From "Manufacturing" to "Intelligent Manufacturing": The Transformation of Value Logic in Future Industries

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Abstract: This article systematically explores the industrial paradigm revolution from traditional "manufacturing" to future "intelligent manufacturing", focusing on the fundamental changes in the value logic behind it. The study points out that the traditional manufacturing paradigm is centered on economies of scale and linear value chains, and value creation relies on the standardized production of tangible elements and cost control; The emerging "intelligent manufacturing" paradigm, with data, algorithms and computing power as key production factors, drives the value logic towards economies of scale, ecological synergy and meaning creation. By constructing a three-dimensional analytical framework of "source of value creation - path of value realization - way of value capture", the article reveals the essential differences between the two paradigms and elaborates in depth on the intrinsic connections among the three core pillars of data-driven, intelligent interconnection and people-oriented under the "intelligent manufacturing" paradigm. Further, the study dissects the underlying mechanisms of value logic from "linear" to "network", from "product-centered" to "user-centered", and from "solidified" to "emergent". Finally, the article offers insights from three dimensions: industrial policy, corporate strategy, and individual development, providing a systematic theoretical lens and practical reference for understanding the essential characteristics and development directions of future industries.

Keywords: Future Industries; Value Logic; Smart Manufacturing; Paradigm Shift; Innovation Ecosystem

1. Introduction

We are at a historical juncture where the industrial paradigm is undergoing a fundamental transformation. The leap from "manufacturing" to "intelligent manufacturing" is not just an iteration at the technical level, but a systematic reconstruction of the future industrial value logic. The manufacturing era, marked by mass, standardization and assembly lines, has greatly promoted the prosperity of human material civilization. The core logic of its value creation lies in maximizing profits in the established value chain through efficiency improvement and cost control[1], which has greatly promoted the accumulation and inclusiveness of human material wealth. However, with general-purpose technologies such as artificial intelligence, big data, the Internet of Things, and cloud computing achieving cluster breakthroughs and deep penetration into the industrial fabric[2], a new paradigm of "Intelligent Manufacturing" with "intelligentization" at its core emerged. It is reshaping the boundaries of industries with unprecedented breadth and reconstructing the global industrial competition pattern with unprecedented depth.

"Smart manufacturing" is far more than just a technological upgrade or an increase in automation in the manufacturing process. It represents a profound transformation of the core of the industry, a revolution concerning the underlying logic of value creation. If the core of the "manufacturing" era is "the large-scale processing of the physical world", then the core of the "intelligent manufacturing" era is "the intelligent creation of the data world". The former focuses on how to transform raw materials into products more efficiently, while the latter focuses on how to dynamically perceive, respond to and even create demands through data and intelligence, and thereby organize the production and innovation resources of the entire society.

Therefore, the core argument of this paper is that the technological revolution of future industries will not trigger a superficial technological evolution from "manufacturing" to "intelligent manufacturing", but a comprehensive change in value logic. This transformation encompasses a series of fundamental issues such as the core elements of value creation, the organization of value production, and the fundamental principles of value distribution. Clarifying the intrinsic mechanism of this change in value logic is of indispensable theoretical guidance and practical reference value for the country to seize the global high ground of future industries, for enterprises to reconstruct the core competitiveness moat, and for individuals to adapt to future intelligent working scenarios.

There are many discussions in the existing literature on the technical aspects of intelligent manufacturing, but there is a lack of systematic theoretical integration and interpretation of the economic and sociological implications behind it, especially the fundamental reshaping of the value logic. This paper attempts to make up for this research deficiency by constructing a comprehensive theoretical analysis framework to deeply analyze the internal structure and driving forces of this historic change.

2. Literature Review

2.1 Evolution of Industrial Paradigms: The Theoretical Foundation from "Manufacturing" to "Intelligent Manufacturing"

Research on the traditional "manufacturing" paradigm has mostly focused on economies of scale and value chains. The value chain model proposed by Porter (1985)[1] is a classic theory in this field. He refers to the entire production process that integrates different production links of different enterprises as the value chain. This model analyzes the business activities of enterprises and discovers the value-added of products at different stages from production to end-user consumption. He believes that the value creation of manufacturing enterprises follows a linear chain from research and development to service, and the core of the enterprise strategy lies in optimizing each link of the chain through specialized division of labor and process reengineering to maximize static efficiency. This view has been endorsed by many scholars, and further studies have pointed out that under the traditional manufacturing paradigm, value creation mainly relies on the input of traditional production factors such as capital, labor, and land, while knowledge and technology are mostly materialized in equipment and processes, and their role is limited to improving the efficiency of the established production function[3].

However, with changes in the market environment, the limitations of the traditional manufacturing paradigm have become increasingly apparent. The "smile curve" theory points out that manufacturing enterprises are often locked in the processing and assembly links with the lowest added value, facing problems such as compressed profit margins and sluggish market responses[4].

In recent years, with the cluster breakthroughs of general-purpose technologies such as artificial intelligence[5], big data and the Internet of Things, the "intelligent manufacturing" paradigm has become the focus of industrial research. Many scholars believe that "intelligent manufacturing" is far from a technological upgrade or an increase in the degree of automation of the manufacturing process, but rather a profound transformation of the industrial core, representing a new underlying logic of value creation[6]. Some scholars also stress that data and information have become new key production factors in the "intelligent manufacturing" paradigm, and the core source of value creation lies in extracting insights from data, forming intelligence, and achieving economies of scale and learning effects through algorithmic iterative optimization[7].

