Industry 4.0 Promotes High-quality Development of Industrial Enterprises Analysis of Business Architecture and Supporting Systems

Xu Ouyang [1, a], Qichao Qiao [1, b], and Jiehao Chen [1, c]

[1] Data Management and Application Research Institute,China Academy of Industrial Internet,Beijing, China.

[a] 17717386647@163.com, [b] a13295690310@163.com, [c] ywxsbjb@163.com

Abstract. This article first starts from the macro trend, and sorts out the essential connotation of high-quality development of industrial enterprises, as well as the development characteristics of industrial enterprises in the Industry 1.0 to 4.0 stage. It systematically analyzes the business architecture, the evolution, and the development of supporting systems for industrial enterprises to move towards the Industry 4.0 stage. Secondly, the eight major sectors of current industrial enterprise business development were discussed, including marketing and sales, demand acquisition, manufacturing, research and development design, procurement management, quality management, logistics supply chain, and after-sales service. Once again, the integration scenarios of the MES system as the central operation center of enterprises, intelligent user demand analysis system as the information source for subsequent processes, and how intelligent logistics promotes the transformation and upgrading of logistics supply chain support systems and businesses were explored. The key role of support systems in reconstructing business architecture, re-engineering core processes, optimizing management models, and improving service quality and efficiency was revealed, demonstrating the work strategy of enterprises to achieve high-quality development through a new decision-making mechanism of "data+algorithm". Finally, through case analysis, it is emphasized that creating business value is the core and original intention of supporting system construction, the transformation and upgrading of industrial enterprises need to be driven by customer needs as the key driver. The high-quality development of enterprises is not only a technological system-level innovation but also a process re-engineering of enterprise business architecture. Industry 4.0 has achieved efficient and intelligent production tools, promoted the iterative upgrading of enterprise production methods, and provided effective support for the high-quality development of enterprises through the effective integration of business architecture and support systems.

Keywords: High quality development; industrial enterprise; Industry 4.0; Business architecture; Support system.

1. Introduction

The Central Economic Work Conference held in December 2023 proposed that "adhering to high-quality development must be the absolute principle of the new era". This assertion is an important understanding of the laws put forward by the Party Central Committee with Comrade Jinping Xi at the core to summarize and guide the practical exploration of high-quality development of China's economy and to deeply grasp the characteristics of China's economic development at different stages, which provides important guidance for doing economic work well in the new era. Enterprises constitute the basic unit of macroeconomic growth and the core component of industrial progress. High-quality economic growth must rely on the high-quality development of enterprises too.

The concept of "Industry 4.0" was introduced at the Hanover Industrial Fair held in Germany in April 2011, and took shape in the report "Ensuring the Future of German Manufacturing: Suggestions for Implementing the" Industry 4.0 "Strategy" published by the German "Industry 4.0" Working Group in April 2013. It has led the development direction of high-end manufacturing worldwide and is a key move for Germany to compete for the strategic high ground of global

manufacturing. After 40 years of reform and opening up, China's economy has entered a critical stage of transformation and upgrading. The transformation and upgrading of industrial enterprises have become an important issue in the development strategies of various countries. From the steam era of Industry 1.0, the electrical era of Industry 2.0, the information era of Industry 3.0, to the current new generation of information technology dominated Industry 4.0 intelligent era, information technology is deeply empowering enterprise business through supporting systems, changing human production methods, and promoting the transformation and upgrading of industrial enterprises from large-scale manufacturing, mass customization to personalized customization.

2. Analysis of Enterprise Business Architecture Adapting to the Development of Industry 4.0

Industry 4.0 creates value for enterprise business through supporting systems. Supporting systems do not simply digitize traditional business, but refer to the use of information technology to reconstruct business processes, optimize management models, improve service quality and efficiency, and help enterprises adapt to rapidly changing market demands and consumer behavior. This creates a new decision-making mechanism of "data+algorithm" and enterprise-level new quality productivity within the enterprise, promoting high-quality development of the enterprise.

