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Digitalization and Firm Value: The Evidence from China's Manufacturing Enterprises

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Abstract: In the context of digital transformation, the varying dimensions of digital maturity significantly influence value creation enhancement for enterprises. Optimizing these dimensions to augment corporate value represents an urgent challenge for manufacturing enterprises. This study examines 355 listed automotive manufacturing enterprises (including auto parts and related businesses) through multi-case analysis, grounded theory, and QCA methodology to investigate the intrinsic mechanisms and pathways linking digital transformation with value enhancement in automotive manufacturing. The sample enterprises were categorized by industry type into capital-intensive, technology-intensive, and labor-technology-intensive manufacturers, and were then further segmented into complete vehicle manufacturers, component manufacturers, and related industry manufacturers. The selection criteria emphasized enterprises with explicit digital transformation strategies, sufficient transformation documentation, complete annual reports, stable core operations, and anomaly-free key data. The key findings include the following: (1) Grounded theory identified service digitalization, environmental digitalization, middleware digitalization, marketing digitalization, and R&D digitalization as critical variables, with enterprise value enhancement requiring multi-dimensional synergies rather than single-factor determinants. (2) Configuration analysis revealed that comprehensive empowerment type (consistency > 0.8, coverage 35.9%) drives high-value enhancement, while service-deficiency, R&D-deficiency, and marketing-deficiency configurations characterize non-high-value scenarios. Service, R&D, and marketing digitalization emerge as core-value-enhancing competencies (consistency 0.817, coverage 75.9%). (3) Heterogeneous driving forces were observed across vehicle manufacturers, component manufacturers, and related industry manufacturers, though service digitalization constitutes a common-value-enhancing element. This research provides theoretical insights into manufacturing digital transformation's value creation mechanisms and strategic implications, addressing current academic gaps. However, the automotive industry focus limits generalizability despite its concrete exploration of industry-specific digital transformation. Future studies should expand industry coverage and conduct comparative analyses to enhance theoretical robustness.

Keywords: manufacturing; digital transformation; corporate value

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1. Introduction

The advancement and application of digital technology have transformed the survival and development environment of enterprises. An increasing number of countries and regions have implemented digital transformation strategies, leveraging this technology to propel economic growth within their borders [1]. China has systematically laid out a blueprint for the digitization of manufacturing and the development of the digital economy, aiming to steer market demand towards digital services and products, thereby facilitating the digital transformation of the manufacturing sector. According to China's Digital Economy Development Research Report, the digital economy continues to show robust growth, with its share in the national economy steadily increasing to 41.5% in 2022, comparable to that of the secondary industry. According to the 14th Five-Year Plan for Digital Economy Development, the value added of core products in China's digital economy should account for 10% of GDP by 2025, and it emphasizes improving the supply chain system of industries such as the automotive sector. Therefore, in the digital era, digital technology has disrupted traditional industrial structures and is reshaping them.

Manufacturing, as one of the driving forces of economic development, underscores the significance of advancing digitization as a crucial pathway to achieving high-quality economic growth. Exploring how to leverage digital transformation to enhance the value of automotive manufacturing enterprises holds substantial practical significance. However, traditional manufacturing faces development dilemmas such as inadequate core technologies, excessive reliance on external technologies, and positioning at the lower end of the value chain, resulting in insufficient core competitiveness and sluggish development momentum [2]. Digital transformation can drive rapid renewal and accelerate iterative upgrades in manufacturing, thereby enhancing efficiency, performance, and profits [3,4]. Traditional manufacturing utilizes intelligent and numerical technologies to precisely connect with users and provide services, embedding services within the value chain, effectively conserving resources and enhancing organizational efficiency.

The digital economy has profoundly influenced China's national competitiveness and industry restructuring. The economic consequences of digital transformation have been extensively examined across diverse domains, including innovation, sustainability, resource allocation, and firm performance. Existing studies predominantly adopt a single-dimensional lens to analyze specific outcomes, such as green innovation [5], ESG performance [1], environmental performance [6], and industrial chain resilience [7]. For instance, Wang et al. [6] emphasize the spillover effects of suppliers' digital transformation on downstream innovation through supply chain financial development, while Duan and Zhang [8] link digital transformation to resource allocation efficiency via human capital optimization and reduced information asymmetry. These studies collectively highlight digitalization as a catalyst for value creation, yet they largely overlook the interdependencies among multiple digitalization dimensions. For example, Zhang et al. [9] explore digital transformation's differential effects on profitability and marketability but treat these outcomes as isolated rather than interconnected phenomena. Qiao and Chen [10] find that digital transformation can narrow the income gap within firms, but the research does not address how such systems interact with other digitalization pathways, such as R&D or marketing.

Methodologically, prior research predominantly relies on linear regression models or qualitative case studies [11–14], which, while effective in identifying direct correlations or contextual insights, fail to capture the complex, non-linear configurations of digital transformation dimensions. For instance, Zhao et al. [15] analyze the relationship between digital transformation, firm attributes, and enterprise competitiveness but cannot disentangle how these factors combine to drive performance. Similarly, Zhang and Song [16] demonstrate

that digital transformation enhances corporate value through green technology innovation but do not explore whether this relationship depends on complementary dimensions like service or marketing digitalization. These methodological limitations obscure the mechanisms through which digital transformation generates value, particularly in contexts requiring multi-dimensional synergies.

This study addresses these gaps by employing a fuzzy-set qualitative comparative analysis (fsQCA) to explore the configurations of digital transformation dimensions that drive enterprise value enhancement. Grounded theory identifies five critical variables—service digitalization, environmental digitalization, middleware digitalization, marketing digitalization, and R&D digitalization—and emphasizes the necessity of multi-dimensional synergies rather than single-factor determinants. This approach diverges from prior studies by shifting the focus from isolated dimensions to the interplay between multiple digitalization pathways. Configuration analysis reveals that comprehensive empowerment types, characterized by high consistency and coverage, drive high-value enhancement, while deficiencies in service, R&D, or marketing digitalization characterize non-high-value scenarios. Furthermore, this study identifies service, R&D, and marketing digitalization as core competencies for value enhancement, with heterogeneous driving forces observed across vehicle manufacturers, component manufacturers, and related industry manufacturers. These findings not only resolve the contradiction in prior studies that attribute value creation to single dimensions, but also provide a systematic framework to explain the heterogeneous effects of digital transformation across different contexts.

The contributions of this study are as follows: First, it advances the theoretical understanding of digital transformation by demonstrating that enterprise value enhancement is driven by the synergistic interplay of multiple digitalization dimensions rather than isolated factors. This finding challenges the prevailing single-dimensional perspective in the literature and provides a more holistic framework for analyzing digital transformation. This theoretically generative process advances grounded theory by demonstrating its utility in modeling complex, non-linear phenomena like digital transformation, while providing a replicable analytical framework for future studies. Second, this study introduces a novel methodological approach—fsQCA—to capture the complex, non-linear relationships and configurations that underlie digital transformation. This approach addresses the methodological limitations of traditional regression analyses and offers a more nuanced understanding of how different dimensions interact to create value. Third, this study provides actionable insights for firms seeking to optimize their digital strategies by identifying service digitalization as a common-value-enhancing element across different types of manufacturers.