The value co-creation theory proposed by Prahalad & Ramaswamy (2000)[8] provides important theoretical support for the value realization path of the "intelligent manufacturing" paradigm. They believe that in the "intelligent manufacturing" era, value is no longer sequentially added along the linear value chain, but is co-created in a dynamic network composed of multiple subjects such as enterprises, users, and partners, and the value realization path presents non-linear, parallel, and feedback-driven characteristics. Vargo & Lusch (2004) [9]further pointed out that under the "intelligent manufacturing" paradigm, it emphasizes the co-creation of value by enterprises and customers, and the mutual value creation among value co-creators through shared institutional arrangements and service exchanges is an interactive and resource integration process.

The concept of "Prosumer" proposed by Alvin Toffler in "The Third Wave" has also been further developed in the study of the "intelligent manufacturing" paradigm. Scholars believe that in the era of intelligent manufacturing, users are no longer passive recipients of value but become active value creators through feedback, creativity, and even participation in design. Deep value co-creation involving users is one of the important features of the intelligent manufacturing paradigm[10][11].

2.2 Value Logic Dimension: A Comparative Study of "Manufacturing" and "Intelligent Manufacturing"

2.2.1. Source of value creation: From tangible elements to data intelligence

The traditional manufacturing paradigm focuses on tangible elements and economies of scale, while the intelligent manufacturing paradigm shifts to data elements and intelligent algorithms. There is a broad consensus in existing research on this shift, but there are still differences among scholars in exploring the specific mechanisms. Some scholars emphasize the "new oil" attributes of data, arguing that its shareability, non-exclusivity, replicability and increasing marginal benefit make it a driving force and key support for the intelligentization of manufacturing[12]; Some scholars, however, focus more on the synergy of data with algorithms and computing power, arguing that only through deep analysis of data by algorithms and efficient support for data processing by computing power can the value transformation of data be truly achieved and a new architecture of intelligent productivity be formed[13][14].

2.2.2 Path to value realization: From linear chains to network collaboration

The linear value chain model of the traditional manufacturing paradigm dominated industrial research for a long time, but with the rise of the "intelligent manufacturing" paradigm, more and more scholars are beginning to focus on the construction of the network value field. Research shows that value realization under the "intelligent manufacturing" paradigm relies on platforms and ecosystems to achieve immediate on-demand allocation of resources and pursue the dynamic adaptability and innovative vitality of the network as a whole. As an important carrier of the network value field[15][16], the role of the industrial Internet platform in connecting a vast number of devices, developers and users to form an innovative "value field" has been supported by numerous empirical studies[17], such as the Nanjing Changan Automobile Customization Factory, which has achieved instant free switching among more than 3,000 personalized customization solutions through the "Super Brain" Internet of Things platform.

The rise of the C2B (Customer-to-Business) model and the application of digital twin technology represent significant innovations in the value realization path of the "intelligent manufacturing" paradigm. The C2B model takes user demand as the starting point to trigger production, achieving "production based on sales" or even "personalized customization", and changing the value realization path from Push to Pull[18]; Digital twin technology, by mapping physical entities to a virtual space for simulation, testing and optimization in the digital world, greatly reduces the cost of innovation trial and error and accelerates the cycleof value creation [19].

2.2.3 Ways to capture value: from product transactions to services and ecosystems

Under the traditional manufacturing paradigm, companies mainly capture value by selling physical products and through limited monopolies built by patents and brands, with profits mainly coming from product differentials and market share. In the "smart manufacturing" paradigm, there is a significant change in the way value is captured. Scholars point out that the key to enterprise value capture in the "intelligent manufacturing" era lies in control of core data, algorithms, interfaces and network relationships, and continuous revenue by providing subscription services, solutions and operating platform ecosystems[20][21].

2.3 Technology Enablement Mechanism: The Core Role of AI in "Intelligent Manufacturing"

2.3.1. Technology empowerment: The leap from Automation to cognitive intelligence

As the core technology underpinning of the "intelligent manufacturing" paradigm, the enabling mechanism of artificial intelligence is a key area of existing research. In automotive manufacturing, metallurgy and other fields, the application of artificial intelligence has achieved remarkable results[22]. The specific application mechanisms of artificial intelligence technologies such as deep learning, machine vision, and edge computing in "intelligent manufacturing" have been studied in depth[23]. Deep learning algorithms break through the linear boundaries of traditional production functions and open up a new paradigm[24] of intelligent production driven by both data and knowledge. Intelligent perception systems built with machine vision and edge computing enable quantum-level precise control of the production process. The combined application of these technologies is driving the deep transformationof manufacturing from "mechanical execution to" autonomous decision-making "[25].

2.3.2 Element aggregation: The synergistic resonance of data, algorithms, and computing power

The key to AI-enabled manufacturing lies in the deep integration and synergy of the three core elements: data, algorithms, and computing power. Research shows that the integration of these three elements with manufacturing can empower productivity terminals to build a closed-loop system from perception to decision-making and from generation to feedback, achieving a leap from "human-machine collaboration" to "machine-machine co-intelligence"[26].

In terms of data, "intelligent manufacturing" has achieved leaps in three levels - collection density, processing depth, and circulation breadth - through the elementization of data, breaking through the limitations of traditional manufacturing data usage remaining at the post-event analysis level such as statistical reports[27][28]; In terms of algorithms, swarm intelligence algorithms enable devices to negotiate autonomously to form a "decentralized" elastic production network, and edge computing and real-time algorithms compress control cycles from minutes to milliseconds; In terms of computing power, the computing power architecture of "intelligent manufacturing" is trending towards marginalization, heterogeneity and networking, evolving from "centralized computing" to ubiquitous "cloud-edge-device collaboration".

