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A Research on Adaptive Strategies for Digital Transformation of Small and Medium-sized Enterprises: A Micro-level Analysis Based on the "Dual-Double Support" Model

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Abstract

This paper discusses the adaptive strategies and practical effectiveness of SMEs in Shandong Province during the process of digital transformation. It analyzes the key positive factors within the internal and external environments of enterprises, as well as the mutual support between traditional and emerging digital industries, by constructing a comprehensive influencing model of the "double support" framework. The study adopts a combination of quantitative and qualitative methods, collecting data through questionnaires, the Delphi method, and case studies, and applying the DEMATEL model to reveal the interactions and interdependencies between internal and external factors. The findings show that internal management optimization, technological innovation, market positioning, and supply chain management are the core internal drivers of digital transformation, while government policy, market demand, and industry chain synergy are the key external drivers. Through the application of the DEMATEL model, this study further clarifies the interactions and impacts between these factors, providing both a theoretical foundation and practical guidance for enterprises to formulate targeted digital transformation strategies. In addition, the study proposes differentiated transformation paths according to the different development stages of enterprises, in order to help them achieve smooth and effective digital transformation and enhance their competitiveness and market position. The results not only enrich the micro-level theory of digital transformation in SMEs but also provide concrete guidance for practice, offering important theoretical and practical significance.

Keywords small and Medium-Sized enterprises; digital transformation; "Dual Double Support" model; adaptation Strategies; policy support

1 Introduction

1.1 Background of the Study

In the digital economy of the 21st century, the rapid development and widespread application of information technology is reshaping the global economic landscape[1]. Enterprises are facing unprecedented opportunities and challenges, and digital transformation has become a key strategy for enterprises in adapting

to the digital economy, gaining competitive advantages, and achieving sustainable development. According to the International Data Corporation (IDC), global spending on digital transformation was projected to reach $2.3 trillion by 2023[2].

Digital transformation encompasses all aspects of business operations, including business models, customer experience, internal processes, and the creation of value[3]. The importance of data as a key element of social development is becoming increasingly prominent. In March 2020, the Central Committee of the Communist Party of China (CPC) and the State Council explicitly introduced the concept of data elements, emphasizing the critical role of data in promoting economic and social development.

For SMEs, it is crucial to make full use of data elements during digital transformation to enhance data-driven decision-making, optimize business processes, and improve operational efficiency. However, digital transformation is not an easy task, particularly for SMEs, which face many constraints in terms of resources, technology, and talent, as well as difficulties such as reluctance to transform, lack of confidence to transform, and inability to transform.

In this context, the **Total Factor Influence Model (TFIM)**, as a comprehensive analytical framework, provides essential theoretical support and practical guidance for enterprise digital transformation. This model not only includes traditional factors of production but also incorporates digital factors and their interrelationships, emphasizing that enterprises must comprehensively consider multiple internal and external factors during transformation. By optimizing resource allocation and realizing synergies among these factors, enterprises can improve both the success rate and effectiveness of transformation. Therefore, studying the application of the TFIM in enterprise digital transformation has significant theoretical and practical value.

1.2 Importance of Digital Transformation in SMEs

Small and medium-sized enterprises (SMEs), as an important part of the economic system, contribute significantly to global employment opportunities and innovation dynamics. According to the World Bank, SMEs provide about 70% of employment opportunities worldwide[4]. In the era of the digital economy, SMEs face increasingly intense market competition and rapidly changing demands, and digital transformation has become crucial for enhancing competitiveness and achieving sustainable development. Through digital transformation, SMEs can leverage digital technologies to improve operational efficiency, reduce costs, enhance customer experience, and explore new market opportunities[3].

However, SMEs also encounter many challenges in the process of digital transformation, such as difficulty in technology adoption, lack of skilled talent, and insufficient financial resources[5]. The Total Factor Influence Model (TFIM) provides a comprehensive analytical tool for transformation, emphasizing the consideration of multiple factors—including technology, products, organization, market, and policy—from both internal management and external environment dimensions. This enables the optimization of resource allocation and the realization of synergy among factors.

By applying TFIM, SMEs are better equipped to cope with the challenges of digital transformation, improving both the success rate and effectiveness of transformation, thereby securing a favorable position in fierce market competition and achieving sustainable development. At the same time, the successful digital transformation of SMEs also provides significant impetus and support for the broader digital transformation and upgrading of the entire economic system.

1.3 Scope and Purpose of the Study

This study focuses on the adaptive strategies and practical effectiveness of SMEs in the process of digital transformation, aiming to analyze how enterprises can effectively respond to the opportunities and challenges brought by the wave of digitalization at the micro level. The scope of the study covers key

areas such as internal management optimization, technological innovation, market positioning, and supply chain management, which are central drivers of digital transformation and directly influence its depth and breadth. At the same time, external environmental factors—such as government policies, market demand, and industry chain synergy—also play a crucial role by providing external conditions and support for enterprise transformation.

On this basis, the study incorporates the concept of total factor transformation, focusing on the synergistic configuration of digital factors and traditional factors of production in the process of enterprise digital transformation, as well as the comprehensive effects this produces. By constructing a model of the factors influencing the "dual-support" framework, this study seeks to reveal the interactions and mechanisms between these factors and to assess the practical effectiveness of an all-factor transformation strategy in promoting digital transformation.

The ultimate purpose of this study is to provide enterprises with differentiated digital transformation pathways, to help SMEs move forward steadily in the wave of digitalization, enhance competitiveness, and achieve sustainable development. At the same time, it also aims to provide new perspectives and empirical evidence for academics, thereby enriching micro-level theoretical research on the digital transformation of SMEs.

1.4 Research Methodology and Data Sources

In order to comprehensively and deeply analyze the adaptive strategies and practical effectiveness of SMEs' digital transformation, this study integrates both quantitative and qualitative research methods. The quantitative data mainly come from a questionnaire survey of 500 SMEs in Shandong Province, which was carefully designed to comprehensively cover the key internal factors of enterprises' digital transformation, such as internal management processes, technology application levels, product innovation, and supply chain synergy, as well as the external environmental factors, including governmental policy support, perceived changes in market demand, and upstream and downstream industry chain cooperation. Moreover, financial and operational data, such as revenue growth rate and the proportion of costs and expenses, were also collected. In addition, additional operational indicators, such as the growth rate of revenue, the proportion of costs and expenses, and changes in market share, were gathered to objectively assess the actual impact of digital transformation on enterprise performance. Qualitative data were obtained through the Delphi method and case study collection, inviting industry experts, enterprise managers, and frontline employees to participate in identifying specific cases of enterprises' digital transformation practices, challenges, and problems, as well as the valuable experience accumulated, particularly details regarding the implementation of the total transformation strategy in enterprises and feedback on its effectiveness. During the data analysis process, the DEMATEL model was applied to construct the direct influence matrix, accurately calculate the centrality and causality of each factor, clearly reveal the mutual influence relationships and importance ranking of each factor in the total transformation, and identify the key factors and their paths of action. At the same time, hierarchical regression analysis was employed to construct a multi-level regression model to deeply analyze the degree of influence of different combinations of factors on the effectiveness of digital transformation and ensure the scientific soundness and validity of the research results. Through the organic combination of these methods, this study is able to understand and explain the complex process of digital transformation of SMEs in an all-round and multi-dimensional way, and to provide powerful support for enterprises in formulating more targeted and effective transformation strategies.

