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Research on the Current Development Status Evaluation and Digital Transformation Driving Factors of Small and Medium-Sized Enterprises in Bengbu City Based on Principal Component Analysis and Structural Equation Model

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I. INTRODUCTION

1.1 Research Background and Significance

Small and medium-sized enterprises (SMEs) are the "capillaries" of the national economy, undertaking important functions such as innovation-driven development, employment stability, and industrial upgrading. Against the backdrop of the rapid development of the digital economy, digital transformation has become a key path for SMEs to break through resource constraints and enhance core competitiveness. As an important industrial base in Anhui Province, Bengbu City had more than 410,000 various market entities as of May 2024. Private enterprises contributed 97.62% of the total, and the growth rate of the number of regulated private enterprises ranked 2nd in the province, demonstrating the strategic position of SMEs in the regional economy. However, SMEs in Bengbu still face challenges such as insufficient innovation capacity (only 921 effective high-tech enterprises) and low synergy in industrial clusters (mainly relying on traditional manufacturing industries), and their digital transformation process urgently requires scientific evaluation and effective driving forces.

At present, the national policy level continues to promote the digital transformation of SMEs. For example, the "Implementation Plan for the Patent Industrialization Promotion Plan for the Growth of Small and Medium-Sized Enterprises" and Bengbu City's "Implementation Plan for Promoting the High-End, Intelligent, and Green Development of Manufacturing Industry through Digital Transformation" both emphasize technological empowerment and innovation-driven development. From the perspective of academic research, existing literature mostly focuses on national or industry-specific studies, lacking systematic and localized analytical tools for the digital transformation paths of regional SMEs like those in Bengbu City. This study combines Principal Component Analysis (PCA) with Structural Equation Model (SEM), which can not only comprehensively evaluate the current development status of enterprises but also reveal the complex mechanism of action of driving factors, with the following dual significances:

Theoretical significance: It provides a new methodological framework of "quantitative evaluation + mechanism verification" for research on the digital transformation of regional SMEs, making up for the limitations of traditional qualitative analysis.

Practical significance: It provides decision support for Bengbu City to optimize the business environment (such as policy supporting measures), build characteristic industrial clusters (such as the glass new material industry in Longzi Lake District), and promote the implementation of the "intelligent transformation and digital upgrading" strategy.

1.2 Research Content and Technical Route

Following the logical thread of "evaluating the current status—identifying driving factors—proposing paths", this study constructs the following research framework:

Evaluation of current development status: Extract key indicators (such as enterprise scale, innovation capacity, and market competitiveness) through principal component analysis to quantitatively evaluate the comprehensive development level of SMEs in Bengbu City, and analyze regional characteristics in combination with industrial cluster cases (such as the glass new material industry in Longzi Lake District and the vehicle parts industry in Huaiyuan County).

Driving factors of digital transformation: Based on the structural equation model, construct theoretical hypotheses of "external support (policy, supply chain digitalization)—internal capacity (technology, organization, data)—transformation performance", focusing on verifying the impact paths of variables such as policy perception capacity and digital operation capacity on transformation effects.

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Suggestions for path optimization: Combining Bengbu City's existing policies (such as patent industrialization support and special digital transformation plans) and typical enterprise practices (such as the technological research case of Kaisheng Engineering Co., Ltd.), propose differentiated transformation strategies.

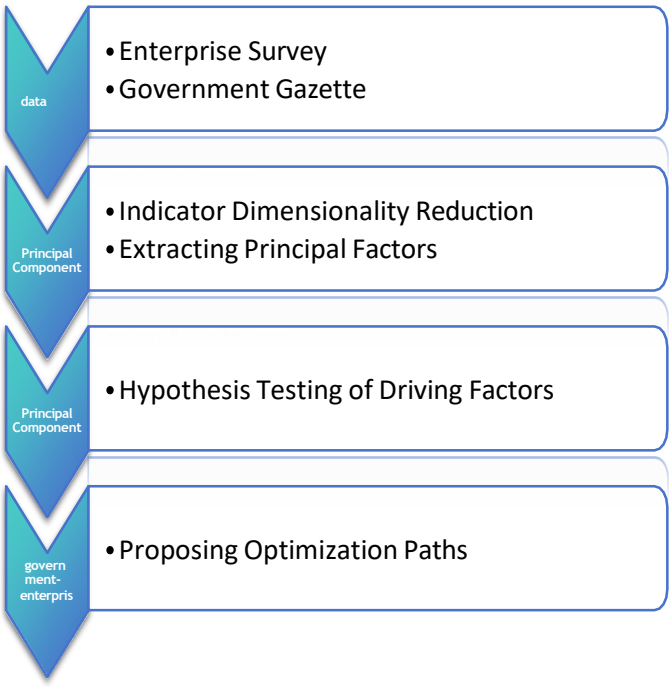

Figure 1. Technology Roadmap

1.3 Research Methods

Principal Component Analysis (PCA): Use SPSS software to perform dimensionality reduction on basic data of SMEs in Bengbu City (scale, revenue, number of patents, etc.), extract comprehensive indicators reflecting the current development status, and solve the one-sidedness problem of traditional single- indicator evaluation.