2.3.3. Organizational evolution: From bureaucracy to platformization and networking

The deep application of artificial intelligence has not only reshaped manufacturing processes, but also driven the evolution of manufacturing organizational forms. The traditional bureaucratic structure, with its long decision-making chain and low efficiency, has become difficult to adapt to the demands of the "intelligent manufacturing" era. Scholars believe that manufacturing organizations under the "intelligent manufacturing" paradigm are evolving from vertical integration to flat, modular intelligent ecosystems, and resource allocation is moving from centralization to multi-node autonomy. The platform plays a key role in organizational evolution. It is not only an interface for information aggregation and distribution, but also a value hub for multi-agent collaborative evolution. The scope of collaboration expands from adaptation among internal enterprise processes to ubiquitous connections upstream and downstream, across regions and across industries.

Although existing research has extensively explored the technical architecture and application cases of intelligent manufacturing, there is still a lack of an integrated theoretical framework for the reconstruction of the value logic system behind this transformation. In this context, this paper constructs a three-dimensional analytical framework of "value creation source - value realization path - value capture method", systematically revealing the mechanism of value logic transformation from "manufacturing" to "intelligent manufacturing", making up for the deficiencies of existing research.

3. Theoretical Framework: A Three-dimensional Analysis of Value Logic

To systematically dissect and explain the fundamental changes in value logic accompanying the industrial paradigm revolution from traditional "manufacturing" to future "intelligent manufacturing", this paper constructs a theoretical analysis framework consisting of three core dimensions. The three dimensions - the source of value creation, the path to value realization, and the way of value capture - are interrelated and nested with each other, jointly outlining the distinct maps of value generation and distribution under the two paradigms. This framework aims to penetrate the technical surface and delve into the underlying logic of the relationship between the economy and society, providing a structured theoretical lens for understanding this paradigm revolution.

3.1 Sources of Value Creation: From the Scale Aggregation of Tangible Elements to the Ecological Emergence of Data Intelligence

The source of value creation answers the fundamental question of "where does value come from?" Under different paradigms, there are essential differences in the core factors of production and mechanisms of action that drive value growth.

In the traditional manufacturing paradigm, the core source of value creation depends on the input and combination of tangible production factors such as capital, labor, and land as defined by classical economics. The dominant logic is economies of scale, that is, by expanding the scale of production and reducing the average cost per unit of product, a greater profit is obtained at a given market price. The "value" here is mainly condensed in the standardized physical product. Knowledge and technology are certainly important in this paradigm, but their role is often auxiliary and materialized. They are embedded in machines and equipment, production processes and management regulations, and their core function is to optimize and enhance the efficiency of a "production function" that is regarded as relatively stable or linearly improved. For example, a technological upgrade of an automotive assembly line that aims to produce the same type of vehicle faster, with less material consumption and a lower defect rate. The pattern of value growth is arithmetic-series, diminishing marginal returns, as it mainly relies on incremental optimization of known factors of production and expansion of external markets. The core of an enterprise's competitiveness lies in delivering pre-defined, functionally stable products on a large scale at a lower cost and with higher efficiency.

The "intelligent manufacturing" paradigm marks a qualitative change in the source of value creation, which is reflected in the economies of scope and learning effects of data elements and intelligent algorithms. Data and information, along with the algorithms and computing power that process them, constitute new, critical factors of production. The core of value creation is no longer just the efficiency of processing the physical world, but the ability to extract insights from data, form intelligence, and use that intelligence to dynamically respond and even create demand. The core mechanism has shifted from economies of scale to economies of scope and powerful learning effects. Economies of scale mean that the same set of data bases, algorithmic models, and intelligent infrastructure can be reused at low cost and high efficiency to meet diverse, personalized, and even rapidly changing market demands. For example, a well-trained predictive maintenance algorithm model can be adapted to thousands of different types of equipment in a factory without having to develop a new maintenance system for each type of equipment. The learning effect is reflected in the fact that the feedback data generated during the operation of the system continuously "feeds back" to the algorithm model, enabling its decision-making and predictive capabilities to continuously iterate and optimize, forming an augmented loop where the more data there is, the smarter the model, the more efficient or better the experience, and then more data is generated. This value growth pattern is geometrically progressive and has the potential for network effects and increasing marginal benefits.

Looking further, the data element itself is non-exclusive, shareable, replicable and extensible in value, which breaks the traditional scarcity constraints of tangible elements. Value is no longer confined to end products but continues to emerge in the flow, integration of data and the iterative cycle of intelligent algorithms. Therefore, value creation under the "intelligent manufacturing" paradigm is a dynamic, open process that is constantly generated within the ecosystem.

3.2 Value Realization Path: From the Optimization of Linear Value Chains to the Synergy of Network Value Fields

The value realization path focuses on "how value is constructed and delivered," which reveals the organizational form and collaborative approach of economic activities.