2. Literature Review

After implementing digital transformation strategies, some enterprises have seized development opportunities and successfully transformed, resulting in significant increases in their market capitalization, while others have struggled due to failed transformations. Digital transformation is not merely an upgrade or improvement of technology and supply chains, in addition, it encompasses critical aspects such as digital marketing, digital experience, digital services, digital research and development (R&D), and digital manufacturing. In essence, digital transformation is a multi-dimensional and dynamic process characterized by complexity and uncertainty, posing challenges for many enterprises. Drawing on cases of successfully transformed enterprises and motivation theory, it is evident that enterprises have strong motivations for digital transformation, which has a certain impact on enhancing corporate value.

Many scholars have investigated how digital transformation affects corporate value and the mechanisms underlying this impact. Climent et al. [17] explored how firms can create value through the complexity of omnichannel practices, emphasizing their evolution within digital transformation. By integrating business models, multi-stakeholder customer engagement, and omnichannel practices, their study identifies four value creation sources and offers tools for firms to evaluate their strategies. De Bernardi et al. [18] analyzed social entrepreneurship's use of digital transformation to address social and economic challenges. Through bibliometric analysis and web scraping, their study mapped four thematic clusters—social entrepreneurship, digital transformation, performance measurement, and ethics—expanding discussions on digital-driven social innovation. Lichtenthaler [19] proposed a strategic framework combining technology-push and market-pull factors to address challenges in digital transformation. Their study highlights actionable steps for integrating digital innovation and strategic renewal to enhance value creation. Omrani et al. [20], using the Technology-Organization-Environment (TOE) framework, examined digital transformation in SMEs. The empirical findings reveal technological readiness, IT infrastructure, and existing innovation levels as drivers of SME value creation through digital adoption. Taneja et al. [21] studied fintech as a sustainable digital strategy, linking it to performance outcomes. By employing a TOE-based model, their study emphasizes technological efficiency, organizational effectiveness, and environmental sustainability as key drivers of value creation. These studies collectively highlight that firm value in the digitalization era is influenced by multiple factors, including strategic integration of technology and market dynamics, organizational readiness, IT infrastructure, sustainability practices, and social innovation. Digital transformation emerges as a multi-dimensional enabler of economic, social, and environmental value creation.

However, discussions on the pathways for enhancing corporate value or the factors influencing this enhancement are relatively scarce. Most studies focus on innovations in products, services, management, business models, and technology, with relatively limited influencing factors considered. The exploration of elements such as digital services, digital experience, digital R&D, digital manufacturing, digital marketing, and digital middle platforms has been lacking, making it difficult to comprehensively grasp the role of digital transformation in enhancing corporate value. Based on the multi-dimensionality of factors influencing digital transformation, this study discusses the mechanisms and corresponding conditional configurations through which manufacturing enterprises' digital transformation influences enterprise value enhancement, attempting to answer the following questions: (1) How do various conditional configurations enhance the value of automotive manufacturing enterprises? (2) Which digital factors play the most significant roles in enhancing the value of automotive manufacturing enterprises? (3) Are there commonalities and heterogeneities in the role of digital transformation in enhancing the value of automotive manufacturing enterprises?

3. Theoretical Framework

3.1. Theoretical Model

This study adopts the grounded theory model to collect relevant data, utilizing interview methods to obtain core data for coding analysis. Concepts are extracted from the raw data and developed in terms of dimensions and attributes. The coding process primarily involves open coding, axial coding, and selective coding, through which core concepts or categories are identified. These are then used to construct a narrative framework, ultimately forming a theoretical system and building a theoretical model. After completing model construction, the concepts related to each described object are interpreted.

Based on the existing literature and the practical digital transformation experiences of automotive manufacturing enterprises, this study examines the impact of digital service, digital experience, digital R&D, digital manufacturing, digital marketing, and digital middleware on the value of manufacturing enterprises. To further explore the intrinsic mechanisms of these elements, this research employs the grounded theory approach to analyze the characteristics, motivations, and implementation pathways of enterprise digital transformation.

To this end, this paper selects successful cases of digital transformation in the automotive manufacturing industry for grounded case analysis. A combination of multiple cases and representative cases is employed to enhance the objectivity of the research, aiming to comprehensively summarize the characteristics of digital transformation in the manufacturing industry.

The sample selection criteria were as follows: (1) excluding automotive manufacturing enterprises listed after 2020 based on their post-transformation market valuation; (2) eliminating enterprises that were delisted during the study period; (3) excluding enterprises that underwent significant changes in their core business operations; (4) removing enterprises whose annual reports did not disclose digital-transformation-related information or exhibited abnormal data; and (5) excluding enterprise samples with missing or anomalous key data. Additionally, this study employed Python 3's web scraping, counting, and text segmentation functions to filter out invalid textual content from the financial reports of the listed companies. Based on this, the frequency of all relevant keywords was statistically analyzed to describe the data sources for digital transformation in China's manufacturing enterprises. Furthermore, to mitigate the potential influence of outliers, all continuous variables in the econometric testing design were Winsorized at 1% and 99% levels.

Based on the aforementioned principles, this paper selects the data of three enterprises—Geely Automobile, BYD Auto, and Beijing Automotive Group—whose transformation processes are clear and definite, data are abundant, and transformation outcomes are evident, as research samples. The relevant data are sourced from the enterprises' official websites and related reports, and an iterative multi-case analysis method is employed for analysis. An overview of the digital transformation of the sampled enterprises is presented in Table 1.

Table 1. Digital transformation status of sample enterprises.

Enterprise	Category	Establishment	Transformation	Digital Transformation Overview
GEELY	Labor-technology-intensive automotive manufacturing	1986	2004	Geely has completed its entire digital transformation from the 1.0 era of comprehensive informatization and process reengineering, to the 2.0 era of deep SAP application in research and development, manufacturing, and marketing, and finally to the 3.0 era of comprehensive empowerment through the Internet of Things, cloud computing, and big data. Digital technology has become an important support for operations, manufacturing, and services, and the results of digital transformation are remarkable.

Table 1. *Cont.*

Enterprise	Category	Establishment	Transformation	Digital Transformation Overview
BAIC	Capital-intensive automotive manufacturing	1958	2020	Developed a three-step plan for digital transformation, collaborated with JD.com and Huawei to drive this transformation, and achieved certain results in digitizing industrial platforms, intelligent manufacturing, operations, marketing, services, and supply chains, among other areas.
BYD	Technology-intensive automotive manufacturing	1995	2011	A recent, medium-term, and long-term digital transformation plan has been formulated, a digital committee has been established, and digitization has been achieved in smart manufacturing, supply chains, sales, and other areas. The digital transformation has yielded good results.

This paper analyzes relevant materials through programmatic coding, ensuring the validity and reliability of the coding, and completes the coding strictly according to the principle of hierarchical coding. Open coding mainly involves summarizing and organizing relevant materials of Geely Automobile and inducing initial conceptual categories according to the degree of relationship between the concepts (the coding process is omitted here due to space limitations). Then, using the initial categories of the primary case of Geely Automobile as a template, auxiliary case coding is conducted for BYD and BAIC, with iterative coding performed on each, to refine the initial concepts (the coding process is also omitted). After iterative coding, 52 related concepts and 30 sub-categories are obtained for the primary case.