2 Literature Review and Theoretical Framework

2.1 Overview of existing research on digital transformation in SMEs

2.1.1 Current status of domestic and international research

Scholars generally agree that the rapid development of information technology has had a profound impact on traditional production methods, and that digital transformation has not only reshaped the processes, technologies, and organizational structures of enterprises, but has also had a significant impact on the ecosystems of entire industries[5-7]. From a micro perspective, SMEs face unique challenges and opportunities in this transformation process. They are required to adapt to the changes brought about by digitization while maintaining business continuity, which includes adjustments to the way they work, the way they are organized, and their business models[8-9].

Bennett pointed out that, due to their own development conditions, most SMEs had deficiencies in technology, capital, and talent, making it difficult for them to establish their own digital platforms[10]. Qiu Ying and Ma Yongkai et al. argued that SMEs tended to be trapped at the low end of the value chain of digitalized production and were unable to bear the high fixed costs required to participate in the value chain, and also lacked core technologies[11-12]. This reveals the resource and capability constraints faced by SMEs in digital transformation. Qi Yudong, He Yingzhe, and Ye Biao et al. believed that the key factors for the digital transformation of SMEs came from both internal and external aspects, where internal factors could be categorized into three levels: technology, product, and organization[13-15]. This implies that SMEs need to pay attention not only to the external market and technological trends, but also to reforms in internal management, product innovation, and technological applications during the process of digital transformation.

According to the International Data Corporation's (IDC) *Global Digital Transformation Spending Guide*[16], global spending on digital transformation was expected to reach $2.3 trillion in 2023, highlighting the worldwide trend and scale of investment in this area. A study by the McKinsey Global Institute emphasized the significant impact of digital transformation on the economic performance of enterprises, noting that it can substantially improve operational efficiency and market competitiveness. In addition, the World Bank's *Global SME Development Report*[4] underscored the critical role of SMEs in the global economy and stressed that digital transformation is essential for their sustainable development.

However, existing academic research on the future development models of SMEs' digital transformation and the theoretical mechanisms underlying its effects remains insufficient. Many studies focus only on a single or a few influencing factors, or explore isolated aspects of the mechanism, while lacking a comprehensive elaboration of the impact of digital transformation on SMEs' value creation from both internal and external perspectives at the micro level. Furthermore, there is still a lack of application and evaluation of the full-factor influence model in the context of SMEs' digital transformation.

2.1.2 Research gaps and limitations

Although existing research has provided many valuable insights into the digital transformation of SMEs, there are still some shortcomings and limitations. First, most existing studies focus on the analysis of single factors or individual aspects of digital transformation, and lack a systematic exploration of the influencing factors as a whole. The digital transformation of SMEs is a complex process involving multi-factor interactions, including internal factors such as management optimization, technological innovation, market positioning, and supply chain management, as well as external factors such as government policy, market demand, and industry chain synergy. However, current research has not yet adequately revealed the interaction mechanisms among these factors. Second, research methodologies have primarily adopted qualitative approaches or single quantitative methods, lacking comprehensive quantitative analyses of all influencing factors, which makes it difficult to examine the strength of interactions and the pathways of influence among them. In addition, research samples are mostly concentrated in specific regions or industries and thus lack broad representativeness, making it difficult to fully capture both the commonalities

and differences of SMEs in the process of digital transformation. To address these shortcomings, this study adopts a combination of quantitative and qualitative methods, taking SMEs in Shandong Province as the research sample. The Total Factor Influencing Factor Model is applied to deeply analyze the interactions and degrees of influence among factors, evaluate the long-term effectiveness of digital transformation, and provide more comprehensive and in-depth guidance for the theoretical research and practical application of SMEs' digital transformation.

2.2 Theoretical Basis and Research Progress of Total Factor Influence Factor Modeling

2.2.1 Origins and Development of the Total Factor Influencing Factors (TFIF) Model

In the study of the digital transformation of SMEs, scholars have gradually realized the limitations of the traditional Total Factor Productivity (TFP) theory in explaining the complexity and multidimensionality of digital transformation. Total Factor Productivity focuses mainly on the contribution of traditional factors of production such as labor and capital to output, while paying insufficient attention to digital factors and the allocation among production factors. However, the core of digital transformation lies in the application of digital technology and its deep integration with traditional business processes, which makes the role of digital factors increasingly prominent.

The Central Committee of the Communist Party of China (CPC) and the State Council clearly put forward the concept of data elements in March 2020, emphasizing the key role of data in promoting economic and social development. Data elements include data, algorithms, and digital platforms, which can bring new ways of value creation and new business models to enterprises. For example, through data analysis, enterprises can accurately capture market demand, optimize product design and marketing strategies, and improve the rigor and accuracy of decision-making. The use of digital platforms can expand sales channels, achieve real-time interaction with customers, and enhance customer experience.

The introduction of digital elements enables the Total Factor Influencing Factors (TFIF) Model to more comprehensively reflect the impact of digital transformation on the production process of enterprises, providing a fresh perspective and a theoretical basis for formulating strategies and optimizing resource allocation in the digital era. At the same time, the configuration and interaction among production factors have become more complex, and the synergistic effects of different factors exert a significant influence on innovation capacity and enterprise competitiveness.

Therefore, the TFIF Model has emerged as an extension of the Total Factor Productivity theory. It incorporates digital factors, emphasizes the impact of resource allocation among production factors on efficiency and performance, and provides a more comprehensive and systematic analytical framework for the digital transformation of SMEs. This model makes up for the shortcomings of existing research regarding factor integration, and enables enterprises to grasp the overall picture of digital transformation, identify key influencing factors, and optimize resource allocation so as to improve the success rate and effectiveness of transformation.

2.2.2 Application of the Total Factor Influence Model to Digital Transformation

In the process of enterprise digital transformation, the *Total Factor Influence Model* has significant application value. First, it can help enterprises comprehensively identify the key influencing factors in digital transformation. Digital transformation involves many aspects of enterprise operations, including technology application, organizational change, and business model innovation. The model incorporates these factors into the analytical framework, enabling enterprises to grasp the whole picture of digital transformation at a macro level.

Second, the model emphasizes the synergy between digital factors and traditional production factors. In digital transformation, the application of digital technology can improve the utilization efficiency of

traditional factors of production, such as optimizing production processes and improving the utilization rate of equipment through data analysis. At the same time, the optimal allocation of traditional factors of production also provides a basis for the effective application of digital technology. By analyzing the interaction between digital and traditional factors, the Total Factor Influence Model guides enterprises to achieve the optimal allocation of resources, thereby improving the effectiveness of digital transformation.

In addition, the model focuses on the relationship between the allocation of production factors and enterprise performance. The ultimate goal of enterprise digital transformation is to improve enterprise performance. The Total Factor Influence Model quantitatively analyzes the degree of influence of each factor on performance, helping enterprises identify key factors and develop targeted strategies to maximize the impact of digital transformation on enterprise performance.

In conclusion, the Total Factor Influence Model provides a systematic and comprehensive analytical framework for enterprise digital transformation, which helps enterprises better understand and respond to various challenges and opportunities in digital transformation.

2.3 Comparative Analysis of Total Factor Influence Factor Model and Total Factor Productivity

2.3.1 Comparative analysis framework

In order to gain a deeper understanding of the differences and connections between the Total Factor Influencing Factor Model (TFIFM) and Total Factor Productivity (TFP) in the study of digital transformation in SMEs, this paper develops a comparative analysis framework. The framework compares them along four dimensions: factor types, factor configurations, factor relationships, and impact on digital transformation. The comparison of factor types aims to clarify the scope of production factors covered by both models; the comparison of factor configurations focuses on how the two models view the combination and utilization of production factors; the comparison of factor relationships analyzes how the two models interpret the interactions among production factors; and the comparison of impact on digital transformation highlights the different roles and contributions of the two models in driving enterprise digital transformation. Through this framework, the unique advantages and innovations of TFIFM compared with TFP in the study of digital transformation can be comprehensively revealed.