Manufacturing Paradigm: Vertical integration and sequential addition of linear value chains. The value chain model proposed by Michael Porter (1985) is the most classic portrayal[1] of the traditional manufacturing paradigm. Value is seen as a process added in sequence along a series of linear, separate links such as R&D - design - procurement - production - marketing - distribution - service. Each link contributes a portion of value to the final product, and it also incurs corresponding costs. The optimization strategy under this path focuses on specialization and process reengineering, aiming to reduce internal losses at each link of the chain and delays in cross-link connections, in pursuit of static efficiency throughout the chain. The core of the enterprise strategy is to occupy a favorable position on this linear chain, or to establish an advantage at a certain link through cost leadership and differentiation. Information flows, logistics, and capital flows basically follow a one-way, sequential flow pattern. This structure, though clear and manageable, has led to slow response, high inventory, and a structural predicament where the value revealed by the "smile curve" is largely accumulated in a few links such as brand and R&D, while the manufacturing link itself has meager profits.

Intelligent manufacturing paradigm: Parallel co-creation and dynamic adaptation of Network value fields. The "intelligent manufacturing" paradigm completely breaks the linear pipeline logic, and value is created and realized in a dynamic value network or value field composed of multiple subjects such as enterprises, users, suppliers, partners, and even competitors. This network is mainly organized in the form of platforms and ecosystems. The value realization path thus presents non-linear, parallel, feedback-driven characteristics. For example, on industrial Internet platforms, massive device data, developers' algorithm models, and users' usage feedback can interact in real time. A personalized demand from an end-user can instantly trigger fine-tuning of the design, reconfiguration of the supply chain, and flexible scheduling of the production line, with multiple links starting up in parallel and working together. Value is no longer a sequential "addition", but rather a "co-creation" and "emergence" in the connection and interaction of nodes in the network. The optimization goal is no longer a single static efficiency, but the dynamic adaptability, resilience and innovative vitality of the entire network. The C2B model, manufacturing on demand, is a typical example of this path, where value flows shift from the traditional "push" model to the "pull" model that starts with user demand. Digital twin technology plays a key role in this path by building a mapping of physical entities in a virtual space for simulation, testing and optimization, which greatly reduces the cost of trial and error in the real world and accelerates the cycle from idea to value.

3.3 Value Capture Methods: From Monopolies of Ownership in Product Transactions to Control of Access Rights in Service Ecosystems

The value capture approach addresses "how value is measured and transformed into revenue," which reflects the essence of the business model and the principles of profit distribution.

Under the manufacturing paradigm, product transactions and limited monopolies based on property rights. Businesses mainly capture value by selling ownership of physical products. Profits mainly come from product price differentiations and market share. In addition, limited monopolies built through patents, Copyrights and trademarks are important means for companies to maintain premiums, prevent imitation and protect the value of their innovations. The logic of value distribution is relatively clear, mainly based on the negotiating position and power structure of each participant in the linear value chain. Workers' remuneration is usually linked to the amount of standardized labor they put in. Customer relationships in this model are often one-off or long-cycle transactions, and the completion of a transaction often means the fundamental end of the value exchange. Corporate financial statements are highly focused on product sales revenue, gross margin and inventory turnover rate.

Under the "smart manufacturing" paradigm, service subscriptions, solutions and ecosystem synergy. The way value is captured has undergone a profound transformation, with the core feature being the shift from "ownership" to "usage rights" and from "one-time easy" to "continuous service". Businesses are increasingly generating sustained, recurring revenue by offering subscription services, pay-as-you-go, operating solutions, and managing platform ecosystems. The key to value capture is no longer just having physical assets or product designs, but having control over core data assets, key algorithmic models, system interfaces, and network relationships. Mastering the core architecture and rules of the platform means mastering the dominance of value distribution. For example, for an intelligent equipment manufacturer, its profits may no longer mainly come from equipment sales, but from subscription fees for predictive maintenance services based on equipment operation data, as well as fees or commissions charged for opening up the platform API to third-party developers. In this model, the customer relationship transforms into a long-term, service-oriented partnership. Value is closely linked to the continuous utility that customers obtain, the increase in productivity, and the improvement in experience. Correspondingly, companies' profit models and valuation logics have changed, with a greater focus on metrics such as recurring revenue, customer lifetime value, and the strength of network effects.

Overall, the three dimensions of the value logic form an intrinsically consistent and mutually reinforcing whole. In the "intelligent manufacturing" paradigm, data intelligence, as a new source of value, requires networked collaborative organizations and implementation paths to unlock its potential, and this collaborative co-creation process naturally leads to a value capture approach based on services and ecosystems. Conversely, the pursuit of service and ecosystem value will encourage enterprises to connect nodes more extensively, accumulate data, and optimize algorithms, thereby further enriching the sources of value creation.

The three-dimensional analysis framework clearly shows that the shift from "manufacturing" to "intelligent manufacturing" is by no means a partial, technical improvement, but a systematic, reconstructive revolution involving production factors, organizational forms, business models and distribution principles. It lays a solid theoretical foundation for our in-depth understanding of the three core pillars of the "intelligent manufacturing" paradigm to be expounded in the next chapter, as well as the underlying mechanism of the value logic to be explored later.

4. The Value Logic of the Traditional Manufacturing Paradigm: An Efficiency-oriented linear World

Before delving into the revolutionary nature of the "intelligent manufacturing" paradigm, it is necessary to systematically deconstruct the traditional cornerstone on which it transcends - the "manufacturing" paradigm centered on efficiency. This paradigm was established amid the roar of the Industrial Revolution and reached its peak in the 20th century. Its value logic, like a precise and straight conveyor belt, profoundly shaped the industrial landscape, corporate strategy, and social structure that lasted for two centuries.