Axial coding is based on the integration and analysis of the research topics derived from the 30 sub-categories, discovering and constructing various relationships between sub-categories, and refining 12 main categories according to the relationships and logical order among the levels of categories, as shown in Table 1.

Selective coding identifies the core categories based on axial coding and open coding. Through an in-depth analysis of the characteristics of the enterprises' digital transformation, the original concepts, main categories, and sub-categories are sorted out and analyzed, from which the following five core concepts are extracted: digital research and development, digital manufacturing environment, digital marketing, digital experience, and digital middleware platform, as shown in Table 2.

Table 2. Results of selective coding and axial coding.

Core Category	Main Category	Sub-Category	Core Category	Main Category	Sub-Category
Digital R&D	Opening Source and Reducing Expenditure	R&D Efficiency Development Capability	Digital Service	Product Service	Full-cycle Service Derivative Services Omni-directional Experience
	Collaborative R&D	Unified Platform Joint Operation and Maintenance		Virtual Service	Data Intelligence Business Ecosystem

Table 2. *Cont.*

Core Category	Main Category	Sub-Category	Core Category	Main Category	Sub-Category
Digital Manufacturing Environment	Business Scenarios	Training Algorithms Smart Management	Digital Middleware Platform	Digital Middleware	Data Processing Hub Consolidated Data Areas
	Digital Middleware	Talent Training Operations Management		Business Middleware	Business Middleware Service Capability
Digital Marketing	Granular Marketing Approaches	Detailed Decision-making Consumption Chain		Organizational Middleware	Resource sharing Multi-Dimensional capabilities
	Digital Ecosystem	AI Empowerment Intelligent Advertising Placement		Intelligent Middleware	Algorithm Models

Since the factors are not independent in enhancing corporate value, they form various combinations through linkage and matching to enhance corporate value. Therefore, this paper refers to the fuzzy-set qualitative analysis method in the literature, taking five core concepts of digital transformation as the influencing factors of corporate value, and analyzes their internal mechanisms of influencing corporate value from a configurational perspective. It discusses the synergistic effect of various elements on enhancing corporate value. Thus, the constructed theoretical model is shown in Figure 1.

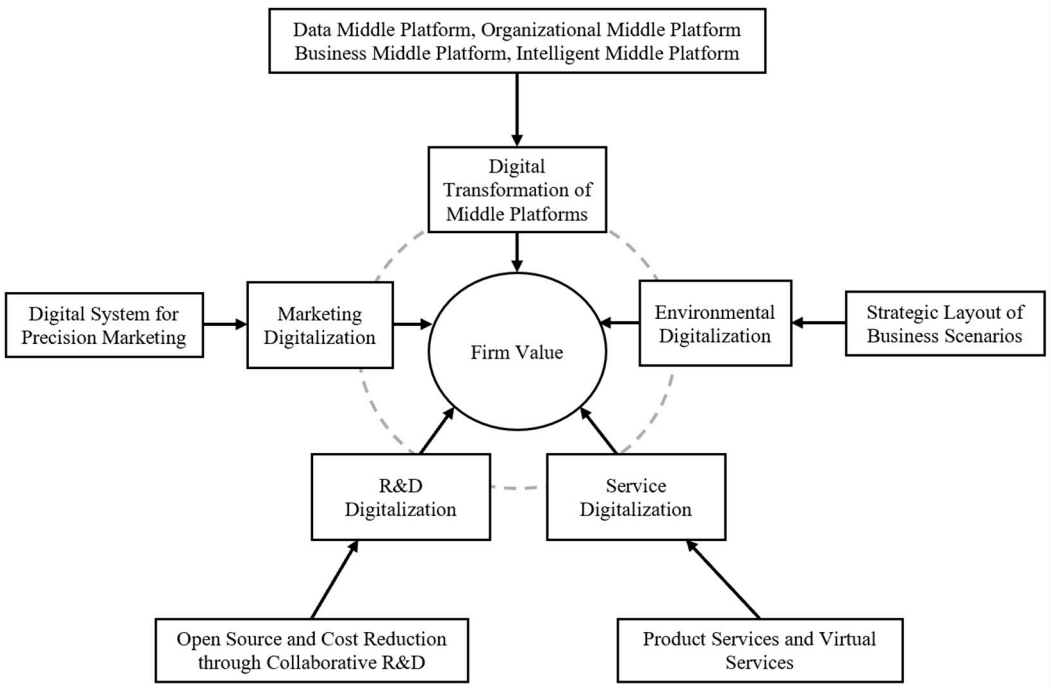

Figure 1. Theoretical model of digital transformation in manufacturing for enhancing enterprise value.

3.2. Core Concepts

3.2.1. Digital Marketing

The main characteristic of digital marketing management discussed in this paper is refined digital marketing. In the mobile internet era, digital marketing has become

more challenging, with low conversion efficiency in chain marketing. It is necessary to shift the marketing model from light operation to heavy operation. Implementing refined digital marketing across the board has become the key to breaking the deadlock. Refined operation enables the refinement of automobile user consumption chains and decision making, formulating targeted marketing strategies and influence methods across the user's full lifecycle consumption chain. This allows the marketing potential to be continuously released, subtly influencing users at various stages, enhancing their willingness to purchase vehicles, and achieving the conversion of purchasing behavior. At the same time, leveraging big data to deeply observe and mine user behavior allows for the creation of user personas, dynamically restoring user experience and scenarios, deeply understanding users, and building a user-based operation system. Additionally, AI digital empowerment reinforces the basic capabilities of marketing operations, while utilizing targeted digital marketing tools and strategies such as intelligent placement, diagnostic systems, and effectiveness assessments enhances corporate marketing capabilities. Enhanced marketing capabilities can bolster corporate competitiveness, drive business development, and thus promote an increase in corporate value.

3.2.2. Digital Research and Development (R&D)

Digital R&D addresses issues such as low efficiency in automobile R&D and design, a lack of software and hardware integration and development capabilities, and significant declines in profit per vehicle. However, to better realize digital R&D, it is necessary to ensure internal and external coordination, adopting collaborative R&D. The collaborative R&D platform is a platform for multi-person collaborative R&D and serves as the basic tool for digital R&D. Collaborative R&D clarifies various triggering mechanisms among R&D tasks. The same development platform enables joint early warning and rapid decision making, breaking down barriers between after-sales, production, and R&D. The R&D decision-making chain can quickly access more valuable data, effectively avoiding systemic issues. Collaborative R&D facilitates the integration and coordinated linkage of various chain elements, thereby promoting the enhancement of corporate value.