2.3.2 Comparative table of all elements

Compared with Total Factor Productivity (TFP), the Total Factor Influencing Factor Model (TFIFM) shows unique advantages and provides a more comprehensive perspective in the study of digital transformation in SMEs. First, in terms of factor types, TFIFM overcomes the limitations of traditional TFP by incorporating digital factors. Digital factors are at the core of digital transformation, including data, algorithms, and digital platforms, which can bring new ways of value creation and competitive advantages for enterprises. For example, through data analysis, enterprises can accurately grasp market demand and optimize product design and marketing strategies, while the use of digital platforms can expand sales channels and enable real-time interaction with customers. TFP, on the other hand, mainly focuses on traditional factors of production such as labor and capital, and pays little attention to the role of digital factors, making it difficult to fully capture the impact of digital transformation on enterprises' production processes.

Second, in terms of factor allocation, the *Total Factor Influencing Factor Model* emphasizes the synergistic allocation of digital factors and traditional factors of production. Digital transformation requires enterprises to recombine and optimize the allocation of production factors to fully leverage the potential of digital technology. For instance, enterprises need to invest funds in digital technology research and development and equipment purchases, while rationally allocating human resources to cultivate versatile talents with expertise in both technology and business. This synergistic allocation can improve the utilization efficiency

of production factors and promote enterprise innovation and transformation. *Total Factor Productivity*, on the other hand, is more concerned with the optimal combination of traditional factors of production, and it lacks an in-depth exploration of how to integrate digital and traditional factors.

Table 1: Comparative table of all elements

Comparison Dimension	**Total Factor Productivity (TFP)**	**Total Factor Influence Model (TFIM)**
Type of element	Mainly includes traditional factors of production such as labor and capital	Includes traditional factors of production such as labor and capital as well as digital factors
Element configuration	Focus on the optimal combination and utilization of traditional factors of production	Emphasizes the synergistic allocation of digital factors with traditional factors of production
Essential factor	Independent or simple linear relationships between traditional factors of production	Complex interactions and synergies among production factors
Implications for digital transformation	Limited direct contribution to digital transformation, mainly indirect impact through productivity improvements	Directly drives digital transformation and facilitates changes in enterprise business models, organizational structures, etc.

Furthermore, in terms of factor relationships, the *Total Factor Influencing Factor Model* recognizes the complex interactions and synergies among factors of production. Digital transformation is a systematic project that involves the collaboration of multiple internal departments and external partners. Factors of production are no longer engaged in simple linear relationships but form complex patterns of interdependence and mutual reinforcement. For example, technological innovation can improve production efficiency and reduce costs, thus increasing profit margins for enterprises, which in turn provide financial support for R&D and talent investment, forming a virtuous cycle. *Total Factor Productivity (TFP)*, on the other hand, usually assumes that the factors of production are independent of each other or exist in simple linear relationships, which makes it difficult to capture the complex interactions among factors in digital transformation.

Finally, in terms of its influence on digital transformation, the *Total Factor Influencing Factor Model* can directly promote digital transformation and facilitate changes in enterprise business models, organizational structures, and other aspects. It provides a comprehensive analytical framework that assists enterprises in identifying key influencing factors in digital transformation and developing scientific and effective transformation strategies. For example, enterprises can prioritize the optimization of internal management processes, enhance technological innovation capabilities, and strengthen synergies and cooperation with upstream and downstream enterprises in the industrial chain based on model analysis, thereby achieving success in digital transformation. *Total Factor Productivity (TFP)*, on the other hand, plays only a limited role in directly promoting digital transformation and instead indirectly affects the transformation process of enterprises mainly through improving production efficiency.

2.3.3 Discuss the uniqueness and comprehensiveness of this paper's model of total factor influences

The introduction of digital factors and their importance

The uniqueness of the *Total Factor Influencing Factor Model* in this paper lies in the inclusion of digital factors within the category of production factors, which is significantly different from the traditional *Total*

Factor Productivity (TFP) theory. In the digital era, digital factors have become key resources for enterprises to gain competitive advantages and achieve sustainable development. These include data, algorithms, digital platforms, and more, which can bring new ways of value creation and innovative business models for enterprises. For example, through data analysis, enterprises can accurately grasp market demand, optimize product design and marketing strategies, and improve the scientific rigor and accuracy of decision-making. The use of digital platforms can expand sales channels, achieve real-time interaction with customers, and enhance customer experience.

The introduction of digital elements enables the *Total Factor Influencing Factor Model* to more comprehensively reflect the impact of digital transformation on enterprise production processes, providing a fresh perspective and a sound basis for enterprises to formulate strategies and optimize resource allocation in the digital wave. It emphasizes that enterprises should pay greater attention to the application and innovation of digital technology and regard it as the core driving force for promoting enterprise development, so as to adapt to the evolving trend of the digital economy.

In-depth study of production factor allocation and its relationship

In addition to the introduction of digital factors, this paper's *Total Factor Influencing Factor Model* also provides an in-depth study of the allocation of production factors and the relationships among them, which represents another major expansion of the traditional *Total Factor Productivity* theory. Digital transformation requires enterprises to recombine and optimize the allocation of production factors in order to fully exploit the potential and synergy of each factor.

The model emphasizes the synergistic allocation between digital factors and traditional factors of production (e.g., labor, capital), pointing out that enterprises need to rationally allocate resources, including investment in digital technology research and development (R&D) and equipment acquisition, while at the same time allocating human resources to cultivate composite talents who understand both technology and business.

In addition, the model also focuses on the interactions and synergies among the factors of production, arguing that digital transformation is a systematic project that involves collaboration across multiple internal departments and external partners. Production factors no longer exist in a simple linear relationship, but rather in a complex system of interdependence and mutual reinforcement. For example, technological innovation can improve production efficiency and reduce production costs, thus bringing higher profit margins for enterprises, which in turn provides financial support for further R&D and talent investment, thereby forming a virtuous cycle.

This in-depth study of the allocation of production factors and their relationships enables the *Total Factor Influencing Factor Model* to more accurately reveal the internal mechanisms of digital transformation, providing strong theoretical support for enterprises to optimize resource allocation and enhance the effectiveness of transformation.

Supplementation and Expansion of Existing Research

The proposal of the *Total Factor Influencing Factor Model* (TFIFM) in this paper has an important complementary and expanding effect on the existing research on the digital transformation of SMEs. First, it makes up for the shortcomings of the traditional *Total Factor Productivity* (TFP) theory in explaining the complexity of digital transformation. Traditional TFP focuses mainly on the contribution of traditional factors of production to output and pays insufficient attention to digital factors and the allocation relationships among production factors. The TFIFM, on the other hand, takes digital factors into account and emphasizes the synergy among production factors, which enables a more comprehensive analysis of the impact of digital transformation on the productivity and competitiveness of enterprises.

Second, the model provides a more systematic and comprehensive analytical framework for the digital transformation of SMEs. It covers internal factors such as management optimization, technological innovation, market positioning, and supply chain management, as well as external factors such as gov-

ernment policies, market demand, and industry chain synergy, enabling enterprises to grasp the overall picture of digital transformation at a macro level, identify key influencing factors, and formulate scientific and effective transformation strategies.

In addition, the model expands the perspective of digital transformation research by guiding scholars and practitioners to focus on the synergistic configuration of digital and traditional production factors and their comprehensive impact on enterprise performance. This promotes the further development and innovation of digital transformation theory.

In conclusion, the proposal of the *Total Factor Influencing Factor Model* provides innovative ideas and tools for the theoretical research and practical application of digital transformation in SMEs, and has important theoretical as well as practical value.