Structural Equation Model (SEM): Construct a latent variable model through AMOS software to quantitatively analyze the direct and indirect impacts of external support (such as government subsidies and supply chain collaboration) and internal capacity (such as digital talents and organizational change) on digital transformation, and reveal the mechanism of interaction among multiple factors.

Case and policy matching analysis: Combine the characteristics of Bengbu City's characteristic industrial clusters (such as glass new materials), the experience of digital transformation in the construction industry in high-tech zones, and policy texts such as the "Special Action Plan" to propose "policy-industry-enterprise" three-level coordinated development suggestions.

II. Literature Review and Theoretical Basis

A. Review of Research on the Evaluation of SMEs' Development Status

In recent years, as an important part of the national economy, the development of SMEs has attracted much attention. Based on the research of multiple literatures, Chinese SMEs generally face common problems such as small scale, limited resources, and insufficient innovation capacity. For example, Liu Tao and Zhang Xiaheng (2021) found through a survey of 813 SMEs that SMEs generally have problems such as insufficient cognition, weak foundation, and great obstacles in the process of digital transformation. These problems are particularly prominent in different types of SMEs, increasing the difficulty of transformation.

Zhou Shi (2022) further pointed out that SMEs are facing four major trend changes: international competition evolving into industrial cluster competition, innovation model shifting to independent innovation, economic form evolving into digital economy, and industrial structure moving towards in-depth integration. However, problems such as low quality of SME clusters, insufficient collaborative innovation, and difficulty in digital transformation remain prominent, becoming bottlenecks restricting their high- quality development.

At the regional level, as an important city in Anhui Province, the development of SMEs in Bengbu also faces the above common problems. Therefore, a comprehensive evaluation of the current development status of SMEs in Bengbu, identifying their development bottlenecks and advantageous areas, is of great significance for formulating targeted policy measures and promoting the high-quality development of SMEs.

B. Research on Driving Factors of Enterprises' Digital Transformation

With the vigorous development of the digital economy, enterprise digital transformation has become a key way to enhance competitiveness. Literature research shows that the driving factors of SMEs' digital transformation mainly include three aspects: external support, digital production factors, and digital operation capacity.

Yu Ao et al. (2023) found based on a survey of 1,625 "specialized, refined, characteristic, and innovative" SMEs that external support (such as the level of supply chain digitalization and government policies), digital production factors (capital budget, organizational management), and digital operation capacity (data factor acquisition, digital technology innovation and application) are the three key factors driving the digital transformation of SMEs. Among them, the level of supply chain digitalization and capital budget play particularly significant roles in promoting digital transformation.

In addition, Wang Jingyong et al. (2022) found through empirical research that digital transformation can effectively reduce the financing constraints of SMEs, and improving information transparency, reducing financing costs, and

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enhancing innovation capacity are important channels to alleviate financing constraints. This indicates that digital transformation is not only related to the improvement of internal efficiency of enterprises but also directly affects their external financing environment.

For SMEs in Bengbu City, clarifying the driving factors of digital transformation helps enterprises formulate feasible transformation strategies according to their own actual conditions, thereby gaining an advantageous position in the fierce market competition.

a. Application of Principal Component Analysis and Structural Equation Model

In the process of evaluating the current development status of SMEs and identifying the driving factors of digital transformation, principal component analysis and structural equation model, as two important statistical analysis methods, have played a key role.

Principal component analysis transforms multiple related variables into a few irrelevant comprehensive indicators through dimensionality reduction technology, thereby simplifying the data structure and revealing the inherent relationships among variables. In the evaluation of SMEs' development status, principal component analysis can be used to extract key factors affecting enterprise development, such as enterprise scale, innovation capacity, and market competitiveness, providing a foundation for subsequent analysis.