According to Figure 1, the basic business process of enterprise operation is formed through the linkage of demand, marketing, research and development, manufacturing, logistics, after-sales, and value realization steps. In the actual operation of enterprises, it is also necessary to consider four aspects: starting from business opportunities and value, achieving external and internal closed loops, setting KPIs(short for Key Performance Indicators) with hierarchical levels, and how to improve business capabilities.

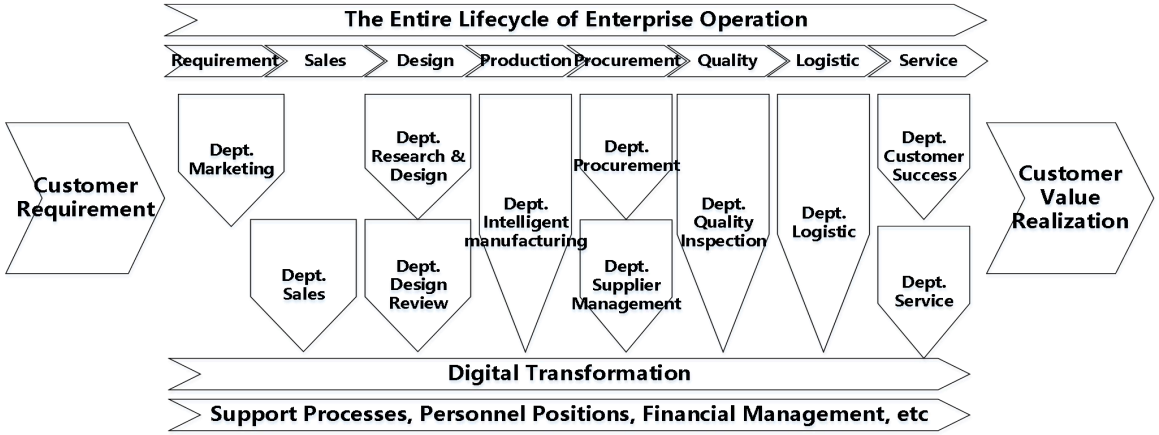

Figure 1. Schematic diagram of the entire life-cycle business process of the enterprise

The first aspect of business processes should start with business opportunities and value. Taking business opportunity prediction in business opportunity management as an example, it needs to be analyzed from the following three points: firstly, possessing multi-dimensional, deep-level, and fine-grained market insight capabilities; The second is the insight ability based on customer classification and grading; The third is the ability to have effective marketing skills to obtain potential customer leads. In terms of the key value points of each business process, taking market insight business analysis as an example, it mainly includes in-depth analysis of the sources of business opportunities, accurate evaluation of the authenticity of the market and customers, and evaluation as an effective basis for enterprise product planning.

The second aspect is that the business process must achieve a closed loop between external and internal aspects. External customer closed loop refers to the circulation of customer demand in departments such as marketing, sales, research and development, design, production, procurement,

supplier ecology, quality management, logistics supply chain, customer success, and customer service, ultimately serving customers to achieve business value. Internal enterprise closed-loop is achieved through supporting elements such as goals, processes, personnel positions, finance, business processes, digital transformation, etc., to support the closed-loop of project, business, organizational, and individual KPIs and provide support for the efficient flow of customer needs.

The third aspect is that the development of business process KPIs is differentiated at a hierarchical level. The first layer is when the enterprise identifies the KPIs; The second layer is the definition and calculation formula of KPIs marked by the enterprise; The third layer is to clarify the logic of KPI data retrieval; The fourth layer is to publicly benchmark peers and clarify one's competitive ability; The fifth layer is to analyze the business capability improvement system behind KPIs, that is, through what kind of capacity building can we do better; The sixth layer is the quantification of KPIs, for example, if the current inventory turnover days are 35 days and compared to the benchmark enterprise's 14 days, a 21-day improvement indicator can be clearly defined.

The fourth aspect is that the key to improving business capabilities lies in the organization and construction of business rules. Clear business rules can ensure the smooth implementation of business value streams with the support of digital tools. For example, when using an ERP system, some companies can generate huge value while others have almost no value. The reason lies in whether the business rules are integrated into the system operation, and whether the system has control points, warning points, and gates for the business.

