.52

Data Source: Guotai'an Database

Second, the profit cash ratio is selected to measure the profit quality of Wanhua Chemical. The calculated ratios from 2020 to 2024 are 1.62, 1.12, 2.13, 1.46, and 2.03 respectively. Although there are fluctuations, the ratio is greater than 1 and ranks among the industry leaders, indicating that Wanhua Chemical has good profit quality.

5.1.2. Operational capacity

As shown in Table 2, inventory turnover rate, accounts receivable turnover rate, and total asset turnover rate are selected to analyze Wanhua Chemical's operational capacity. It is not difficult to find that Wanhua Chemical's accounts receivable turnover rate has continued to rise for four consecutive years since 2020, fully indicating that its assets have strong liquidity and it has strong short-term debt-paying ability. In 2024, due to weak industry demand, some customers faced cash flow pressure, leading to a turning point in the accounts receivable turnover rate that year.

Wanhua Chemical's total asset turnover rate continued to rise from 2020 to 2022, and began to decline from 2023 to 0.62 in 2024, but it is still higher than 0.55 in 2020. This means that although Wanhua Chemical is under the pressure of declining net profit, it still insists on optimizing resource

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allocation, improving production efficiency, and optimizing inventory management through digital transformation, ultimately achieving steady growth in the overall asset scale and revenue scale.

Table 2. Operational capacity indicators of Wanhua Chemical (2020–2024)

	2020	2021	2022	2023	2024
Accounts Receivable Turnover Rate (times)	11.64	16.83	18.27	19.18	14.80
Inventory Turnover Rate (times)	6.18	5.87	7.60	7.07	6.33
Total Asset Turnover Rate (times)	0.55	0.76	0.82	0.69	0.62

Data Source: Guotai'an Database

The reasonable range of the industry's inventory turnover rate is usually 5 to 10 times. Comparing with Table 2, Wanhua Chemical's inventory turnover rate is generally within the healthy range. In 2022, Wanhua Chemical realized online management of its global sales plan, optimized inventory dynamics, and the intelligent warehouse distribution system effectively reduced inventory costs and significantly improved the inventory turnover rate. In the following two years, affected by the general environment, Wanhua Chemical experienced a slowdown in the inventory turnover of new materials, but it was able to take this opportunity to achieve capacity accumulation.

5.1.3. Growth capacity

As can be seen from Table 3, Wanhua Chemical's growth rate of owners' equity has two decline points. The growth rate dropped significantly in 2022, which was attributed to the high investment costs in the initial stage of digital transformation. The growth rate declined again in 2024, which can be attributed to the dilution effect of Wanhua Chemical's heavy asset investment and the long cycle of return on intelligent investment. The growth rate of 9.58% is a manifestation of the pain period of deepened transformation, rather than a decline in growth capacity.

Table 3. Growth capacity indicators of Wanhua Chemical (2020–2024)

	2020	2021	2022	2023	2024
Growth Rate of Owners' Equity (%)	17.57	38.81	13.45	16.13	9.58
Net Profit Growth Rate (%)	84.84	-15.53	-18.52	-3.50	-25.18

Data Source: Guotai'an Database

It is worth noting that after reaching a high value of 84.84% in 2020, Wanhua Chemical's net profit growth rate remained negative in the following four years. On the one hand, Wanhua Chemical launched the S4 HANA project in 2021, and the project investment period increased costs, affecting short-term profits. On the other hand, in 2024, the chemical industry was severely impacted by external factors, and the efficiency improvement brought by digitalization may have been offset by the market environment. However, in the long run, Wanhua's digital transformation will help enhance its cost control capabilities and operational efficiency, enabling the company to maintain revenue growth and a relatively high profit margin during the industry downturn. With the deepening of project effects in the future, its growth capacity is expected to recover.

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5.2. Non-financial performance

5.2.1. Organizational structure

Digital transformation has changed Wanhua Chemical's organizational structure, promoting a fundamental transformation from a traditional hierarchical system to a data-driven network organizational structure. First, Wanhua Chemical established a digital strategy committee, which uses a digital platform for communication to improve decision-making efficiency. Second, digital business units have replaced traditional business units, and work efficiency has been improved through the S4 HANA system. Finally, the talent structure has transformed from manual technical positions to human-machine collaboration positions, improving employees' digital literacy and helping optimize the personnel structure.

5.2.2. R&D innovation

Wanhua Chemical attaches great importance to R&D innovation and expenses all R&D expenditures, which suppresses short-term profits. As shown in Table 4, Wanhua Chemical has continuously increased its R&D investment over the five years, and the ratio of R&D investment to operating income has remained above 2%, leading domestic peers. At the same time, the number of R&D personnel in Wanhua Chemical has increased year by year, indicating that it continues to attract R&D and innovation talents and enhance innovation vitality.

Table 4. R&D investment of Wanhua Chemical (2020–2024)

	2020	2021	2022	2023	2024
R&D Investment (10,000 yuan)	204,303.96	316,807.04	342,009.21	408,070.93	455,035.79
Operating Income (10,000 yuan)	7,343,296.85	14,553,781.76	16,556,548.44	17,536,093.57	18,206,911.92
Ratio of R&D Investment to Operating Income (%)	2.78	2.18	2.07	2.33	2.50
Number of R&D Personnel (person)	2,771	3,126	3,258	4,079	4,763

Data Source: Guotai'an Database, Wanhua Chemical ESG Reports, and Enterprise Annual Reports

In addition, according to Wanhua Chemical's Sustainability Reports and Annual Reports, Wanhua Chemical filed 757 patent applications in 2020 and 1,220 in 2024. Its patent activities are characterized by three features: high-intensity investment, high-quality output, and global layout.

5.2.3. Green and low-carbon development

On the one hand, through digital transformation, Wanhua Chemical has effectively managed ESG risks and promoted green and low-carbon development. The company has released Sustainability Reports consecutively since 2020 and issued its first ESG Report in 2022. It has won many awards for its practices in technological innovation, green production, and other fields. During this period, Wanhua Chemical realized real-time collection and visual analysis of ESG data through IoT sensing technology, accurately identifying directions for governance improvement.

On the other hand, since 2021, Wanhua Chemical has comprehensively carried out carbon emission management, and the carbon emission intensity per unit product has continued to decline.

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This achievement benefits from the circular economy model and the synergy of the low-carbon industrial chain and ecosystem.

Table 5. Carbon emissions of Wanhua Chemical (2021–2024)

	2021	2022	2023	2024
Total Carbon Emissions (million tCO_2e)	26.89	30.07	32.57	28.03
Carbon Emission Intensity (tCO_2e/t)	1.11	0.96	0.89	0.75
Energy Consumption Intensity (kg ce/t)	144	129	122	133

Note: kg ce/t refers to kilograms of standard coal equivalent per ton. Data Source: Wanhua Chemical ESG Reports and Enterprise Annual Reports

6. Conclusion

As a leading chemical enterprise in China, Wanhua Chemical is gradually transforming from an outstanding chemical company into an innovation organizer and value integrator that takes digitalization as a link to lead and reshape the chemical new material industry ecosystem. The construction and development of its digitalization have not only strengthened its own competitive barriers and sustainability, provided a strong driving force for the upgrading and transformation of the entire industry, but also provided experience and reference for other enterprises. Enterprises should be aware that digital transformation is not a simple stacking of technologies, but requires a comprehensive layout and continuous promotion from a strategic height in combination with their own characteristics. At the same time, digital transformation is not an overnight process; enterprises need determination and patience, continuous trial and error and optimization, and will eventually achieve a leap from quantitative to qualitative change.

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