3.2.3. Digital Manufacturing Environment

Automobile manufacturing belongs to high-level intelligent manufacturing, with a higher degree of automation and digitization compared to other traditional industries. Intelligence has become the technological competitive high ground for automobile manufacturing enterprises. How to better enhance industrial intelligence through digital manufacturing is a key research focus. The digitization of the manufacturing environment is a significant factor influencing this level of intelligence. Essentially, the digitization of the manufacturing environment precisely focuses on business scenarios and breaks through large-scale, systematic overall strategic layouts, creating a favorable application environment for industrial intelligence. This optimizes production, operations, and decision making in the automobile manufacturing industry, enhances the level of intelligent management, realizes systematic and large-scale industrial intelligent manufacturing, and thus enhances corporate production and operational capabilities, strengthens its competitiveness, and increases corporate value.

3.2.4. Digital Services

Digital services primarily provide consumers with derivative, surrounding, and full-cycle services, offering a one-stop, scenario-based digital experience. The automobile manufacturing industry provides consumers with multi-digital touchpoint scenario-based services based on a thorough understanding of their needs, offering comprehensive,

360-degree digital experiences such as optional configurations, highlight displays, financial insurance, benefit packages, and exterior and interior designs.

Furthermore, digital services can leverage the diverse and multi-endpoint touchpoints of digital scenarios to accumulate more consumer data assets. Automobile enterprises can gain insights into, understand, and mine the demand characteristics of consumer groups through this data analysis, providing a basis for product R&D and innovation and creating more corporate value.

3.2.5. Digital Middle Platform

Corporate digitalization and scaled growth are inseparable from the network effects formed by ecosystems. Transformations in digital marketing, experiences, manufacturing, and R&D are closely interconnected. Each dimension generates an efficient collaborative network through the intersection of multiple independent units, creating critical conditions for rapid innovation and high efficiency within enterprises. For example, Geely Automobile's digital manufacturing and digital marketing have formed a new C2M manufacturing model, and the digital experience industry drives the improvement of digital R&D efficiency. Regardless of the type of collaborative network, a unified middle platform is indispensable as the operating system for digital transformation to support it, thereby solving the issue of islands among systems, capabilities, business, data, and innovation, and maximizing the scaled innovation and response speed of front-end business. The digital middle platform includes the organizational, business, and technical layers, and the synergistic effect it forms promotes the enhancement of corporate value.

In summary, digital R&D, digital marketing, digital services, and the digital environment can directly and indirectly promote the increase in manufacturing enterprise value and facilitate their high-quality development. Based on this, this paper analyzes the impact of these five factors on enhancing corporate value, deeply exploring their degree of influence and providing references for corporate digital transformation.

4. Data and Methodology

4.1. Data Source and Processing

The data are sourced from A-share listed automotive manufacturing enterprises on the Shanghai and Shenzhen stock exchanges as samples. The screening criteria are as follows: (1) Based on the market value after the enterprise transformation, automotive manufacturing enterprises listed after 2020 are excluded. (2) Enterprises that have been delisted during the period are excluded. (3) Enterprises with significant changes in their main business are excluded. (4) Enterprises that have not disclosed information related to digital transformation in their annual reports and enterprises with abnormal data are excluded. After screening, 61 automotive manufacturing enterprises (including auto parts and other related businesses) are obtained.

To ensure cross-validation of the data, the stock codes, names, listing dates, and other information of relevant automotive manufacturing enterprises are obtained through API. Python is used to extract keywords related to digitization from their annual reports. Online channels, internal publications, news reports, etc., are utilized to ascertain the starting time of their digital transformation. Core data are obtained from their annual reports and measured to acquire their post-transformation stock issuance volume and price for assessing enterprise value.

4.2. Methodology

The digital transformation process in the manufacturing industry is relatively complex, making it difficult to effectively conduct quantitative research. Based on this, this paper

employs a case study method for qualitative analysis to identify the characteristic factors of digital transformation in the manufacturing industry. Since there are multiple influencing factors between digital transformation in manufacturing and the enhancement of enterprise value, it is not feasible to determine specific impacts. Therefore, a fuzzy qualitative approach is adopted for research and analysis.

4.3. Variable Definition

4.3.1. Firm Value

In related research on enterprise value, its measurement methods primarily involve assessing enterprise value through assets (stock price and total assets), operating conditions (asset turnover, main business income rate, etc.), and the value chain. Drawing on the literature, this paper uses the market value during the period when the enterprise successfully completes its digital transformation as the criterion for value measurement. The higher the market value, the higher the enterprise value.

4.3.2. Digital Marketing

Ramon Saura [22] stated that a measurement method for digital marketing in the manufacturing industry is established by using the logarithm of the total sum of word frequencies related to digital marketing to reflect the level of digital marketing in the manufacturing industry.

4.3.3. Digital R&D

Most studies use R&D expenditure as an indicator to measure the R&D level and value of enterprises. That is, higher R&D expenditure indicates stronger R&D capabilities and a greater innovative value of the enterprise. However, this method ignores the R&D output, i.e., the R&D output rate, to a certain extent. Therefore, in 2012, Wang et al. [23] pointed out enterprise R&D capability assessment indicators to measure the digital R&D capabilities of manufacturing enterprises, including indicators such as digital R&D input capability, digital R&D output capability, and digital R&D input–output conversion capability.

4.3.4. Digital Environment

A digital manufacturing environment creates a favorable atmosphere for digital transformation. This paper uses Python programming to collect public information related to the digital transformation of the automobile manufacturing industry, with keywords such as business scenarios, artificial intelligence, industrial intelligence, data acquisition, digital production, digital operations, digital management, and intelligent systems. The cumulative word frequency is extracted as a measurement indicator for the quality of the digital environment. A higher frequency indicates a superior digital environment for automobile manufacturing enterprises and a greater potential to enhance enterprise value.

4.3.5. Digital Services

Digital transformation affects the degree of digitization within an enterprise, and enhancing an enterprise's digitization level also boosts its information collection and processing capabilities, service capabilities, research and development capabilities, and management capabilities. The measurement of digital service levels refers to the consumption coefficient model by Fang et al. [24] used to determine service level measurement indicators, with its complete consumption coefficient expressed as follows:

$$servitization_{sr} = a_{sr} + \sum_{k=1}^{n} a_{sk}a_{kr} + \sum_{k=1}^{n}\sum_{l=1}^{n} a_{sk}a_{kl}a_{lr} \quad (1)$$

wherein the service level of the manufacturing industry (r) is represented by $servitization_{sr}$, with the first term on the right side representing direct consumption of services, the second term representing the first round of indirect consumption, and so on, with the n + 1th term representing the nth round of indirect consumption. The direct consumption relationship is expressed as follows:

$$servitization_{sr} = \frac{\sum_r^n q_{sr}}{Q_r} \quad (2)$$

wherein q_{rs} represents the service input of the manufacturing industry and Q_r denotes the total input.

Based on Models (1) and (2), the measurement indicators for the digital service level of the manufacturing industry are constructed as indices for the input levels of product services, derivative services, professional services, and other services, including a derivative service index, a professional service index, and other service indices. A higher index indicates a higher level of digital service.

4.3.6. Digital Middle Platform

The systematization of the digital middle platform is an important support for ensuring the coordinated linkage of various elements and forming an ecosystem network effect. This paper uses Python programming to collect public information related to the digital transformation of the automobile manufacturing industry, with keywords such as digital operations, digital manufacturing, digital experience, digital R&D, digital technology, digital innovation, digital business, digitalization capability, digital systems, and big data. The cumulative word frequency is extracted as a measurement indicator for the systematization of the digital middle platform. A higher word frequency indicates stronger systematization of the digital middle platform in the automobile manufacturing industry and a greater potential to enhance enterprise value.