4.1 Core Source: The Ultimate Pursuit of Economies of Scale and Cost Control

Value creation in the traditional manufacturing paradigm is rooted in an infinite pursuit of economies of scale. The core assumption is that the average cost per unit of product will continue to decline as output increases. This logic drives enterprises to view the large-scale input and efficient combination of tangible factors of production such as capital, labor, and raw materials as the only way to create value.

On the one hand, Fordism and Taylorism materialized the philosophy of efficiency. This source is most vividly embodied in Fordism and Taylorism. Henry Ford revolutionized the production process by breaking down the complex car manufacturing process into countless simple, repetitive steps through a mobile assembly line. Frederick Winslow Taylor, through time and motion studies, attempts to find the "one best way" for each labor task, viewing the worker as an optimizable and replaceable "part" in the production system. The common goal of both is to shape the production process itself into a huge and precise machine, to obtain every bit of potential efficiency through standardization, specialization and division of labor, and to push cost control to the limit. Value is defined here as a standardized physical product that is produced at the lowest cost and the highest speed.

On the other hand, the dilemma of the "smile curve", the structural imbalance of value. The extreme pursuit of economies of scale and cost control also lays the groundwork for paradigmatic limitations. The "smile curve" theory proposed by Mr. Stan Shih, the founder of Acer Group, profoundly reveals the value distribution structure under the traditional manufacturing paradigm. On this curve, the high value-added links are located at the two ends of R&D design and brand marketing and after-sales service, while the middle part of processing and assembly manufacturing is trapped in the lowest profit margin. Manufacturing companies are often "locked" in this low value-added area by powerful economies of scale, trapped in brutal homogeneous price competition. They bear huge fixed asset investment, management costs and market volatility risks, but struggle to share the major profits along the value chain. This is not the mismanagement of individual enterprises, but the inevitable result of the simplification of the source of value creation and the solidification of the structure of value distribution under the linear paradigm.

4.2 Realization Path: Vertical Integration of Linear Value Chains and Order Barriers

On the path to value realization, the traditional manufacturing paradigm is completely dominated by the linear value chain model. Michael Porter's classic theory views business operations as a sequential process[1] of value addition from raw material procurement to final product delivery.

On the one hand, vertical integration and order barriers. In order to take control of the value chain and maximize its efficiency, large manufacturing companies generally adopt vertical integration strategies, incorporating upstream suppliers and downstream distribution channels into their own systems through acquisitions or self-construction. This enables companies to achieve more efficient synergy within themselves and protect their profit margins by setting up order barriers such as capital and technology to keep competitors out. The organizational structure within the enterprise, such as R&D, production, marketing, finance and other functional departments, also strictly corresponds to each link of the value chain, forming a deep well "departmental wall" in which information flows slowly and step by step vertically.

On the other hand, prediction-driven rigid systems and the "bullwhip effect". The entire system operates on a prediction-driven model. Enterprises build long-term production plans based on historical sales data and market forecasts, and then drive materials along the value chain. This driving pattern is bound to be accompanied by high inventory costs, that is, whether it is raw materials, work-in-progress or finished goods inventory, all become key influencing factors that devour the liquidity of enterprises. Worse still, there is an inevitable distortion, delay and amplification of information as it is passed along the value chain from end customers to top suppliers, known as the "Bullwhip Effect". Small fluctuations in end demand can cause upstream manufacturers to receive an extremely amplified order signal, resulting in wild fluctuations in production plans, capacity mismatches and huge waste of resources. This makes the traditional manufacturing paradigm show significant slowness and inadaptability in response to rapid changes in market demand.

4.3 Capture Methods: Product Standardization, Brand Barriers, and Fixed Value Distribution

At the level of value capture, traditional manufacturing paradigms revolve closely around ownership transactions of physical products.

On the one hand, product standardization is a prerequisite for achieving economies of scale and the foundation of value capture. By providing standardized products with uniform functions and specifications to the market, enterprises can spread out R&D and production costs and build brand awareness through large-scale advertising and marketing, thereby establishing a differentiated image in the minds of consumers and obtaining brand premium. In addition, limited monopolies built through patents, trademarks and Copyrights are important means for companies to protect the value of their technological innovations and prevent imitation.

On the other hand, the rules of value distribution strictly follow the "position" and "power" in the linear value chain. Enterprises with core technology and brand power dominate and capture most of the value; Suppliers and assemblers in a weak position have meager profits. For the average worker, their value and remuneration are closely tied to the standardized hours of labor they put in, rather than their creativity or unique skills. Under the Taylor system, workers are like "screws" on an assembly line, their work is highly simplified and deskilled, and human initiative and creativity are greatly suppressed in the pursuit of mechanical efficiency. Customer relationships are mostly one-off or low-frequency transactions, and when the transaction is completed, the exchange of value is basically over. The company's financial statements are highly focused on product sales revenue, gross margin and inventory turnover rate, all of which are direct reflections of this way of capturing value.

5. The Value Logic of the Future "Intelligent Manufacturing" Paradigm: an Innovation-Driven Intelligent Ecosystem

In contrast to the efficiency-oriented traditional manufacturing paradigm, the intelligent manufacturing paradigm builds a new world of value creation with innovation at its core, intelligence as its driving force, and ecology as its organizational form. Its value logic is no longer confined to optimizing established production functions, but is dedicated to stimulating and capturing emergent value through the integration of data, algorithms and computing power.

5.1 Core Pillar 1: Data-Driven - A qualitative Change and Decision-Making Revolution in the Source of Value Creation

Data-driven is the new source of value creation in the "intelligent manufacturing" paradigm, achieving a fundamental shift from the scale effect that relies on tangible elements to the economies of scope and learning effects that exploit data intelligence.