3 Theoretical construction of the "dual-double support" model

3.1 Components of the Model

The "Dual-Double Support" model is constructed on the basis of the *Total Factor Influencing Factor Model*, which aims to comprehensively analyze the key internal and external factors and their interactions in the process of digital transformation of SMEs. The components of the model include internal support factors and external support factors. Internal support factors include internal management optimization, technological innovation, market positioning, and supply chain management, which directly affect the operational efficiency and competitiveness of enterprises. External support factors include government policies, market demand, and industry chain synergies, which provide the external environment and conditions for transformation. By integrating these internal and external factors, the "Dual-Double Support" model provides SMEs with a systematic framework for digital transformation, helping them to develop effective transformation strategies in a complex environment.

3.2 Analysis of Internal Support Factors

Internal support factors are the micro-foundations of digital transformation for SMEs, involving three core dimensions: technology, product, and organization. At the technology level, enterprises need to master and apply emerging technologies, such as cloud computing, big data analytics, and artificial intelligence, to improve productivity and enhance innovation. At the product level, companies must respond to changes in market demand and develop digital products to enhance their competitiveness in a competitive market. At the organizational level, companies need to adapt their organizational structure and culture to support rapid decision-making and innovation processes, which are essential to the success of digital transformation. By optimizing internal management processes, enhancing technological innovation capabilities, and achieving more accurate market positioning, companies can effectively improve supply chain management efficiency to gain an edge in digital transformation.

3.3 Analysis of External Support Factors

External support factors provide SMEs with the external environment and necessary conditions for transformation. At the policy support level, digital transformation policies and incentives provided by the government, such as tax incentives and financial support, create an external impetus for enterprises to transform. Changes in market demand and the emergence of new business opportunities require enterprises to continuously innovate their products and services to meet the demands of the digital era. In terms of supply chain collaboration, digitalized supply chain management can improve the effectiveness and responsiveness of the entire supply chain, which is crucial for SMEs to remain competitive in the market. By effectively

utilizing government policies, responding to market demand, and strengthening synergies across the industry chain, enterprises can better grasp the opportunities of digital transformation and achieve sustainable development.

3.4 Mechanisms of Interaction Between Internal and External Factors

The "dual-double support" model places special emphasis on the interaction mechanism between internal and external factors. In terms of strategic decision-making mechanisms, enterprises need to formulate digital transformation strategies based on their own technological capabilities and external market opportunities to ensure that the direction of transformation is consistent with their long-term goals. In terms of resource allocation, enterprises must rationally allocate resources, including technology investment, talent training, and market development, to support the implementation of digital transformation. In addition, risk management is a part of digital transformation that cannot be overlooked. Enterprises must identify and manage the technological, market, and operational risks that may arise during the transformation process to ensure that the transformation process is robust and sustainable. Through the combined roles of internal management optimization and external environment adaptation, SMEs can achieve more robust and effective progress on the road to digital transformation.

3.5 Application of Digital Factors and Production Factor Allocation in Modeling

In the "dual-double support" model, the application of digital elements and the configuration of production factors are key. The introduction of digital elements not only changes the production mode and business model of enterprises, but also promotes the synergistic configuration of production factors. Enterprises need to organically combine digital technology with traditional production factors, optimize the production process through data analysis, improve the utilization rate of equipment, and enhance the skill level of employees, so as to maximize production efficiency. At the same time, enterprises should base their allocation of production factors on market demand and the external policy environment to ensure the effective use of resources. For example, enterprises can take advantage of government financial support to increase investment in digital technology research and development, cultivate digital talents, and enhance technological innovation capabilities. Through this organic combination of internal and external factors, enterprises can achieve the optimal allocation of resources in digital transformation, enhance their core competitiveness, and achieve sustainable development.

In this study, in order to comprehensively and deeply analyze the interactions of internal and external influences in the process of digital transformation of SMEs and their impact on transformation effectiveness, we integrate hierarchical regression analysis and Boolean algebra-based qualitative comparative analysis (QCA). The research data comes from a questionnaire survey of 500 SMEs in Shandong Province, as well as an in-depth analysis of enterprise reports and interview transcripts, covering both quantitative statistical information and qualitative descriptive content. In the variable-setting stage, we explicitly set the effectiveness of digital transformation as the dependent variable, while fundamental factors such as technology investment, employee training, and market changes are treated as independent variables. By constructing a multilevel regression model, we carefully examined how individual, team, and organizational factors jointly contribute to the results of digital transformation. With the help of SPSS software, we accurately input data, ran the model, and conducted an in-depth interpretation of the regression results, thereby identifying the key factors that have a significant impact on digital transformation and exploring their mechanisms.

At the same time, we systematically transformed the qualitative data into binary format to visualize the availability of conditions, and used QCA software to build a truth table that clearly shows the complex correlations between different combinations of conditions and final outcomes. With the help of Boolean

algebra, we simplified complex logical expressions, pinpointed the core condition combinations, and rigorously tested the robustness of the results through sensitivity analysis. In addition, SAS software was introduced to support more complex statistical analyses, especially in Boolean algebra operations in QCA, by writing macro language code to automate the analysis process, which greatly improved the efficiency and accuracy of the analysis. Throughout the data processing stage, SPSS and SAS software not only carried out statistical analyses but were also involved in data management and cleaning, ensuring high data quality. Finally, we output the analysis results in detail and prepared a report that comprehensively explains the business implications of the analysis process and results. Based on these findings, we customized a data-driven transformation strategy for SMEs, helping them gain deep insights into the complexity of digital transformation, accurately identify key influencing factors, and steadily advance in the digitalization wave.

4 Relationship between the "dual-double support" model and the DEMATEL model

In the study of digital transformation of SMEs, the combination of the "dual-double support" model and the DEMATEL model provides a powerful tool for in-depth understanding and analysis of the complex factors and their interactions in the transformation process. As the theoretical basis of the "dual-double support" model, the Total Factor Influence Model emphasizes the comprehensive influence of internal factors such as internal management optimization, technological innovation, market positioning, and supply chain management, as well as external factors such as government policies, market demand, and industry chain synergy. Together, these factors constitute a comprehensive factor framework for the digital transformation of SMEs, providing enterprises with a broad analytical perspective.

4.1 The value of the DEMATEL model in total factor transformation studies

The value of applying the DEMATEL model in the study of total factor transformation lies in its ability to quantitatively assess the interaction and degree of influence among factors. By constructing a direct impact matrix, the DEMATEL model can reveal the causal relationships between factors and identify the key factors and their role mechanisms in the transformation process. For example, internal management optimization may directly affect the implementation of technological innovation, which in turn may further reinforce or hinder the optimization of internal management processes. This analysis of interactions helps enterprises identify key links in the transformation process and formulate targeted strategies to ensure the effective allocation of resources and the smooth progress of transformation.

4.2 Interaction of the DEMATEL model with total factor transformation

In the study of digital transformation of SMEs, the combination of the DEMATEL model and the Total Factor Influencing Factor Model provides a systematic tool for comprehensively analyzing complex factors and their interactions. The DEMATEL model, which serves as an analytical extension of the "dual-double support" model, highlights the joint influence of internal factors such as internal management optimization, technological innovation, market positioning, and supply chain management, and external factors such as government policies, market demand, and industry chain synergy. Together, these factors constitute a comprehensive framework for the digital transformation of SMEs, enabling enterprises to form a holistic analytical perspective.

By constructing a direct influence matrix, the DEMATEL model quantitatively analyzes the interaction and degree of impact between factors, reveals the causal relationships among them, and identifies the key factors and their role mechanisms in the transformation process. For example, internal management optimization may directly affect the implementation of technological innovation, which in turn feeds back into the further optimization of management processes. This interaction analysis assists enterprises

in recognizing the most critical links in the transformation process and in developing targeted strategies to ensure efficient resource allocation and smooth advancement of transformation.