5. Empirical Research Results

5.1. Descriptive Statistics

The explanatory and control variables were input into fsQCA for calibration to obtain anchor points, full membership, crossover points, and full non-membership. These were represented by the maximum, minimum, mean, and 90%, 50%, and 10% levels of the anchor points. After calibration, if the consistency of necessary conditions for the variables exceeded 0.9, further testing was required. Ultimately, the consistency threshold was determined. Based on the current research findings and the relevant literature, this study employed the existing literature results to calibrate the data using the direct calibration method. The full membership calibration standard was set at 0.9, the crossover point calibration standard at 0.5, and the full non-membership calibration standard at 0.1. A configuration consistency greater than 0.8 was considered acceptable, with a threshold of greater than 0.5. According to the sample data, the digital transformation of the automotive manufacturing industry began in 2014 and was largely completed by 2022. The average market value increase before and after the transformation was 149.2%, revenue grew by 40.1%, and average profits increased by 52.3%. The descriptive statistics of the variables and membership values are shown in Table 3.

Table 3. Descriptive statistics and calibration values of variables.

Dimension	Descriptive Statistics				Membership Value		
	Mean	Min	Max	S.D.	0.1	0.5	0.9
Service Digitization	12.311	0.991	179.500	19.961	1.990	6.894	22.907
Environment Digitization	12.883	0.000	132.655	15.645	0.000	8.436	27.229
Marketing Digitization	29.952	1.185	79.011	7.186	19.825	27.558	37.862
R&D Digitization	53.961	0.003	2070.211	110.751	14.972	33.955	93.864
Middleware Digitization	7.977	0.031	15.983	4.497	1.918	8.175	15.046
Increase in Corporate Value	534.851	13.001	51,013.044	2839.994	24.971	95.442	1830.002
Market Volatility	6.752	0.041	12.310	3.117	1.724	2.391	6.014
Regulatory Changes	7.251	0.107	13.021	4.306	2.004	3.115	5.933
Technological Disruption	12.956	0.022	17.588	3.961	4.025	5.007	7.182
Year Fixed Effects	5.891	0.017	7.551	5.211	2.682	4.033	4.601
Industry Fixed Effects	3.971	0.058	6.927	4.007	2.079	4.118	5.924

Due to words limitations, the data results are rounded to three decimal places based on a sample of 61 automobile manufacturing enterprises. As shown in Table 3, the standard deviations for service digitization, R&D digitization, and enterprise value enhancement are relatively large, indicating significant variations among automobile manufacturing enterprises in terms of R&D investment and digital service levels, which in turn lead to differences in enterprise value enhancement. The minimum values for middle-platform digitization, R&D digitization, and environmental digitization are approximately zero, suggesting that, within the sample of automobile manufacturing enterprises, there are companies with relatively weak digital environments, R&D capabilities, and middle-platform systematization levels.

5.2. Necessity Analysis of Single Conditions

According to the $fsQCA$ principles of quantitative and qualitative analysis in research methods, multi-configurational analysis requires first examining the necessity of multiple antecedent variables to determine if they meet the requirements of core variables for configurational analysis. If a certain condition always exists when a result occurs, this condition is considered a necessary condition for producing that result. In Table 4, each antecedent variable demonstrates coverage and consistency, with consistency being the key criterion for assessing necessity. A consistency value greater than 0.9 indicates that the condition is a necessary condition for the result. To better assess the degree of impact of digital transformation on enterprise value, this study uses high enterprise value enhancement to represent a significant impact on enterprise value and non-high enhancement to represent an insignificant impact. The analysis of necessary conditions for high and non-high enterprise value enhancement is conducted using 2.0 software. Table 4 shows that the consistency of each condition is less than 0.9, therefore, there are no necessary conditions among the antecedent variables that affect high or non-high enhancement of the enterprise value.

Table 4. Necessary conditions.

Variable Characteristics	High Increase in Corporate Value		Non-High Increase in Corporate Value	
	Coverage	Consistency	Coverage	Consistency
High Service Digitization	0.599	0.710	0.667	0.497
Non-High Service Digitization	0.445	0.611	0.801	0.710
High Environmental Digitization	0.512	0.597	0.739	0.578

Table 4. *Cont.*

Variable Characteristics	High Increase in Corporate Value		Non-High Increase in Corporate Value	
	Coverage	Consistency	Coverage	Consistency
Non-High Environmental Digitization	0.522	0.691	0.704	0.562
High Marketing Digitization	0.501	0.621	0.687	0.599
Non-High Marketing Digitization	0.560	0.709	0.700	0.589
High R&D Digitization	0.612	0.721	0.664	0.517
Non-High R&D Digitization	0.458	0.605	0.783	0.700
Platform Digitization	0.622	0.647	0.675	0.458
Non-High Platform Digitization	0.447	0.668	0.757	0.744

5.3. Analysis of Sufficient Conditions

In the analysis of sufficient conditions for high enterprise value enhancement, the sufficiency of the results triggered by different configurations formed by multiple conditions is analyzed through configurational analysis. This analysis differs from the necessity condition analysis. Using truth tables to calculate the normalization of combinations (configurations), and based on the characteristics of the empirical sample size and specificity, this paper sets the frequency value to 3 and the threshold to 0.8. Combinations with a consistency test value of less than 0.6 are assigned a value of 0. The empirical results are shown in Table 5. Table 5 indicates that there is only one combination of conditions that can contribute to high enterprise value enhancement, and the consistency is greater than 0.8, indicating that this combination is a sufficient condition with a coverage of 35.9%.

Table 5. Overall configuration analysis results.

Dimension	Type of Models						
	Service-Weak Model		Marketing-Weak Model		R&D-Weak Model		
	A1	A2	B1	B2	C1	C2	C3
Service digitization	○	○					○
Marketing digitization			○	○	○	○	
Environment digitization	●	●		○			
Platform digitization			●			●	●
R&D digitization		○			○	○	○
Original coverage	0.367	0.376	0.351	0.369	0.377	0.400	0.365
Consistency	0.928	0.904	0.897	0.899	0.918	0.900	0.913
Unique coverage	0.006	0.004	0.005	0.007	0.003	0.012	0.007
Overall solution coverage				0.759			
Overall solution consistency				0.817			

Note: ● and ○ indicate the presence and absence of core conditions, as well as the presence and absence of peripheral conditions, respectively.

From Table 5, it is found that there are seven configurations for non-high enterprise value enhancement, namely, service-weak, marketing-weak, and R&D-weak types. Specifically, these are B1 and B2, where the core capability of marketing digitization is absent while the core of middle-platform digitization is present. A1 and A2 represent the absence of the core conditions of service digitization matched with the presence of the core conditions of environmental digitization. Alternatively, there is a core deficiency in R&D digitization, middle-platform digitization, or marketing digitization. In C1, C2, and C3, the absence of the core conditions of R&D digitization is matched with the presence of the core conditions of environmental digitization and middle-platform digitization, or there is a core deficiency in R&D digitization and marketing digitization. The configuration consistency is greater than 0.8, and the original coverage is greater than 0.3.