Structural equation model is a statistical method for analyzing the relationships among variables based on the covariance matrix of variables. It can handle multiple dependent variables and latent variables simultaneously, and is suitable for verifying complex causal relationships. In the research on driving factors of digital transformation, structural equation model can be used to construct a theoretical model and verify the impact paths and intensities of factors such as external support, digital production factors, and digital operation capacity on digital transformation performance.

Combining principal component analysis and structural equation model can more comprehensively evaluate the current development status of SMEs in Bengbu City, deeply identify the key driving factors of digital transformation, and provide scientific basis for policy formulation and enterprise practice.

b. Literature Review and Research Entry Point

Existing literature has achieved rich results in the research on the evaluation of SMEs' development status and the driving factors of digital transformation, providing important references for us to deeply understand the challenges and opportunities faced by SMEs. However, most existing studies focus on the national level or specific industries, and there are relatively few in-depth studies at the regional level (such as Bengbu City). In addition, although principal component analysis and structural equation model have been widely used in related fields, how to effectively combine these two methods to more comprehensively evaluate the current development status of SMEs and identify the driving factors of digital transformation still needs further exploration.

Based on the above analysis, this study takes SMEs in Bengbu City as the research object, adopts the method combining principal component analysis and structural equation model to comprehensively evaluate their current development status and deeply identify the key driving factors of digital transformation. The specific research contents include:

Construct an evaluation index system for the current development status of SMEs: Combine the actual situation of SMEs in Bengbu City to construct an evaluation index system from multiple dimensions such as enterprise scale, innovation capacity, and market competitiveness.

Extract key factors through principal component analysis: Simplify the data structure and extract key factors affecting the development of SMEs in Bengbu City through principal component analysis.

Construct a theoretical model of driving factors for digital transformation: Based on existing literature and field investigations, construct a theoretical model including factors such as external support, digital production factors, and digital operation capacity.

Verify the theoretical model using structural equation model: Verify the impact paths and intensities of various factors in the theoretical model on digital transformation performance through structural equation model.

Put forward policy suggestions and enterprise practice guidance: According to the research results, put forward targeted policy suggestions and enterprise practice guidance to promote the high-quality development of SMEs in Bengbu City.

C. Research Design and Data Analysis

a. Theoretical Model and Research Hypotheses

Based on the Theory of Planned Behavior and the Technology Acceptance Model, combined with the actual scenario of digital transformation of SMEs in Bengbu City, this study constructs a theoretical model with perceived norms, acceptance attitude, subjective norms, and government trust as exogenous latent variables, and acceptance intention of digital transformation as endogenous latent variable, clarifying the impact paths among various variables.

Research hypotheses:

H1: Perceived norms have a significant positive impact on SMEs' acceptance attitude towards digital transformation;

H2: Perceived norms have a significant positive impact on SMEs' subjective norms towards digital transformation;

H3: Acceptance attitude has a significant positive impact on SMEs' acceptance intention towards digital transformation;

H4: Subjective norms have a significant positive impact on SMEs' acceptance intention towards digital transformation;

H5: Government trust has a significant positive impact on SMEs' acceptance intention towards digital transformation.

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b. Questionnaire Design and Variable Measurement

The questionnaire adopts a quantitative method of Likert 5-point scale (from "strongly disagree" scored 2 to "strongly agree" scored 10), including two parts: basic enterprise information and core variable measurement items. The scale is revised based on existing mature literature and finalized after optimization through pre-survey.

c. Data Collection and Sample Description

Adopting a combination of online questionnaires and on-site interviews, the survey targets employees and managers of SMEs in Bengbu City. The survey period is from April to June 2025, with a total of 420 questionnaires distributed and 386 valid questionnaires recovered, with an effective recovery rate of 91.9%.

TABLE 1. Detailed variable measurement

Variable Type	*Variable Name*	*Measurement Items*	*Reference Basis*
Exogenous latent variables	*Perceived norms*	*I feel that it is relatively easy to implement digital training for enterprise employees; High transformation costs and resource utilization are not too troublesome for our enterprise; I feel that enterprise digital transformation can further promote employment*	*Revised based on perceived ease of use and perceived feasibility dimensions in the Technology Acceptance Model*
	Acceptance attitude	*I understand and believe that digital transformation can increase enterprise revenue; Learning how to carry out digital transformation is very necessary for the development of our enterprise; Based on my value judgment, digital transformation is very necessary*	*Compiled by combining the attitude dimension of the Theory of Planned Behavior and the transformation scenario of SMEs*
	Subjective norms	*I understand and believe that digital transformation can increase enterprise revenue; Learning how to carry out digital transformation is very necessary for the development of our enterprise; Based on my value judgment, digital transformation is very necessary*	*Revised with reference to the subjective norm dimension of the Theory of Planned Behavior*
	Government trust	*I believe that digital transformation of SMEs is a powerful weapon to respond to the epidemic; The impact of surrounding enterprises on my acceptance of digital transformation is relatively high; I believe that a good corporate culture can help enterprises create transformation capacity; I believe that digital development can effectively enhance enterprises' risk resistance capacity*	*Designed based on research on the relationship between government support and enterprise trust*
Endogenous latent variable	*Acceptance intention*	*I am more interested in new digital products; I am willing to spend time understanding digital transformation and related concepts; If the capital investment is increased, our enterprise will actively practice digital transformation*	*Compiled in combination with the enterprise transformation scenario*