On the one hand, from "large-scale processing in the physical world" to "intelligent creation in the data world". In the "intelligent manufacturing" paradigm, data is no longer a by-product of the production process, but a key factor of production on par with capital and labor. The core of its value creation logic lies in extracting insights from massive, multi-dimensional data through algorithms, forming intelligence, and using this intelligence to dynamically respond to and even create demand. Data elements have the characteristics of non-exclusivity, replicability and increasing marginal returns, which enables value creation to break through the scarcity constraints of traditional tangible elements. Predictive maintenance, for example, can accurately predict the probability of failure by continuously analyzing equipment operation data, transforming the traditional "post-event repair" into "pre-event intervention", which not only avoids downtime losses but also creates a whole new value stream - from "selling equipment" to "ensuring the continuous and stable operation of equipment".

On the other hand, a leap in value discovery from "experience-based decision-making" to "algorithmic decision-making". Data-driven has sparked a deep revolution in the way value is created: from the "problem-solving" model that relies mainly on human experience to the "opportunity discovery" model that uses intelligent algorithms. Algorithms such as deep learning can discover correlations, patterns and potential demands that are hard for the human brain to detect from complex data, thus opening up new value Spaces. This is essentially a qualitative change in the source of value creation: value no longer stems merely from the optimization of known problems, but from the exploration and definition of unknown possibilities and market gaps under the guidance of data intelligence. Therefore, data is not only the "new oil" as a source of power, but also the "new light cooperative application", which can continuously and self-grow new value through the synergy with algorithms and computing power.

5.2 Core Pillar 2: Intelligent Interconnection - Reconstruction of Value Realization Paths and Network Synergy

Intelligent interconnection is a revolutionary carrier of the value realization path of the "intelligent manufacturing" paradigm. It completely breaks the shackles of the traditional linear value chain and builds a dynamic, parallel networked value field.

On the one hand, the production organization revolution from "linear chains" to "value networks". The realization of value in the "intelligent manufacturing" paradigm depends on the value network composed of platforms and ecosystems. The industrial Internet platform, as the core hub, connects a vast number of devices, developers, users and partners, forming a "value field" where resources are instantly allocated on demand, capabilities are rapidly reorganized, and innovations collide at high speed. Value is no longer added in a fixed sequence of links, but is co-created and emerges in the parallel interaction of multiple subjects. For instance, Nanjing Changan Automobile's custom factory, through an industrial Internet platform, enables instant switching among more than 3,000 personalized solutions, and the path of value realization shifts from manufacturer "push" to user demand "pull".

On the other hand, digital twins and C2B models: Accelerating the cycle of value creation. Digital twin technology is a key enabler for smart connectivity. By building virtual mappings of physical entities, it simulates, tests, and optimizes in the digital space, significantly reducing the cost and cycle of trial-and-error innovation in the physical world and enabling the value creation cycle to iterate at high speed. At the same time, the popularity of the C2B model has made user demand the starting point for triggering production, achieving true "production based on sales" and even "personalized customization". This is not only an optimization of the value realization path, but also a redistribution of the right to define value - value is increasingly defined by end users in the continuous "dialogue" with enterprises and ecosystems.

5.3 Core Pillar 3: People-Oriented-Deepening the Value Capture Approach and Returning to Meaning

People-oriented is the ultimate destination and source of vitality for value capture in the "intelligent manufacturing" paradigm. It marks the ontological return of value logic from "product-centered" to "user-centered" and redefines the role of people in value creation.

On the one hand, the role evolution from "consumer" to "product-consumer" and "creator". The "Prosumer" predicted by Alvin Toffler has become a universal reality in the "intelligent manufacturing" era. Users are no longer passive recipients of value; instead, they become active co-creators of value by giving back data, contributing ideas, participating in open source communities, or modularizing. This deep engagement not only enhances the user experience, but also brings a continuous stream of innovative inspiration and market insights to the enterprise, making it key for the enterprise to capture sustained value. The way businesses capture value has shifted from selling product ownership to offering subscription services, operational solutions, and building enabling platforms.

On the other hand, the value of meaning and experience is highlighted and human capital is being restructured. In the era of materially abundant "smart manufacturing", value is increasingly attached to the meaning, stories, and contextual experiences carried by products and services. The competition among enterprises has shifted from functional performance to the ability to provide scenario solutions and build emotional connections. Correspondingly, the value of human capital is being profoundly restructured. Repetitive physical and mental labor has been replaced by automation, and the unique value of human beings has shifted to creativity, empathy, critical thinking, and the ability to solve complex problems. As labor education for future industries emphasizes, cultivating workers with digital literacy, innovative spirit, interdisciplinary collaboration skills and engineering ethics is at the core of capturing the emerging value under the "intelligent manufacturing" paradigm. Value capture is increasingly closely associated with these highly advanced human capitals based on "developmental rationality" that are difficult to be replaced by automation.

6. The Underlying Mechanism of the Evolution of Value Logic

The paradigm revolution from "manufacturing" to "intelligent manufacturing" is by no means a superposition of superficial technologies or a fine-tuning of models; it underlies a profound transformation of the logic of value creation. This transformation is not a linear evolution in a single dimension, but a systematic reconstruction at three interrelated and reinforcing levels: structure, ontology, and process. This section will delve into these three mechanisms and reveal how they collectively drive and constitute fundamental changes in the logic of value.