The overall analysis of sufficient conditions shows that the lack of service digitization, marketing digitization, and R&D digitization capabilities in automobile manufacturing enterprises is the main factor contributing to non-high enterprise value enhancement, which aligns with the actual characteristics of manufacturing enterprises. Some enterprise managers lack the necessary understanding of the value of digital technology and still adopt traditional methods to carry out service and marketing activities, failing to deeply understand user needs. Coupled with a focus on short-term corporate profits, overly cautious decision making, a poor digital environment, weak middle-platform systematization, and attempts to increase revenue and value enhancement by reducing current costs and expenditures, these factors hinder the enhancement of enterprise value. The poorer the digital manufacturing environment of an enterprise, the less likely it is to form a digital development atmosphere. Moreover, the weaker the systematization of the digital middle platform, the smaller the synergistic effect across various dimensions, which is not conducive to enhancing enterprise value. From the horizontal distribution of configurations A, B, and C, it can be seen that, despite the presence of the core dimensions of environmental digitization and middle-platform digitization, there is still non-high-value enhancement in automobile manufacturing enterprises due to the absence of R&D digitization, marketing digitization, and service digitization. The high enhancement of automobile manufacturing enterprise value is not the result of a single factor but may be caused by the absence of core dimensions.

5.4. Robustness

5.4.1. Changing Anchor Points and Adjusting Thresholds

In quantitative analysis, robustness is of paramount importance. According to the steps in the QCA methodology, adjustments in sample selection, condition measurement, calibration, and threshold analysis (such as case frequency, PRI consistency, raw consistency, and consistency thresholds for frequency) can all affect the number of sufficient conditions for configuration analysis, the relationships among configuration sets, and related parameters. Therefore, to determine whether significant changes occur in the aforementioned indicators under different operational choices, and to ensure the reliability of the research conclusions, it is necessary to test the robustness of the sample enterprises. To this end, this study examines the robustness of the 355 automotive manufacturing enterprise samples by altering calibration anchor points, adjusting analysis thresholds, and conducting endogeneity tests. The configuration results formed by the four calibration methods show no significant differences or substantive changes compared to the baseline regression model, and the adjusted parameters do not yield superior results, indicating that the baseline model is robust (see Table 6 for results).

Table 6. Results of robustness analysis.

Analysis	Type of Robustness Analysis	Solution Item Quantity	Overall Solution Consistency	Overall Solution Coverage	Difference	Results
High Increase in Corporate Value	Change Anchor Point	84%/0.81/3	2	0.789	0.438	Increased solution items and coverage with decreased consistency
		79%/0.81/3	5	0.799	0.359	Increased conclusion items with decreased consistency

Table 6. *Cont.*

Analysis	Type of Robustness Analysis	Solution Item Quantity	Overall Solution Consistency	Overall Solution Coverage	Difference	Results
	Threshold Adjustment	89%/0.77/3	1	0.875	0.359	No Difference
		89%/0.84/5	1	0.875	0.359	No Difference
	Baseline	89%/0.59/3	1	0.875	0.359	/
		89%/0.59/5	1	0.875	0.359	No Difference
Non-High Increase in Corporate Value	Change Anchor Point	84%/0.79/7	7	0.802	0.650	Consistency and coverage decrease
		79%/0.79/6	6	0.820	0.529	Increased solution items and coverage with decreased consistency
	Threshold Adjustment	89%0.74/3	11	0.817	0.789	Decreased coverage consistency
		89%/0.84/4	14	0.810	0.718	Decreased coverage consistency
	Baseline	89%/0.58/3	7	0.830	0.758	
		89%/0.58/4	12	0.825	0.789	

Using two methods—changing anchor points and adjusting thresholds—the robustness of the baseline regression model was tested. The results show that threshold adjustments do not alter the overall solution coverage and consistency of configurations leading to high enterprise value enhancement. However, the coverage and consistency of configurations resulting in non-high enterprise value enhancement decline, failing to meet expectations. The configuration condition analysis results under altered anchor points and threshold adjustments do not reach the baseline of this study, and adjustments to related parameters do not improve the configuration results, though no substantive changes are observed. Therefore, the conditional configurations in this study exhibit robustness, indicating that the empirical results are highly reliable and consistent with the core conclusions.

5.4.2. Multiple Regression Analysis

Furthermore, to mitigate potential biases in the econometric tests that may arise from omitting important variables, this study also incorporates and controls for several potential factors that could influence the enhancement of manufacturing enterprise value. These include macroeconomic indicators such as market volatility, regulatory changes, and technological disruptions, as well as year fixed effects and industry fixed effects. The relationship model between digital transformation and enterprise value is specified as follows:

$$TobinQ_{it} = \alpha_0 + \alpha_1 DT_{it} + \sum Control_{it}{}'\theta + \sum Year_t + \sum Industry_j + \varepsilon_{it} \quad (3)$$

To account for unobservable macroeconomic factors and industry-specific characteristics that could affect the regression results, year fixed effects and industry fixed effects are included in the control variables.

The baseline model regression results and the regression results incorporating control variables are shown in Table 7. The results indicate that, prior to including control variables, the regression coefficient between digital transformation and enterprise value enhancement is 0.059, with a test statistic of 5.197, passing the 1% significance test. After incorporating control variables, the regression coefficient between digital transformation and enterprise value enhancement in manufacturing enterprises increases to 0.132, with a test statistic of 11.941, also passing the 1% significance test. Additionally, the regression coefficients for

year fixed effects and industry fixed effects are 0.047 (test statistic 6.704) and 0.039 (test statistic 5.021), respectively. This suggests that the enhancement of enterprise value in manufacturing enterprises follows a gradual time-series progression and exhibits industry-specific variations.

Table 7. Baseline regression of digital transformation and manufacturing enterprise value enhancement.

Variables	Baseline Regression Coefficient	Baseline Regression Coefficient Including Control Variables
Digital Transformation	0.059 (5.197) *	0.132 (11.941) *
R&D Digitalization	2.501 (20.441) ***	2.712 (21.107) ***
Marketing Digitalization	2.035 (2.792) **	0.461 (2.150) *
Middleware Digitalization	0.432 (2.033) *	2.117 (2.560) **
Environmental Digitalization	0.514 (2.063) *	0.528 (2.227) *
Service Digitalization	2.307 (19.781) *	2.511 (18.953) *
Year Fixed Effects	-	0.047 (6.704)
Industry Fixed Effects	-	0.039 (5.021)
Regulatory Changes	-	0.055 (3.951)
Market Volatility	-	0.107 (8.220)
Technological Disruption	-	0.359 (13.058)

Note: Figures in parentheses represent *t*-test values. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

These test results validate the core conclusion that digital transformation alone is not a necessary condition for enhancing enterprise value. They also demonstrate that, during the process of digital transformation, enterprises are more susceptible to macroeconomic indicators such as market volatility, regulatory changes, and technological disruptions, which can create positive anticipatory effects and significantly contribute to enterprise value enhancement. Thus, it can be concluded that a higher degree of digital transformation in manufacturing enterprises is more conducive to enhancing enterprise value, although it is not the sole necessary factor. These findings are consistent with the core conclusions of this study.