Through the analysis results of the DEMATEL model, enterprises can clarify the importance and mutual interactions of each factor, thereby maximizing resource allocation. For example, if technological innovation and internal management optimization are identified as key factors, enterprises can prioritize investment in technological R&D and management process re-engineering, while simultaneously leveraging government policy support and industry chain synergy to reduce transformation costs and enhance outcomes.

In addition, the results of DEMATEL analysis can serve as dynamic monitoring indicators throughout the enterprise digital transformation process, helping enterprises adjust their strategies in a timely manner. As market environments and internal conditions change, the importance and interactions of factors will also shift. Enterprises can regularly apply the DEMATEL model to identify problems and adjust strategies promptly, ensuring the continuity and effectiveness of transformation.

In summary, the combination of the DEMATEL model and the Total Factor Influencing Factor Model provides SMEs with a systematic and comprehensive analytical framework for digital transformation. By identifying key factors, analyzing causal relationships, optimizing resource allocation, and dynamically monitoring and adjusting transformation strategies, enterprises can more effectively address the challenges of digital transformation, achieve smoother progress, and enhance their competitiveness and market position.

5 Constructing a DEMATEL Model of Digital Transformation for Small and Medium-sized Enterprises in Shandong Province from a Micro Perspective

5.1 Study Design

This study selects SMEs in Shandong Province as a sample, seeking to gain a deeper understanding of the development status and related experiences of their digital transformation. The research design includes two parts: market research analysis and policy analysis. The market research analysis aims to assess the current status of digital transformation of SMEs in Shandong Province, collect transformation experiences, and provide effective decision support for market changes. The policy analysis focuses on the government's supportive policies for SMEs' digital transformation and how these policies affect firms' resource integration and utilization, the stability of executive teams, supply chain innovation performance, digital platform synergies, and the further adoption of digital technologies. The research design employs a multi-factor analysis framework and the DEMATEL model to define and analyze the key internal and external factors affecting SMEs' digital transformation, and to provide SMEs with data-driven transformation strategies.

5.2 Data Collection and Sample Description

Data collection was conducted through a combination of on-site interviews and questionnaires, with a sample of 500 SMEs selected. Each enterprise involved 30 respondents, including senior managers, middle managers, and front-line staff. This multi-level approach was intended to obtain a comprehensive perspective and to ensure both the depth and breadth of the findings. The questionnaire was designed to cover multiple dimensions such as enterprise structural upgrading, industry chain influence, and adoption and diffusion of the digital economy, as well as external factors such as government incentives, perceptions of digital transformation, and stakeholder influence, together with internal driving and resistance factors. With these data, this study is able to comprehensively analyze the full range of factors influencing SMEs in the process of digital transformation, thereby providing a solid data foundation for the construction of the DEMATEL model.

5.3 Variable Definition and Measurement

In constructing the "dual-double support" model, the research team first identified the key factors affecting the digital transformation of SMEs through an extensive literature review and theoretical framework analysis. These factors include internal management optimization (Factor 1), technological innovation (Factor 2), market positioning (Factor 3), supply chain management (Factor 4), government policy (Factor 5), market demand (Factor 6), and industry chain synergy (Factor 7). These factors were further validated and refined by combining empirical research methods such as questionnaires, the Delphi method, and case studies. Through these methods, the research team analyzed the digital transformation process of SMEs from a micro perspective, especially the practical application and effect of the "dual-double support" model.

The application of the DEMATEL model enabled the research team to reveal the interactions and impacts of these internal and external factors, and thus provide more targeted recommendations for SMEs' digital transformation. Furthermore, the application of the DEMATEL model allowed the researchers to uncover the causal mechanisms among the factors, identifying how internal management optimization, technological innovation, and external policy support interact and reinforce each other. Finally, the application of the DEMATEL model helped the team to identify the relative centrality and causality of each factor by constructing a direct impact matrix, calculating the centrality and causality indices, and creating a comprehensive impact matrix. This process made it possible to highlight the key factors with the most significant influence on digital transformation and to explore the mechanisms through which they operate.

This integrated approach, which considers both internal capabilities and the external environment, provides new perspectives for understanding SMEs' transformation behaviors in complex environments and offers concrete guidance for practice. The data in the direct influence matrix reflect the degree of interaction between these factors and provide a reliable basis for subsequent modeling analysis.

5.4 Analysis and Results of the DEMATEL Model

In this study, the DEMATEL model was applied to analyze the interactions and degrees of influence between internal and external factors affecting the digital transformation of SMEs in Shandong Province. The following section presents the specific data analysis and results of the model.

5.4.1 Direct Influence Matrix (D)

The direct influence matrix was constructed using the expert scoring method, where each element a_{ij} indicates the degree of direct influence of factor S_i on factor S_j. The following table presents the constructed direct influence matrix data:

Table 2: Data for the constructed direct influence matrix

Factor	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7
Factor1	0	3	2	1	2	1	1
Factor2	1	0	4	3	2	3	2
Factor3	1	2	0	2	1	4	3
Factor4	2	1	3	0	3	2	4
Factor5	1	2	1	2	0	3	2
Factor6	3	1	2	2	2	0	3
Factor7	2	3	2	1	2	2	0

Note: The values in the matrix represent the level of impact, where 0 indicates no impact, and 1–5 indicate a gradual increase in the level of impact.

5.4.2 Degree of Centrality and Degree of Causality

The degree of centrality (m_i) and the degree of causality (n_i) are calculated using the following formulas:

$$m_i = \frac{1}{n} \sum_{j=1}^{n} (a_{ij} + a_{ji}) \tag{1}$$

$$n_i = \frac{1}{n} \sum_{j=1}^{n} a_{ij} \tag{2}$$

where a_{ij} represents the degree of direct influence of factor i on factor j, and a_{ji} represents the degree of direct influence of factor j on factor i.

The degree of centrality reflects the importance of a factor within the network, while the degree of causality measures the extent to which a factor acts as a source of influence on other factors. The following are the results of the calculations:

5.4.3 Integrated Impact Matrix (G)

The Integrated Impact Matrix (G) is calculated from the Direct Impact Matrix (D) and centrality (m), which reflects both the direct and indirect impacts among factors. The data of the Integrated Impact Matrix are shown below.

Table 3: Data of the Integrated Impact Matrix

Factor	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7
Factor1	0.0	0.6	0.4	0.2	0.4	0.2	0.2
Factor2	0.2	0.0	0.8	0.6	0.4	0.6	0.4
Factor3	0.3	0.4	0.0	0.4	0.2	0.8	0.6
Factor4	0.4	0.2	0.6	0.0	0.6	0.4	0.8
Factor5	0.3	0.4	0.2	0.5	0.0	0.6	0.4
Factor6	0.5	0.2	0.4	0.3	0.5	0.0	0.6
Factor7	0.4	0.6	0.5	0.2	0.4	0.5	0.0

The Integrated Impact Matrix allows us to identify the key factors that exert the greatest influence on digital transformation. For example, if Factor 2 has the highest centrality in the Integrated Impact Matrix, it can be regarded as the most important factor driving digital transformation.

5.5 Conclusions and Recommendations

By applying the DEMATEL model, this study provides an in-depth analysis of the key factors and their interactions in the digital transformation of small and medium-sized enterprises (SMEs) in Shandong Province, revealing the importance of internal management optimization and technological innovation as the core internal drivers. These factors not only directly affect the operational efficiency and market competitiveness of firms, but also further drive the digital transformation process through synergies with market positioning and supply chain management. Meanwhile, government policies, as key external drivers, provide SMEs with the necessary support and resources, while the interplay of market demand and industry chain synergies emphasizes the need for firms to pay close attention to market dynamics and work closely with industry chain partners to achieve transformation goals. These findings suggest that SMEs undergoing digital transformation must comprehensively consider their internal capabilities and ex-

ternal environment, as well as the interactions between them, in order to achieve a smooth and effective transformation.