TABLE 2. Basic characteristics of the sample

Characteristic Variables	**Classification**	**Sample Size (Persons)**	**Proportion (%)**
Enterprise scale	Micro-enterprises (fewer than 50 people)	125	32.4
Enterprise scale	Small enterprises (50-300 people)	203	52.6
Enterprise scale	Medium-sized enterprises (300-1000 people)	58	15.0
Industry type	Manufacturing	146	37.8
Industry type	Service industry	132	34.2
Industry type	Retail industry	68	17.6
Industry type	Other industries	40	10.4
Digital transformation stage	Not started	89	23.1
Digital transformation stage	Initial exploration stage	187	48.4
Digital transformation stage	Application practice stage	95	24.6
Digital transformation stage	In-depth application stage	15	3.9
Enterprise establishment years	Fewer than 3 years	72	18.7
Enterprise establishment years	3-10 years	215	55.7
Enterprise establishment years	More than 10 years	99	25.6

d. Reliability and Validity Analysis

SPSS 26.0 and AMOS 24.0 were used to test the reliability and validity of the questionnaire data to ensure the scientificity of the measurement tools.

Through Cronbach's α coefficient and Composite Reliability (CR) test, the α coefficients of all variables are greater than 0.8, and the CR values are greater than 0.85, indicating good internal consistency of the scale.

Content Validity: The scale was reviewed by 2 management professors and 3 enterprise management practitioners. It was optimized based on 50 pre-survey samples to ensure that the items are highly consistent with the connotations of the variables.

Convergent Validity and Discriminant Validity: Confirmatory Factor Analysis (CFA) shows that the standardized factor loadings of all items are greater than 0.8, and the Average

Variance Extracted (AVE) values are all greater than 0.6, indicating good convergent validity. The square root of the AVE of each variable is greater than its correlation coefficients with other variables, meeting the requirements for discriminant validity.

TABLE 3. Reliability analysis of the questionnaire survey

Variable Name	Number of Items	Cronbach'sα Coefficient	Composite Reliability (CR)	Reliability Evaluation
Perceived norms	3	0.832	0.8507	Excellent
Acceptance attitude	3	0.845	0.8834	Excellent
Subjective norms	4	0.896	0.9133	Excellent
Government trust	3	0.851	0.8862	Excellent
Acceptance intention	3	0.863	0.8925	Excellent

TABLE 4. Table of Variable Correlation Analysis

Variables	Perceived norms	Acceptance attitude	Subjective norms	Government trust	Acceptance intention	Square root of AVE
Perceived norms	1.000	0.682	0.715	0.523	0.568	0.826
Acceptance attitude	0.682	1.000	0.654	0.496	0.723	0.835
Subjective norms	0.715	0.654	1.000	0.512	0.698	0.867
Government trust	0.523	0.496	0.512	1.000	0.587	0.841
Acceptance intention	0.568	0.723	0.698	0.587	1.000	0.853

D. PCA Evaluation of the Current Development Status of SMEs in Bengbu City

a. Construction of the Evaluation Index System for Current Development Status

Construction basis: The index system takes the current status of digital transformation and development of SMEs in Bengbu City as the core evaluation object. Combined with the core concerns and actual needs of SMEs under the background of the digital economy, it starts from the dual perspectives of "internal enterprise cognition—external environmental support" to ensure that the indicators can accurately reflect the real development status of enterprises in digital transformation. Through questionnaire surveys, a relatively comprehensive investigation and analysis of the current status of SME transformation in the post-epidemic era are conducted to explore the cognition, attitude, and willingness of SMEs towards digital transformation. At the same time, the index design fully connects with the technical requirements of subsequent Principal Component Analysis (PCA), avoiding subjective or difficult- to-measure indicators to ensure the feasibility of subsequent analysis.