5.5. Heterogeneity Analysis

In the configurational analysis of sufficient conditions, the overall solution consistency of various configurations is 0.875, and the overall solution coverage is only 35.9%. It is necessary to explore whether heterogeneity among enterprises has weakened its coverage or whether group characteristics have caused differentiation in results. Therefore, the sample enterprises are classified according to the automotive industry report classification, dividing automotive manufacturing enterprises into full-vehicle manufacturing, parts manufacturing, and related industry manufacturing enterprises. Among them, there are 21 full-vehicle manufacturing enterprises (34.42%), 29 parts manufacturing enterprises (47.54%), and 11 related industry manufacturing enterprises (18.03%), indicating a significant heterogeneity in characteristics.

The necessity test results show that the consistency of conditional variables in both high and non-high enterprise value enhancement is less than 0.9, indicating that they are not necessary. According to the configurational thresholds set earlier, the calibration anchor points are set at 0.9, 0.5, and 0.1. The original consistency of the configurational conditions is set at 0.8, and the frequency threshold is set at 3 (note: the value “0.6” mentioned in the original text seems out of context here and is omitted for clarity).

5.5.1. Full-Vehicle Manufacturing Enterprises

The consistency analysis results for full-vehicle manufacturing enterprises show that there is only one path for configurations leading to high enterprise value enhancement, which includes R&D digitization, marketing digitization, and service digitization. The overall solution consistency for this configuration is 0.927, with a sample coverage rate of 21.1%. The presence of core antecedent variables such as environmental digitization, middleware digitization, and R&D digitization are key conditions for driving high enterprise value enhancement in full-vehicle manufacturing enterprises. The absence of environmental digitization has a relatively small impact on high enterprise value enhancement in these enterprises.

The test results in Table 6 for non-high enterprise value enhancement show that there are seven configurational conditions affecting non-high enterprise value enhancement in full-vehicle manufacturing enterprises, with an overall solution consistency of 0.857 and a sample coverage rate of 71.8%. Configuration B1 has the highest coverage rate of 47.9%, which is due to the absence of service digitization and impact digitization. Configurations B5 and B6 explain the impact of the absence of service digitization and marketing digitization capabilities on enhancing the value of full-vehicle manufacturing enterprises. Horizontally, the presence of environmental digitization and middleware digitization cannot ensure the reversal of non-high enterprise value enhancement status. The absence of service digitization, R&D digitization, and environmental digitization are important factors contributing to non-high enterprise value enhancement in full-vehicle manufacturing enterprises.

5.5.2. Parts Manufacturing Enterprises

The configurational analysis of parts manufacturing enterprises, as shown in Table 6, shows that there are two configurations for high enterprise value enhancement in this type of enterprise, with an overall solution consistency of 0.889 and a sample coverage rate of 36.1%. These configurations are middleware digitization and service digitization, as well as service digitization, environmental digitization, and R&D digitization. Service digitization, environmental digitization, R&D digitization, and middleware digitization are key factors for high enterprise value enhancement in parts manufacturing enterprises. However, there is complementarity between environmental digitization and middleware digitization, and they have a greater impact on high enterprise value enhancement in parts manufacturing enterprises.

There are six configurational conditions in the analysis of configurations driving non-high enterprise value enhancement in parts manufacturing enterprises, with an overall solution consistency of 0.877 and a sample coverage rate of 60.9%. Among them there is an absence of R&D digitization and service digitization, although parts manufacturing enterprises possess service digitization and environmental digitization elements, and the absence of middleware digitization and R&D digitization remains a key factor affecting their non-high enterprise value enhancement. The configurational coverage of the absence of service digitization capabilities reaches 79%, and the configurational coverage of the absence of R&D digitization capabilities is 49%. Both are core factors affecting non-high enterprise value enhancement in parts manufacturing enterprises. If an enterprise possesses one of the core capabilities, such as service digitization, marketing digitization, or middleware digitization, but lacks other elements, it will still result in non-high enterprise value enhancement.

5.5.3. Related Industry Enterprises

The configurational analysis of related industry enterprises shows that there are two configurations driving high enterprise value enhancement, namely marketing digitization and R&D digitization, with an overall solution consistency of 0.889 and a sample coverage rate of 50.9%. Overall, the two configurations driving high enterprise value enhancement have high similarity, and marketing digitization plays only an auxiliary role when matched with the presence or absence of other elements. Partially, the marginal absence of environmental digitization has little impact on high enterprise value enhancement.

There is only one configuration for non-high enterprise value enhancement in related industry manufacturing enterprises, with a consistency of 0.847 and a sample coverage rate of 26.1%. This is mainly due to the absence of middleware digitization, service digitization, and R&D digitization, matched with the presence of other marginal elements.

5.6. Generalization Analysis by Industry Attributes

5.6.1. Labor-Intensive Manufacturing

The heterogeneity analysis of labor-intensive enterprises reveals that, among the 28 samples, there is only one feasible path for configurations that enhance enterprise value in the high-value enhancement group: the combination of R&D digitalization, marketing digitalization, and service digitalization. The overall configuration consistency is 0.941, covering 21.4% of the sample. The presence of middleware digitalization and R&D digitalization as core antecedent variables is a critical condition for driving high-value enhancement in manufacturing enterprises. The absence of environmental digitalization has a minimal impact on the high-value enhancement of complete vehicle manufacturing enterprises.

In the non-high-value enhancement group, there are eight configurations leading to value enhancement, with an overall solution consistency of 0.871 and a sample coverage rate of 73.9% (the configuration analysis table is omitted). Longitudinally, the B1 configuration has the highest coverage, at 49.3%, indicating that the absence of marketing digitalization and the absence of service digitalization are key factors affecting value enhancement in labor-intensive manufacturing enterprises. Horizontally, neither environmental digitalization nor middleware digitalization can reverse the state of non-high-value enhancement. The lack of R&D digitalization, service digitalization, and environmental digitalization are the primary reasons for non-high-value enhancement. R&D digitalization and service digitalization are critical for improving the marginal product of labor and overcoming demographic dividend constraints.

5.6.2. Capital-Intensive Manufacturing

There are two configurations driving high-value enhancement in capital-intensive enterprises (table omitted), with an overall solution consistency of 0.885 and a sample coverage rate of 34.9%. These configurations are as follows: (1) middleware digitalization and service digitalization, and (2) service digitalization, environmental digitalization, and R&D digitalization. Among these, the core elements are R&D digitalization, service digitalization, middleware digitalization, and environmental digitalization. Middleware digitalization and service digitalization can complement each other, while R&D digitalization plays a more prominent role in enhancing the value of capital-intensive enterprises.

In the non-high-value enhancement group for capital-intensive enterprises, there are eight possible configurations, with an overall solution consistency of 0.891 and a sample coverage rate of 61.7%. The absence of R&D digitalization and service digitalization, despite the presence of marketing digitalization and service digitalization as core elements, can still lead to non-high-value enhancement. The coverage rates for configurations lacking service

digitalization and R&D digitalization are 78.1% and 48.3%, respectively, indicating their critical influence. Capital-intensive enterprises may possess one of the core capabilities—marketing digitalization, service digitalization, or middleware digitalization—but the absence of other core elements can still result in non-high-value enhancement.