3. How can support systems empower industrial enterprises to move towards Industry 4.0

The support system explores new paths to empower the business development of industrial enterprises through information technology, to achieve a leap beyond traditional upgrading models. Enterprises need to fully utilize supporting systems for business transformation and upgrading in areas such as user demand analysis, sales and marketing, production implementation, logistics supply chain, after-sales service, and data decision-making. In the entire life-cycle of industrial enterprise operation, production is the core of the enterprise, which can integrate and consolidate the business sectors of the enterprise. As shown in Figure 2, based on the MES system as the central operation of the enterprise, it can help the enterprise achieve order management and cost control, and improve production efficiency. It can also promote the development of lean manufacturing direction, and effectively empower the entire life-cycle business sectors of industrial enterprises such as marketing and sales, demand acquisition, production manufacturing, research and development design, procurement management, quality management, logistics supply chain, and after-sales service. Service enterprises can create new production tools, achieve production efficiency improvement and complex environment response, use the data generated by Industry 4.0 to extract high-value information, and promote enterprises to move from experience decision-making to a new decision-making mode of "data+algorithm".

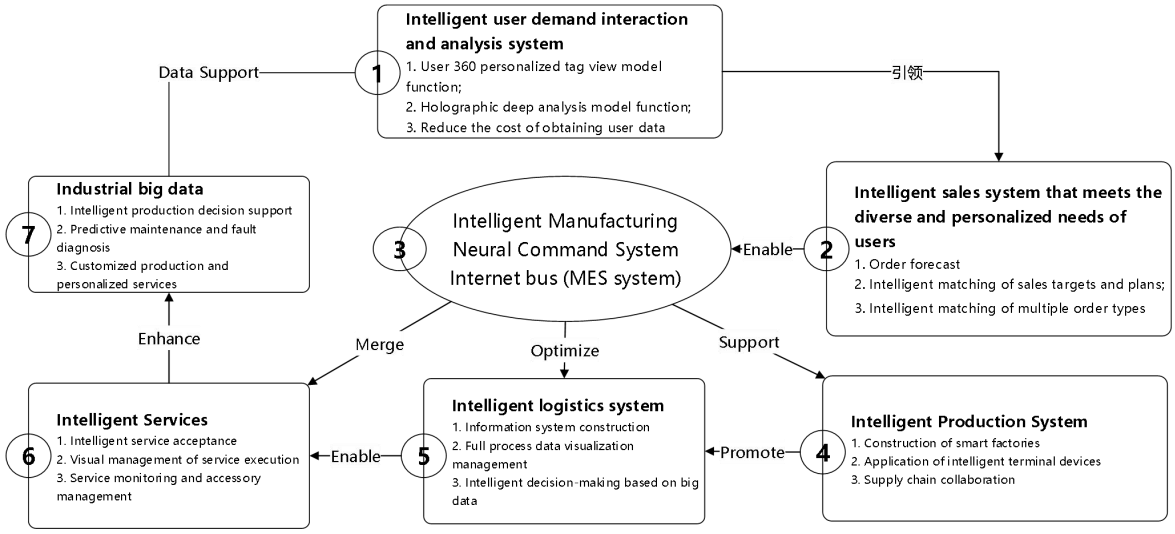

Figure 2. The MES system plays a central role in Enterprise Industry 4.0

3.1 The intelligent user needs analysis system provides a source of clues for subsequent processes

As the customer-facing window of the intelligent sales system, the intelligent user demand analysis system can accurately capture the diversified and personalized needs of users by relying on mobile Internet technology, and can significantly improve marketing accuracy and user satisfaction. This system needs to have a personalized tag view model function for users, to comprehensively collect and process contact data, form a complete customer profile, and through multidimensional data analysis, help enterprises deeply understand customer needs and provide customized services.

3.2 How can sales intelligent systems meet the diverse and personalized needs of customers

Sales intelligence systems play an important role in order forecasting. Accurate order forecasting is crucial for businesses facing complex and diverse market environments. Sales intelligent systems can build high-precision order prediction models, and through multi-dimensional and omnichannel big data analysis, more accurately predict order demand. This predictive ability can enable enterprises to better adjust production plans, optimize inventory management, and thus better meet customer needs.