Based on the findings, it is recommended that SMEs should first strengthen the optimization of internal management processes and the improvement of technological innovation capabilities in the process of digital transformation. This includes investing resources in technology research and development and management process re-engineering to improve operational efficiency and enterprises' market responsiveness. Second, enterprises should use market research to accurately position themselves and optimize supply chain management in order to quickly react to market changes and enhance customer satisfaction. At the same time, they should actively utilize the policy support provided by the government, such as tax incentives and capital subsidies, to reduce transformation costs and risks. In addition, enterprises should promote cooperation with upstream and downstream industry chain partners, share resources, and enhance the level of digitization and competitiveness of the entire industry chain. Given the continuously changing market demand, SMEs need to establish a flexible monitoring mechanism in order to make timely adjustments to their digital transformation strategies, and pay attention to the cultivation and introduction of digital talents to support technological applications and management innovations to ensure the successful implementation of digital transformation. Through these comprehensive measures, SMEs will not only be able to enhance their competitiveness and market position, but also achieve sustainable development in the era of the digital economy.

6 Analysis of the Effectiveness of the Practice

Based on empirical data, this section provides an in-depth analysis of the impact of internal and external factors on the digital transformation of SMEs in Shandong Province, as well as the interactions among these factors.

6.1 Impact of Internal Factors on Digital Transformation

Through a questionnaire survey and data analysis of 500 SMEs in Shandong Province, this study finds that internal management optimization, technological innovation, market positioning, and supply chain management are the core internal drivers of digital transformation. Specifically, 76% of enterprises that have implemented internal management optimization report that the digital transformation process is significantly faster. This suggests that by optimizing internal management processes, companies are able to allocate resources more effectively and improve decision-making efficiency, thereby accelerating implementation. In terms of technological innovation, the digital transformation success rate of enterprises with higher investment is 54% above the industry average. This indicates that enterprises' investment in new technologies not only enhances their technological capabilities but also provides solid technical support for digital transformation. In addition, enterprises with accurate market positioning have increased customer satisfaction by 30% during digital transformation, while enterprises with optimized supply chain management perform better in cost control, with an average cost-saving rate of 25%. These data fully illustrate that internal factors play a critical role in the digital transformation of SMEs, and enterprises should prioritize the optimization and enhancement of these factors to achieve transformation goals.

6.2 Impact of External Factors on Digital Transformation

Regarding external factors, government policies, market demand, and industry chain synergy are key external drivers. Empirical analysis shows that the return on investment in digital transformation for enterprises receiving government policy support is 40% higher than that of enterprises without such support.

This indicates that government policy support not only reduces the cost of transformation but also improves the success rate and benefits. Changes in market demand have prompted enterprises to accelerate the pace of digitization, with those most responsive to market changes increasing their market share by 15%. This shows that the ability to capture and respond to market changes in a timely manner is essential for maintaining competitiveness in digital transformation. As for industry chain synergy, enterprises collaborating with partners on digital transformation report a 28% increase in supply chain efficiency. This suggests that the collaboration of upstream and downstream enterprises creates synergies that jointly advance the transformation process. These results underscore the importance of external factors in SMEs' digital transformation, and enterprises should actively leverage these external resources to enhance transformation outcomes.

6.3 Analysis of the Interaction of Internal and External Factors

The interaction between internal and external factors is critical to advancing digital transformation. The study finds that efficient internal management and improved technological capabilities not only enhance operational efficiency but also attract external investment and partners, creating a virtuous cycle that further drives digitalization. Specifically, enterprises that receive both government support and implement internal management optimization achieve twice the digital transformation success rate of those relying on a single factor. At the same time, the combination of growing market demand and internal technological innovation allows companies to launch new products more quickly, thus gaining a competitive edge. These findings suggest that SMEs must comprehensively consider their internal capabilities and external environment, as well as the interactions between them, in order to develop effective transformation strategies and achieve smooth and sustainable digital transformation.

6.4 Synthesis of the Empirical Analysis

This section synthesizes the results of the empirical research and provides an in-depth discussion of the influencing factors and their effects on the digital transformation of SMEs in Shandong Province. Through quantitative data analysis and qualitative research, we confirm the significant impact of internal factors—such as internal management optimization, technological innovation, market positioning, and supply chain management—as well as external factors—such as government policies, market demand, and industry chain synergy—on digital transformation. The empirical data show that internal management optimization and technological innovation are the core drivers: enterprises optimizing internal management processes accelerate transformation speed by 76%, while those with higher investment in technological innovation exceed the industry-average success rate by 54%. In addition, government policy support significantly improves ROI, market demand changes accelerate digitization, and industry chain synergy enhances supply chain efficiency.

Further analysis reveals the synergy between efficient internal management and enhanced technological capabilities on the one hand, and external policy support and market demand on the other, which together are key to driving profitable digital transformation. In particular, enterprises that both receive government support and optimize internal management have twice the digital transformation success rate of single-factor firms. Meanwhile, the combination of growing market demand and internal technological innovation enables firms to launch new products more quickly, giving them an edge over the competition. These findings emphasize that in the process of digital transformation, SMEs must comprehensively consider internal capabilities, external environment, and their interactions to formulate effective strategies. Through such comprehensive consideration, companies can better achieve digital transformation and enhance their competitiveness and market position. Synthesizing the results of the empirical analysis, we conclude that SMEs in Shandong Province should prioritize internal management optimization and

technological innovation while actively responding to external policies and market demands, in order to achieve a smooth and effective digital transformation.

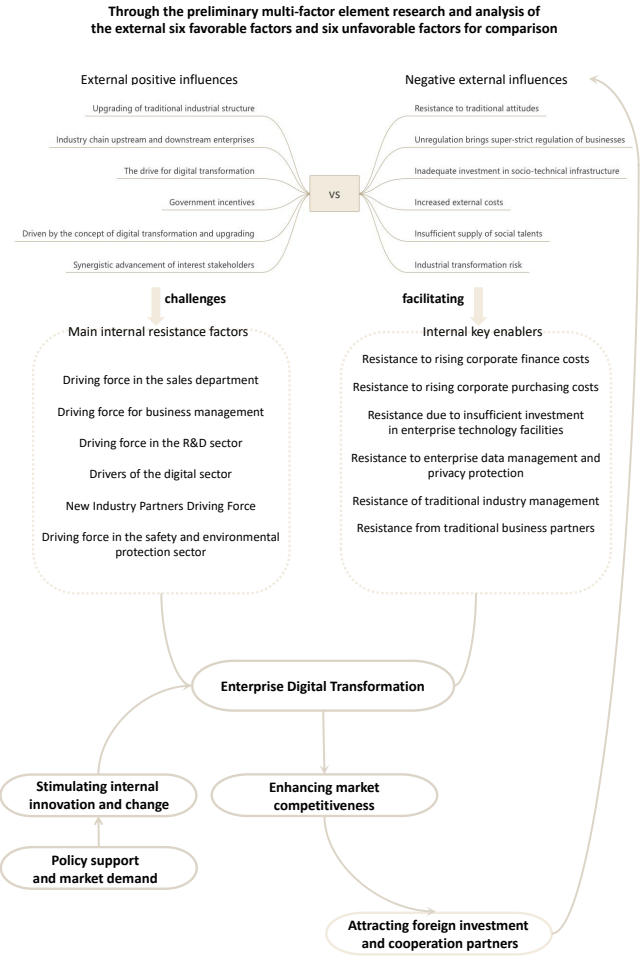

Figure 1: Evaluation System Model of Internal and External Factors' Influence on Digital Transformation Research for Small and Medium-sized Enterprises in Shandong Province

7 Paths to Realize Digital Transformation of SMEs in Shandong Province

7.1 Integration of Internal and External Factors

The path to digital transformation for SMEs in Shandong Province is mainly realized by integrating key internal drivers and positive external influences, using a "dual-double-support" model. Internal drivers involve the functional roles of sales, management, R&D, informatization, and equipment departments, as well as positive feedback from internal beneficiaries. These factors lay the foundation and provide the impetus for digital transformation by improving enterprise management, R&D efficiency, and informatization. Meanwhile, external influences, such as government incentives, positive impacts from upstream and downstream enterprises in the industry chain, and the popularization of the digital economy, indicate the direction of transformation and help enterprises seize digital opportunities.