6.1 From 'Linear' to 'Network': A Structural Revolution in Value Creation

This mechanism is rooted in fundamental changes in organizational forms and ways of collaboration and is the structural basis for the evolution of value logic.

The mechanistic core of the traditional "manufacturing" paradigm: order, control, and zero-sum games. The traditional paradigm follows a linear, pipeline-like logic of value creation, and its worldview is derived from the mechanism of the industrial age. It views the entire production system as a precise machine that can be decomposed, optimized and controlled, mainly in the following two aspects.

One is the pursuit of sequential addition and controllability: value is sequentially added along the "value chain" as defined by Michael Porter, from research and development, design, procurement, manufacturing to marketing and service, with the flow of information, logistics and capital flowing unidirectionally and sequentially. This structure pursues static efficiency and absolute controllability on a given track. The core of corporate strategy is to gain a competitive edge by establishing an advantage (such as cost leadership or differentiation) at one or several links of the chain.

The second is zero-sum games and clear boundaries: Under linear logic, the distribution of benefits along the value chain is often a "zero-sum game", and the profit squeeze from suppliers may become a cost advantage for manufacturers. Under this paradigm, business boundaries are clear, transaction costs are managed through vertically integrated or tightly coupled supply chains, and competition mainly occurs between enterprises or supply chains.

The organic leap in the "smart manufacturing" paradigm is characterized by emergence, synergy, and positive-sum games. The "intelligent manufacturing" paradigm constructs a networked, ecological logic of value creation, whose ideas are derived from the network science and complex systems theory of the information age, viewing economic behavior as a dynamically evolving organic life form, mainly manifested as:

One is parallel co-creation and value emergence: value is no longer sequentially added, but co-created in parallel within a dynamic value network composed of multiple subjects, such as enterprises, users, partners, and even competitors. Industrial Internet platforms, innovation communities and other platforms act as hubs, connecting various nodes and facilitating the high-speed collision and reorganization of resources, capabilities and demands within the network structure. Value is not pre-set at the end of the chain, but emerges in the interaction of the nodes. For example, a third-party developer, using the open API of an industrial Internet platform, developed a brand-new process optimization application for smart machine tools, and together with machine tool manufacturers and end factories, created unprecedented efficiency improvement value.

The second is positive-sum games and fuzzy boundaries: Network logic pursues positive-sum games and network effects. Having more developers, users, and partners join the network will increase the value density and innovation potential of the entire network, benefiting all participants. In this context, the boundaries of enterprises become blurred, permeated and dynamic, the core of competition shifts from "occupying advantageous positions in the chain" to "building or dominating the most dynamic value network", and the form of competition evolves into "ecological warfare".

6.2 From Product-centered to User-centered: An Ontological Revolution of Value Sources

This mechanism concerns philosophical inquiries about what value is and where value comes from, and is the ontological core of the evolution of value logic.

The product-centeredness of the traditional "manufacturing" paradigm is embodied in value embedding and passive transfer. The traditional paradigm is typical product-centeredness, whose value philosophy holds that value is an inherent attribute of objects such as products, and is "embedded" in physical products by producers through research and development and manufacturing processes, mainly manifested in:

The first is the presupposition and certainty of value: before a product is manufactured, its value categories such as function, quality, and brand image are basically defined, and the purpose of marketing is to make users recognize and accept these presupposition values.

The second is the standardization and passive acceptance: The moment a transaction is completed, ownership of value is transferred and the process of value creation comes to an end. Users are passive recipients of value, and their personalized demands are often regarded as cost factors that need to be ignored under the efficiency criteria of mass production.

The user-centric leap of the "intelligent manufacturing" paradigm is manifested as value contextualization and co-creation. The "intelligent manufacturing" paradigm establishes a user-centered value philosophy, whose core assertion comes from the "service-led logic" that value cannot be created by the enterprise alone, but can only be created jointly by the enterprise and the user in the usage context, manifested as:

One is the contextualization and experientialization of value: the essence of value is use value and context value. The value of a smart car lies not only in its hardware parameters, but also in the seamless experience it provides in specific travel scenarios, the continuous renewal brought by upgrades, and the synergy with other services. Users move from the end of the value chain to the starting point of value creation and the co-creator of ongoing participation.

The second is continuous dialogue and dynamic service: the relationship between the enterprise and the user shifts from a one-off transaction point to an ongoing "dialogue". This dialogue is achieved through data feedback, community interaction, personalization, and ongoing service delivery. What enterprises offer is no longer a fixed "product", but a dynamically evolving value proposition. The way value is captured has shifted from selling product ownership to models such as subscription services and pay-as-you-go.

6.3 From 'Solidification' to 'Emergence': A

Process Revolution in Value Generation

This mechanism reveals the dynamic nature of the value generation process and represents the process theory of the change in value logic.

Linear structure and product-centeredness together lead to the fixed nature of value under the traditional paradigm, manifested as presupposition, rigidity and certainty, manifested as:

One is the presupposition and deterministic framework of value: the research and development, design, and production processes of enterprises are all aimed at achieving a presupposition and deterministic value goal. The entire system operates within a highly deterministic framework, with the aim of achieving optimization within predictable ranges.

The second issue is the rigid system and resistance to change: Production lines, supply chains, and organizational structures are all designed to efficiently deliver preset value. Once established, they tend to remain stable and resist change, making it difficult for them to adapt to rapidly changing markets and personalized demands, thus showing a high degree of path dependence.