The sales intelligent system can achieve intelligent matching of various order types, including standardized orders, customized orders, and personalized orders. In the process of Industry 4.0 in enterprises, customers' personalized needs for products are increasing day by day, and traditional sales systems are no longer able to meet them. Industrial enterprises can use sales intelligent systems to intelligently select the most suitable product models, performance requirements, quality requirements, and delivery requirements based on customers' specific needs, achieving intelligent matching of different types of orders, thereby improving the level of product customization and meeting customers' personalized needs.

3.3 How does an Internet-based Manufacturing Execution System become the operation center of enterprises?

The MES system will be the decision-making and control center for enterprises to achieve Industry 4.0. The MES system will be responsible for planning, controlling, and executing the overall production process, with the ability to monitor the production environment in real time, collect data, and dynamically adjust production, achieving a higher level of automation and intelligence. On the front-line production line, it can help industrial enterprises effectively control

production parameters, improve efficiency and product quality, and ensure accurate execution of production plans.

In response to the challenges of diversified and personalized market demands, MES systems support rapid response and adjustment of production lines, real-time transmission, and processing of order information, personalized customization of production processes, and provide full life-cycle support for products from user demand acquisition, virtual space design, intelligent production lines to self logistics distribution. In addition, the MES system also needs to play a role in cost control, by monitoring and refining production costs, helping industrial enterprises to timely explore optimization points, improve resource utilization, enhance profitability, and market competitiveness.

3.4 How to operate the intelligent factory sector based on the MES system

Realizing Enterprise Industry 4.0 requires the construction of smart factories. The smart factory is a highly automated, digitized, and intelligent production model that achieves intelligent management and optimization of the production process through the comprehensive application of advanced manufacturing and information technologies. In smart factories, material positioning, movement, and control systems, various intelligent devices and instruments, quality inspection and traceability systems, core process automation, etc. are all essential elements. The integration and collaborative operation of these elements require unified management support based on the data collection, processing, and monitoring functions provided by the MES system.

The scope of the MES system has expanded from simple production and manufacturing to supply chain collaboration. Imagine a clothing manufacturing factory receiving an instruction from a brand on June 1st to produce 1000 pieces of each of two clothing styles, AB, with a delivery date set for July 1st. The factory focuses on producing two types of clothing, AB, completing tasks on time and in quantity, and shipping before the delivery date. This is the basic production and manufacturing activity. In contrast, the operation mode of "supply chain collaboration" is as follows: during the production period, the manufacturer obtains market dynamics from the brand, A style is hot selling, and inventory is in short supply in mid-June, while B style has poor sales and inventory backlog. Based on this, the manufacturer quickly adjusted its strategy, accelerated the production progress of style A, and delivered it ahead of schedule, while slowing down the production plan of style B and even reducing the order volume, reflecting the collaborative advantages of supply chain information sharing and instant response.

3.5 How intelligent logistics can promote the transformation and upgrading of logistics supply chain

There is significant room for improvement in the transportation efficiency of China's logistics industry. Despite having sufficient resources such as trucks, drivers, and cargo companies, the entire logistics life-cycle is largely driven by communication and coordination between natural persons, resulting in low overall logistics transportation efficiency. Therefore, in terms of improving transportation efficiency, the application of intelligent logistics systems has become crucial.

To improve transportation efficiency, the intelligent logistics system needs to create multiple functions, including system-based warehousing management of raw materials and components, real-time monitoring and automatic deployment of material status, real-time supply under time series scheduling conditions, as well as automatic shipment and warning functions. The implementation of these functions cannot be separated from the big data analysis model of intelligent logistics systems, and accurate analysis of data is the key to improving transportation efficiency. Therefore, in the development and application of intelligent logistics systems, improving data quality, and strengthening data management and analysis are of great significance for improving transportation efficiency.