7.2 External Relations Drive Changes in Internal Relations

The framework diagram of external relationships driving changes in internal relationships in the "dual-double-support" model illustrates how external factors contribute to digital transformation by influencing

internal decisions and actions. The DEMATEL model plays a crucial role in this process by constructing a direct influence matrix and an integrated relationship matrix, and by calculating the centrality and causality of the factors. Centrality and causality reveal the causal relationships between internal and external factors, enabling enterprises to specify which factors are key drivers and which act as resistance to digital transformation. This allows firms to develop targeted strategies to optimize internal management and enhance transformation efficiency.

7.3 Specific Transformation Paths

The digital transformation path of SMEs in Shandong Province can be clarified through the combined analysis of the "dual-double-support" model and the DEMATEL model. For example, Qingdao Hisense Group Co., Ltd. achieved a 30% increase in productivity and a 25% increase in inventory turnover by introducing an ERP system and a cloud computing platform. This reflects the central role of internal management optimization (Factor 1) and technological innovation (Factor 2). Meanwhile, government policy support (Factor 5) and market demand growth (Factor 6) provided favorable external conditions for Hisense Group.

However, the case of Weifang Huaguang Machinery Manufacturing Co., Ltd. highlights the challenges of insufficient market research and lack of government support. Its investment in an automated production line exceeded the budget by 50%, resulting in a tight capital chain.

This study summarizes the digital transformation realization paths of SMEs in Shandong Province. As a visualization of the transformation path, Figure 1 illustrates the internal and external factors and the realization mode of transformation, helping readers to understand the mechanisms of digital transformation more intuitively.

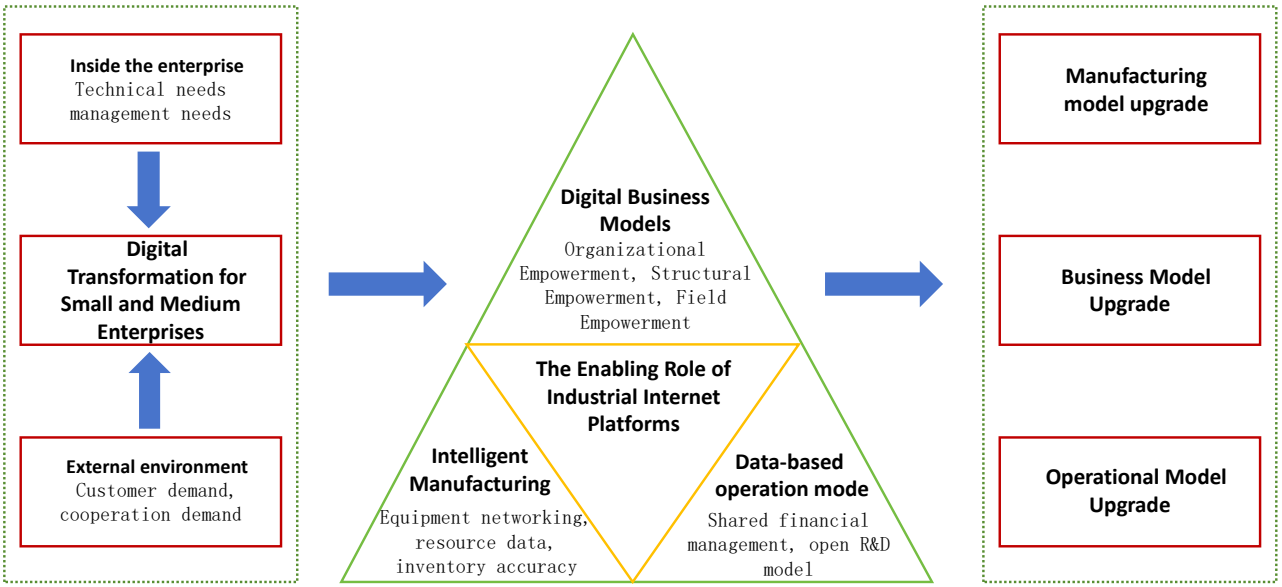

Figure 2: Digital Transformation for SMEs

7.4 Recommendations for Differentiated Transformation Paths

For SMEs at different stages, differentiated transformation paths are suggested as follows: for traditional businesses in the upturn phase, firms should achieve growth through technological innovation and management optimization; those in the boom phase should explore digital products and services; and those in

the decline phase should reorganize or transform and shift resources to emerging digital businesses. Transformation paths for emerging digital businesses include market research, R&D investment, branding, and customer relationship management. The business portfolio strategy plan should be customized according to the development stage of an enterprise's traditional and digital business, such as conservative, balanced, or transformational strategies, to achieve a smooth and effective digital transformation.

7.5 Transformation Paths for Emerging Digital Businesses

The transformation path for emerging digital businesses is equally critical. Undeveloped digital businesses require firms to conduct in-depth market research to design products that meet market needs. In the nascent stage, companies should increase R&D investment and rapidly iterate products to adapt to market changes. Digital businesses in the development stage should then expand market share, increase brand awareness, and strengthen customer relationship management. For digital businesses in the rapid advancement stage, companies should consider scaling operations, optimizing supply chain management, and improving operational efficiency. This continuous process requires firms to adopt stage-appropriate strategies to ensure the success of digital transformation.

7.6 Business Mix Strategy Program

By combining strategies for both traditional and emerging businesses, SMEs can design appropriate strategic programs. For instance, firms whose traditional business is on the rise but whose digital business has not yet developed may adopt a conservative strategy to maintain their existing business while gradually exploring digital transformation. Firms whose traditional business is booming and whose digital business is in the nascent stage may adopt a balanced strategy, consolidating their traditional business while actively investing in digital development. Firms whose traditional business is in decline but whose digital business is progressing may adopt a transformational strategy, devoting resources primarily to the rapid expansion of digital business. With such a strategic plan, SMEs in Shandong Province can choose the right path according to their transformation stage, achieve smooth and effective digital transformation, and lay a solid foundation for sustainable growth in the future.