The "intelligent manufacturing" paradigm embraces the emergent nature of value, a concept derived from the theory of complex systems, which refers to simple micro-interactions spontaneously generating complex and novel patterns and structures at the macro level, manifested as generation, adaptation, and handling of uncertainty, mainly reflected in:

One is the dynamic generation and uncertainty of value: value is no longer completely preconceived, but is constantly generated and evolved in the process of human-machine collaboration, data flow, and network interaction. It has a certain degree of uncertainty and infinite possibilities. For example, based on massive user behavior data, intelligent recommendation algorithms may give rise to user demands or product feature combinations that even product managers did not anticipate, thus opening up entirely new market space.

The second is the agile system and adaptive construction: In order to adapt to and navigate the emergent nature of value, the "intelligent manufacturing" system must be agile and adaptive. Digital twin technology allows for countless tests and iterations at low cost in the virtual space, which leads to the emergence of the best solution in the physical world. Modular design, flexible manufacturing, and platform-based architecture enable systems to quickly reconfigure resources in response to emerging new value opportunities. Uncertainty is no longer a risk to be avoided, but a source of managed innovation.

From "linear" to "network", from "product-centered" to "user-centered", from "solidified" to "emergent", these three mechanisms do not exist in isolation but form a profound, self-reinforcing logical closed loop, together constituting the deep driving force of the value logic transformation of the "intelligent manufacturing" paradigm. It is the co-evolution, mutual catalysis and positive feedback among the three that completely reshapes the competition rules and survival philosophy of future industries - from pursuing static efficiency on a definite track to stimulating dynamic innovation and continuous adaptability in an uncertain environment.

7. Conclusions and Implications

This paper systematically dissects the industrial paradigm revolution from traditional "manufacturing" to future "intelligent manufacturing" by constructing a three-dimensional analytical framework of "source of value creation - path of value realization - way of value capture", revealing the fundamental changes in its underlying value logic.

The research shows that this change is not a partial technological upgrade or model adjustment, but a systematic reconstruction involving production factors, organizational forms, business models and distribution principles. The traditional "manufacturing" paradigm is efficiency-oriented, relying on economies of scale and linear value chain optimization of tangible factors, and its value logic is based on standardized products and cost control; The emerging "intelligent manufacturing" paradigm, with innovation at its core, relies on the deep integration of data, algorithms and computing power, and its value logic shifts to economies of scale, ecological synergy and meaning creation, showing a deep mechanism evolution from "linear" to "network", from "product-centered" to "user-centered", and from "solidification" to "emergence". This profound change in value logic poses new requirements and challenges for industrial policy, corporate strategy and individual development, and has significant implications.

7.1 Implications for Industrial Policy

The role of the government needs to shift from being an "industry selector" or "resource allocator" to an "innovation ecosystem builder". Policy focus should be on: investing in and improving digital infrastructure, laying out new infrastructure such as 5G, industrial Internet, and computing power centers in advance to provide a solid material and technical foundation for the "intelligent manufacturing" paradigm; Promote the establishment of rules for data openness and governance, establish and improve relevant laws and regulations on data property rights, circulation, trading and security, and promote the efficient circulation and value release of data elements while ensuring privacy and security; Deepen the reform of the education system, focus on the demands of future industries, promote the reform of higher education and vocational education, strengthen interdisciplinary education, digital literacy cultivation and the shaping of innovative spirit, and provide sustainable talent support for the "intelligent manufacturing" paradigm; Design an inclusive social safety net to adapt to the trend of diverse employment forms and frequent job mobility under the "intelligent manufacturing" paradigm, and build a broader and more flexible social security system to provide buffering and support for the transformation of the workforce.

7.2 Implications for Corporate Strategy

The future industrial transformation will have a profound impact on the development of enterprises, and enterprises must undergo a profound strategic repositioning and core capability reconstruction. In terms of strategic repositioning, enterprises need to clarify their new role in the value network, whether to become the builder of platforms and ecosystems, the "hidden champion" in niche fields, or the modular provider of professional capabilities? In terms of the transformation of core competencies, core competencies need to shift from traditional cost control and supply chain management to data acquisition and governance capabilities, algorithmic innovation capabilities, platform operation capabilities, and ecosystem collaboration capabilities;

In terms of organizational and cultural innovation, corporate culture needs to shift from closed and controlled to open, empowering and tolerant of failure in order to stimulate internal innovation vitality; At the same time, break the traditional bureaucratic structure and build a flat, networked and agile organizational form.

7.3 Implications for Individual Development

Individuals need to proactively adapt to the new world of labor and build careers oriented towards future industries. One is to embrace lifelong learning: In the "intelligent manufacturing" era of rapid technological iteration, constantly updating knowledge and skills is no longer an option but a necessity for survival. Individuals need to develop self-directed learning abilities. Second, focus on human-machine collaboration and higher-order capabilities: repetitive tasks will accelerate automation, and the unique value of people will be more reflected in creativity, empathy, critical thinking, complex problem-solving skills, and the ability to collaborate effectively with people and machines. Third, shaping personal branding and network value: Careers will be more project-oriented and fluid. The value of an individual is not only determined by the organization to which they belong, but is also closely related to their reputation, contributions and the breadth and depth of their connections within the professional network.

The future is here. The future industrial paradigm revolution from "manufacturing" to "intelligent manufacturing" is essentially a profound transformation of value logic. Only by accurately grasping the deep context of this transformation can nations seize the commanding heights in global industrial competition, enterprises can open up new horizons in the changing situation, and individuals can ride the waves. This transformation challenges established perceptions and patterns, while also nurturing new values, new opportunities and new possibilities that have never been seen before.

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