This is because the role of leadership talent in enhancing enterprise value is more pronounced in capital-intensive enterprises than in labor-intensive or technology-intensive enterprises. The revenue of capital-intensive enterprises is driven by capital investment, and the direction of capital allocation is influenced by the abilities and preferences of leaders. Insufficient or short-sighted leadership can lead to significant crises and risks for technology-intensive enterprises, stagnating their development and hindering value enhancement.

5.6.3. Technology-Intensive Manufacturing

Among the technology-intensive configurations, there are three configurations driving high-value enhancement, with an overall solution consistency of 0.895 and a sample coverage rate of 50.7%. These three configurations share high similarity and are complemented by the presence or absence of other peripheral elements. Marketing digitalization plays a supportive role, while the absence of environmental digitalization does not hinder value enhancement.

In the non-high-value enhancement group for technology-intensive enterprises, there is only one configuration leading to non-high-value enhancement, with an overall solution consistency of 0.861 and a sample coverage rate of 25.5%. This configuration is characterized by the absence of service digitalization, middleware digitalization, and R&D digitalization, combined with the presence of other peripheral elements. Technology-intensive enterprises are characterized by high product technology and knowledge content and significant R&D investment. If the key technological aspects fall behind, it can constrain the enterprise's development. When external environments change rapidly and competitive challenges intensify, technology-intensive enterprises are the first to be affected. The lack of key core elements can prevent these enterprises from overcoming critical bottlenecks.

The analysis of manufacturing enterprises by industry attributes reveals strong heterogeneity among technology-intensive, labor-intensive, and capital-intensive enterprises. This indicates that the core conclusions of this study exhibit significant heterogeneity and generalizability.

6. Conclusions and Policy Implications

6.1. Conclusions

This study adopts grounded theory to analyze the relationship and pathways between digital transformation in manufacturing and enterprise value enhancement. It extracts relevant measurement indicators of digital transformation through grounded theory and then uses research methods to reveal the internal mechanisms and configurational pathways that enhance the value of automotive manufacturing enterprises. Our conclusions are as follows:

Digital service, digital middleware, digital environment, digital R&D, and digital marketing are important variable factors in the digital transformation of manufacturing and are not independent influencing factors or necessary conditions for enhancing the value of automotive manufacturing enterprises. In digital transformation, the enhancement of enterprise value requires the joint drive of all elements. However, digital capabilities such as digital R&D, digital service, and digital impact have a more universal role and can increase enterprise value. If an enterprise's capabilities in digital marketing, digital R&D, and digital service are relatively weak, their driving role in enhancing enterprise

value will not be significant. The digital service capability and digital R&D capability of manufacturing enterprises are especially important factors affecting the enhancement of enterprise value. Once an enterprise lacks these two digital capabilities, or they are relatively weak, the promotional effect of digital transformation on enterprise value enhancement will not be obvious, and the implications will be accepted. The digital transformation of enterprises can drive the enhancement of enterprise value. In terms of enterprise revenue, the digital transformation of manufacturing can expand markets, change business models, and enhance enterprises' ability to create value.

6.2. Research Implications

Digital transformation in enterprises can drive the enhancement of enterprise value. In terms of enterprise revenue, digital transformation in the manufacturing sector can expand markets, transform business models, and improve the ability of enterprises to create value. This study reveals that there are seven configuration paths through which digital transformation in automotive manufacturing enterprises enhances enterprise value, and it analyzes the impact of each path. These findings provide a reference for various enterprises to leverage digital transformation for value enhancement. In other words, if enterprises achieve service digitalization, marketing digitalization, and R&D digitalization, they are more likely to drive significant improvements in enterprise value. Conversely, the absence of service digitalization, marketing digitalization, and R&D digitalization can hinder high-value enhancement. Based on these insights, the following recommendations are proposed:

First, align with the trend of digital transformation and establish policy support mechanisms to promote digital transformation in manufacturing enterprises. Currently, accelerating the development of the digital economy and making it a new growth driver has become an international consensus. However, the external characteristics and scalability of the digital economy make it highly dependent on policy support. In other words, its full potential and ability to drive the development of traditional industries can only be realized with the backing of economic policies. This is particularly true for the digital transformation of individual enterprises, which heavily relies on policy guidance and support. Only through such measures can enterprises deeply integrate digital technologies into their organizational structures and technological innovations, enhancing their digital capabilities in marketing, services, R&D, middleware, and environmental aspects, thereby solidifying the role of digital transformation in driving enterprise value enhancement.

Second, clarify the challenges and pain points of digital transformation and identify the transmission pathways of its driving effects. Whether from the perspective of digital transformation or enterprise value enhancement, the driving relationship between the two is not achieved overnight. Instead, it is realized through optimizing various attributes of manufacturing enterprises to enhance their overall value. This study primarily examines how digital transformation enhances enterprise value through the synergistic effects of service digitalization, R&D digitalization, marketing digitalization, middleware digitalization, and environmental digitalization. The results show that the synergy, refinement, and optimization of these capabilities can drive digital transformation and, in turn, enhance enterprise value. Manufacturing enterprises can leverage their digital technology capabilities to improve data governance, market adaptability, and risk control.

Third, strengthen digital technology R&D capabilities and create an internal mechanism and external environment conducive to transformation. Value enhancement is a key focus of enterprise development. During the digital transformation process, greater emphasis should be placed on integrating and promoting digital technologies with traditional core business operations. Attention should be given to digital technology R&D

capabilities, combining the application and R&D of digital technologies with enterprise value enhancement. By using R&D to drive application and value enhancement, the internal governance systems of manufacturing enterprises can be continuously optimized. Externally, the synergistic effects of policies and markets should be leveraged to guide the flow of talent and capital, as well as societal attention, toward the digital transformation of manufacturing. This can be achieved through talent development, policy support, patent protection, cultural recognition, and social acceptance, thereby concentrating limited resources to create an external environment conducive to transformation and driving R&D capabilities, ultimately promoting enterprise value enhancement.

Therefore, managers of manufacturing enterprises should advance digital transformation based on their developmental realities, selecting transformation models and pathways that align with their specific circumstances.

6.3. Research Limitations

Since this study focuses solely on the relationship between digital transformation and enterprise value in the automotive manufacturing industry, the findings exhibit strong typicality. However, due to the limited sample size and research scope, this study does not address regional differences among manufacturing enterprises or variations in digital transformation behaviors. Consequently, the generalizability of the results is not sufficiently evident. Future research should incorporate larger sample sizes and comprehensively consider various differentiating factors to ensure broader applicability. Additionally, this study has several limitations, such as the lack of in-depth analysis of time-series data, the relationship between digital transformation and enterprise value at the industry level, and comparative analysis between digital and non-digital enterprises. These limitations narrow the scope of factors influencing enterprise value enhancement and, to some extent, affect the completeness and systematicity of the conclusions. Therefore, further exploration and analysis will be conducted in subsequent studies.

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