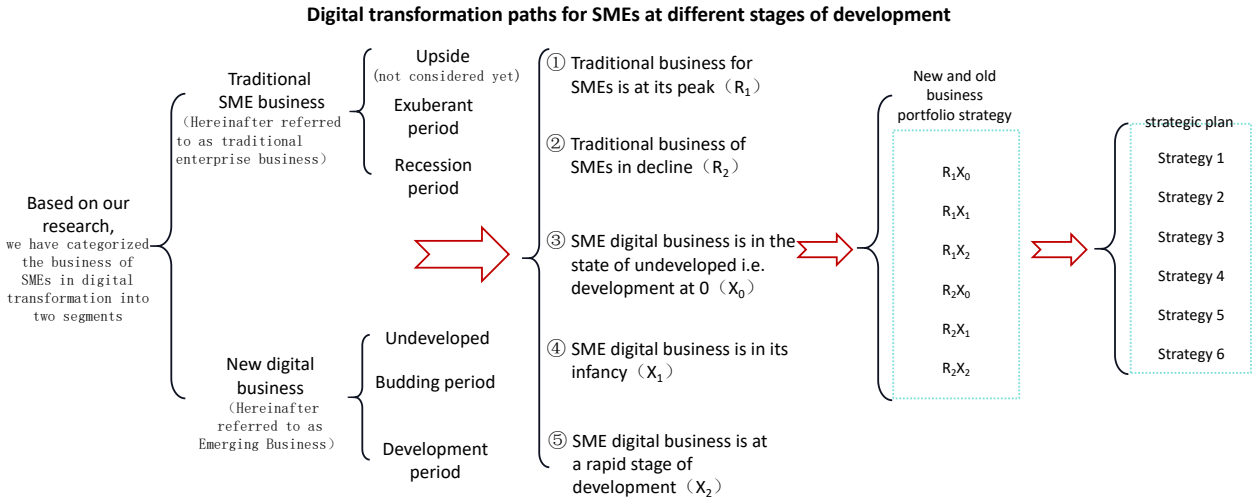

Figure 3: Digital transformation paths for SMEs at different stages of development

8 Policies and Recommendations for Digital Transformation for Businesses and Governments at Different Stages of Development

8.1 Comparative Data Before and After Policy Implementation

According to the latest data from the Department of Industry and Information Technology of Shandong Province (2023), the number of SMEs participating in digital transformation increased significantly after the implementation of relevant policies. Specifically, participation rose by 40%, while the success rate of digital transformation improved by 25% compared with the period prior to policy implementation. These figures directly reflect the positive impact of government policies in promoting digital transformation among SMEs.

8.2 Policy Satisfaction Survey Data

The Policy Satisfaction Survey conducted in 2023 revealed that more than 70% of the enterprises interviewed were satisfied with the policy support provided by the government, particularly in terms of tax incentives and capital subsidies. However, about 20% of enterprises noted that policy dissemination and interpretation were insufficient, suggesting that the government should strengthen policy communication and guidance.

8.3 Policy Recommendations

To further enhance the effectiveness of digital transformation for SMEs, the following recommendations are proposed:

Enhance policy advocacy and education: The government should increase policy visibility and understanding through seminars, online platforms, and media campaigns. This includes organizing regular seminars on digital transformation, providing online educational resources and training, and publicizing success stories and policy advantages through media channels.

Provide customized support: The government should tailor digital transformation support and resources to enterprises at different stages of development. For example, basic digital tools and training should be provided to start-ups, while advanced technical and market analysis support should be available for mature enterprises.

Establish a feedback mechanism: The government should implement an effective feedback system to collect and respond to enterprise feedback in a timely manner through systematic surveys, workshops, and consultation meetings. This will enable timely policy adjustments and ensure that policies remain aligned with business needs and market dynamics.

8.4 Purpose and Role of Government Satisfaction Surveys

The purpose of government satisfaction surveys is to assess the effectiveness of existing policies, measure enterprises' satisfaction with these policies, and collect specific suggestions for policy improvement. The results of such surveys provide valuable information for governments, helping them identify shortcomings in policy implementation, optimize resource allocation, and enhance the relevance and effectiveness of policies. By conducting these surveys, governments are better able to understand the needs and challenges faced by enterprises in the process of digital transformation, thereby formulating policies that are more aligned with practical requirements.

8.5 Government Guidance and Incentives

Governments play a crucial role in the digital transformation of SMEs and should continue to provide incentives such as tax concessions and capital subsidies to reduce transformation costs. They should also strengthen digital infrastructure development, for example by enhancing broadband network coverage and promoting the application of cloud computing and big data centers, thereby lowering both cost and technological barriers for SMEs. In addition, governments need to further raise policy visibility through seminars, online platforms, and media campaigns, provide tailored support for digital transformation, and establish effective feedback mechanisms to ensure that policies remain responsive to business needs and market changes.

8.6 Enterprise Top-Level Design and Risk Management

Enterprises need to establish top-level design during digital transformation to unify understanding and secure support at the decision-making level. Senior managers should participate collectively in the decision-making process to ensure that digital transformation strategies are consistent with overall corporate strategy, and that resources are allocated appropriately to support implementation. At the same time, enterprises should develop a risk management mechanism to identify and mitigate potential technological, market, and operational risks. This includes risk assessment, the formulation of response strategies, and the establishment of monitoring mechanisms, in order to guarantee the robustness and sustainability of the transformation process.

9 Conclusion and Outlook

9.1 Summary of the Study

This study thoroughly explores the realization path of SMEs in Shandong Province in the process of digital transformation and reveals the micro-mechanisms of SMEs' digital transformation by integrating key internal drivers and positive external influences through the "dual double support" model. The findings indicate that internal management optimization, technological innovation, market positioning, and supply chain management are central internal factors driving digital transformation, while government policies, market demand, and industry chain synergy are critical external drivers. Through the application of the DEMATEL model, this study further clarifies the interactions and influences between internal and external factors, providing a theoretical basis and practical guidance for enterprises to develop targeted digital transformation strategies. Moreover, differentiated transformation paths are proposed for enterprises at different stages of development, assisting them in achieving smooth and effective digital transformation.

Supported by empirical data, the study summarizes the strength of the impact of key factors on digital transformation. Specifically, 76% of companies that implemented internal management optimization reported significantly faster transformation processes. Companies with higher investments in technological innovation achieved a 54% higher digital transformation success rate than the industry average. Enterprises with accurate market positioning increased customer satisfaction by 30%, while those with optimized supply chain management performed better in cost control, with an average cost saving rate of 25%. Regarding external factors, companies that received policy support achieved a 40% higher ROI compared with those without support. Firms that responded most rapidly to market changes grew their market share by 15%, while enterprises collaborating with partners in digital transformation improved supply chain efficiency by 28%. These results directly reflect the positive role of government policies in promoting digital transformation among SMEs and highlight the central role of internal management optimization and technological innovation in enhancing competitiveness and market position. Overall,

SMEs in Shandong Province must focus on internal management optimization and technological innovation while actively responding to external policies and market demand in order to achieve successful digital transformation.

9.2 Theoretical and Practical Implications of the Study

At the theoretical level, this study enriches the micro-level theory of digital transformation of SMEs, especially by explaining the mechanisms through which internal and external factors interact in the transformation process. The proposal of the "dual double support" model offers a new perspective for understanding SME transformation behavior in complex environments. At the practical level, the study provides specific transformation paths and strategies for SMEs in Shandong Province, helping them identify key factors and potential obstacles, and thereby formulate more effective transformation plans. In addition, the suggestions for differentiated transformation paths provide enterprises with strategies to flexibly respond to market changes and enhance competitiveness and adaptability in the digital economy era.

9.3 Research Limitations and Future Research Directions

Although this study provides valuable insights and recommendations, it has several limitations. First, the sample is limited to SMEs in Shandong Province, which may reduce the generalizability of the findings. Future studies may expand the sample to include SMEs from different regions and industries to improve representativeness. Second, the study mainly focuses on the current status and short-term effects of digital transformation, with insufficient exploration of long-term impacts. Future research should emphasize longitudinal tracking of digital transformation and assess the lasting influence of transformation strategies. Finally, as digital technologies continue to evolve, new transformation factors and patterns may emerge. Therefore, future studies should continuously monitor technological developments and investigate their potential impact on SMEs' digital transformation. These directions will deepen understanding and provide stronger support for the sustainable digital transformation of SMEs.

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