3.6 How intelligent services can promote the transformation and upgrading of after-sales service

Information technology helps after-sales service systems achieve an intelligent management system throughout their entire life cycle, from service acceptance to settlement. In the service acceptance stage, traditional call centers should be replaced by user interaction centers. Users can interact with enterprise service platforms through various channels such as WeChat, client, and web, thereby improving user feedback efficiency; During the service execution phase, the product usage information is transmitted back to the enterprise service platform through intelligent chips and networks, enabling proactive warning and remote maintenance. At the same time, the enterprise service platform utilizes IoT technology, intelligent terminal devices, and other technologies to provide visual services such as remote diagnosis, repair, and maintenance; During the service monitoring phase, the enterprise service platform collects various types of data, extracts the best matching points between user needs and service quality through big data models, and locks in the optimal matching strategy between services and costs; In terms of accessory management, industrial enterprise service platforms should cover functions such as accessory procurement, inventory management, and supply chain collaboration to ensure timely supply and efficient use of accessories; As the final step, service settlement is achieved through cloud-based automatic settlement on industrial enterprise service platforms, shortening service cycles and reducing manual error rates.

3.7 The positioning and value of industrial big data models in enterprise Industry 4.0

The industrial big data model relies on massive industrial data and extracts valuable information through collection, storage, processing, analysis, data mining, and machine learning algorithms. It has the following five values. One is production decision support, which optimizes production processes, improves efficiency and product quality through real-time monitoring and analysis of production data, and reduces operating costs for enterprises; The second is predictive maintenance and fault diagnosis, which monitors and predicts the status of equipment and production through data analysis of equipment operation, prevents faults, reduces downtime and maintenance costs, and improves customer satisfaction through control of product quality and service level; The third is customized production and personalized services, utilizing big data technology to analyze customer needs and market trends, and then carrying out targeted production and services to enhance product competitiveness, improve enterprise innovation capabilities, and differentiate competitive advantages; The fourth is intelligent management of the supply chain. Industrial big data models can comprehensively monitor and analyze various links in the supply chain, helping enterprises reduce inventory costs, improve inventory turnover, and enhance supply chain response speed and flexibility; The fifth is product innovation and differentiated competition, based on data analysis results to explore market opportunities, promote continuous innovation of enterprises, warn potential risks, and help enterprises achieve sustainable development.

4. Case analysis of Industry 4.0 promoting high-quality development of industrial enterprises

4.1 The intelligent user needs analysis system provides a source of clues for subsequent processes

According to the research results on the development of an industrial enterprise, its support system covers areas such as marketing, sales, production, logistics, and after-sales, including ERP, MES, PDM, PLM, and SRM, as well as human resources and financial systems. When the management views data, they need dedicated personnel from each department to retrieve, verify, and modify it from the support system. Due to differences in data statistical rules between different systems, more than 25% of the office staff will be involved in these data processing tasks.

Therefore, it seems that every business node has a supporting system, but the cost of data analysis remains high, and there is a lack of ability for forecasting, in-process control, and post-analysis.

The reason for analyzing this phenomenon is that before deploying the support system for business nodes, the mechanism analysis at the business level was not completed, and the enterprise organization was not fully matched with the business. Therefore, most of the support systems implemented by enterprises are led by the IT department, and the business department is not aware that they are the masters of the system. Due to the low status of the IT department within the enterprise, the head of the IT department has not been able to enter the executive team and cannot closely integrate business processes, development goals, and support systems, resulting in the enterprise investing a large amount of funds, but the support system has not played a key role in empowering the business. Therefore, the promotion of Industry 4.0 requires creating value through service business as the basic premise, otherwise, it cannot provide support for the high-quality development of industrial enterprises.

4.2 Customer demand drives industrial enterprises to accelerate transformation and upgrading

The transformation of industrial enterprises towards Industry 4.0 relies on the coordinated optimization of the entire chain of "production sales consumption". Its internal driving force comes from the digitalization process of the customer consumption market, and the improvement of the online and data-driven level of the customer consumption side, which has an increasingly significant reverse effect on the upstream industry. By 2023, the exposure rate of digital reading methods will continue to grow to 80.3%, leading to profound changes in production processes such as "printing and publishing", and digital publishing and online distribution will become popular. According to a report by iResearch Consulting, the online retail sales of clothing, shoes, hats, needles, and textiles in the textile and apparel industry accounted for 22.6% in 2022. This trend has created a strong driving force for the transformation of upstream manufacturing, promoting the widespread deployment of flexible production lines within clothing manufacturing enterprises, reducing production cycles, and iteratively updating production processes and equipment.

For many industrial enterprises serving B-end customers, the practice of Industry 4.0 focuses more on supply chain collaborative optimization, and its driving force is still rooted in changes in downstream customer demand. The rise of intelligent devices and products, such as the cloud-based transmission of product data through built-in sensors, reflects the urgent demand for data sharing and analysis applications in the market. From this, it can be seen that only when downstream customers demonstrate clear needs and an open attitude towards Industry 4.0, can industrial enterprises be effectively stimulated to transform from concept to practice towards Industry 4.0, serve the effective use of digital technology by enterprises, and promote the high-quality development of industrial enterprises.

5. Conclusions

The transition of industrial enterprises towards high-quality development is a systematic and complex process. Industry 4.0 has constructed a feasible path through multidimensional changes in business architecture and deep integration of supporting systems. In terms of business architecture, every aspect of the enterprise's entire life cycle, including marketing, sales, and production, needs to adapt to new market demands and production models, achieving refined management and efficient collaboration across all stages. The support system is a key driving force for business development, such as the MES system becoming the central hub of enterprise operation, intelligent user demand analysis system, intelligent after-sales service system, etc. Communication empowers enterprise business development. In addition, in the process of promoting high-quality development through Industry 4.0, industrial enterprises need to pay attention to the full integration of business

architecture and supporting systems to avoid the occurrence of "digitalization for the sake of digitalization". Only by organically integrating business architecture and supporting systems can industrial enterprises achieve Industry 4.0, thereby creating enterprise-level new quality productivity and achieving high-quality development in the digital economy era.

References

[1] Basic Concepts of Industry 1.0, 2.0, 3.0, 4.0 [J]; Standardization and Quality in the Mechanical Industry; December 2015 issue

[2] Ma Ben, Ye Zimeng, Yang Yuexi Chinese path to modernization and the Fourth Industrial Revolution: Risks and Countermeasures [J] Journal of Shandong University: Philosophy and Social Sciences Edition, 2023 (1): 9

[3] Wei Xiaodong The first lecture of "Industry 4.0 and Integration of Industrialization and Informatization" is about the Industrial Revolution and Industry 4.0 Automation Expo, 2015 (11)

[4] Li Jun, Qiu Jun, come and rain The Current Status and Development Strategies of Business Integration in the Digital Transformation Process of Industrial Enterprises [J] China Science and Technology Forum, 2019 (7): 6

[5] Chi Wanjun, Zhao Jie, Li Lianping, etc Research on the Ideas and Methods of Digital Transformation of Industrial Enterprises [J] Metallurgical Equipment Management and Maintenance, 2023, 41 (2): 56-58

[6] Xiao Jinghua Cross system digital transformation and management adaptability Change of enterprises [J] Reform, 2020 (4): 13

[7] Ren Guangqian, Lai Huanfeng, Zhao Lefan Environmental Regulation, Digital Transformation, and Green Technology Innovation: Data Analysis from Chinese Industrial Enterprises [J] Journal of Beijing Institute of Technology (Social Sciences Edition), 2024, 26 (3): 28-42. DOI: 10.15918/j.jbitss1009-3370.2024.1292

[8] Cheng Liwei Intelligent networking and enterprise digital transformation [J] Industrial Economy Forum, 2019, 000 (001): 84

[9] Bai Jun Five Steps for Digital Transformation of Small and Medium-sized Manufacturing Enterprises [J] China Industrial Review, 2018 DOI: CNKI: SUN: GYPL. 0.2018-04-010

[10] Huang Sujian, Xiao Hongjun, Wang Xinguo The connotation, characteristics, and implementation path of high-quality development of state-owned enterprises [J] China Industrial Economy, 2018 (10)

[11] Mu Hongzhi The 21st National Reading Survey released a slight increase in comprehensive reading rate China Publishing and Media Business Daily, 2024 (4)

[12] IResearch Consulting (2024). 2022 China Clothing Supply Chain Industry Research Report [R] Beijing: iResearch Consulting: 10