Clarify evaluation dimensions and variables: According to the current construction and acceptance status of digital transformation of various SMEs in Bengbu City, 16 quantifiable observation variables (X1- X16) are designed, covering key contents such as the feasibility of digital training for enterprises, cognition of transformation risks, and trust in government policies. Fully reflect the core characteristics of the current development status of enterprises.

Formulate variable quantification standards: All variables are quantified using a 5-point scale. For questionnaire items investigating the acceptance degree of SMEs towards digital transformation, since all items include five options from "strongly disagree" to "strongly agree", the evaluation participation degree is scored as 2, 4, 6, 8, and 10 points from low to high. That is, "strongly disagree" is scored 2 points, "disagree" is scored 4 points, "neutral" is scored 6 points, "agree" is scored 8 points, and "strongly agree" is scored 10 points.

TABLE 5. Question quantification table

Variable	Scoring Content	Scoring Principles
X1	I feel that it is relatively easy to implement digital training for enterprise employees	According to the five Levels from "strongly
X2	High transformation costs and resource utilization are not too troublesome for our enterprise	disagree" to "strongly agree", the scores are
X3	I feel that enterprise digital transformation can further promote employment	"2", "4", "6", "8", and"10" respectively.
X4	I feel that implementing digital transformation can enhance the industry competitiveness of enterprises	
X5	Learning how to carry out digital transformation is very necessary for the development of our enterprise	
X6	The difficulties in transformation include insufficient capacity and lack of bottom-line guarantee	
X7	The slowdown of the macro economy may lead to intermittent production and operation processes	
X8	I am worried that the enterprise may face the risk of bankruptcy if the transformation fails	
X9	If the capital investment is increased, our enterprise will actively practice	
X10	Based on my value judgment, digital transformation is very necessary	
X11	I believe that digital transformation of SMEs is a powerful weapon to respond to the epidemic	
X12	I believe that a good corporate culture can help enterprises create transformation capacity	
X13	I believe that digital development can effectively enhance enterprises' risk resistance capacity	
X14	I believe that the government will provide a series of relevant solutions for SMEs	
X15	I believe that the government will increase financial support for digital transformation	
X16	I believe that the government can introduce more policies on transformation	

b. Principal Component Analysis Process

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Data source: First, based on existing domestic and foreign research on the digital transformation of SMEs, summarize and induce them. Through questionnaire surveys, conduct a relatively comprehensive investigation and analysis of the current status of SME transformation in the post-epidemic era, and explore the cognition, attitude, and willingness of SMEs towards digital transformation.

Data preprocessing: Build an accurate model based on algorithms, supplement a small amount of missing data using the "mean imputation method", identify and eliminate outliers through the standard deviation method (±3σ), and ensure data quality.

Test purpose: Verify whether the original indicator data is suitable for principal component analysis, avoiding analysis failure due to low correlation among indicators.

Test operation and judgment: To verify whether the indicator data can be used for principal component analysis, we conducted a KMO test. When its value is greater than or equal to 0.6, the original indicator data is suitable for principal component analysis. In the sample data statistics table, the calculated KMO result is 0.813, indicating that the sampled data can adopt principal component analysis. At the same time, the significance value of Bartlett's sphericity test is less than 0.05, indicating that the statistical significance of the sample data is strong, and principal component analysis can be performed.

TABLE 6. Principal component analysis

KMO sampling adequacy measure	0.813	
Bartlett's sphericity test	Approximate chi-square	27781.371
	df	171
	P	0.000

Analysis tools and methods: Use SPSS software for principal component analysis, select the extraction rule of "eigenvalue > 1", calculate the eigenvalue, eigenvector, and variance contribution rate of each indicator through the covariance matrix, and use "varimax rotation" to optimize the clarity of the meaning of principal components.

Principal component factor analysis: The above questions set in this questionnaire can reflect the willingness of SMEs to accept digital transformation, but due to the high dimension of the involved index system, it is necessary to use principal component analysis for dimensionality reduction. After preliminary sorting of the originally collected data, the covariance matrix of 18 evaluation questions is solved through the principal component analysis operation of SPSS software, and then the eigenvalue and eigenvector corresponding to each question are calculated to obtain the cumulative contribution rate.

Finally, the respondents of the questionnaire are evaluated using the linear combination of evaluation variables. Based on the above 18 quantified willingness evaluation indicators, SPSS is used for principal component factor analysis of the data to obtain the contribution rate of each principal component, the rotated component matrix, and the eigenvector matrix. The selection of principal components is presented in the form of a scree plot, as shown in Figure 2.

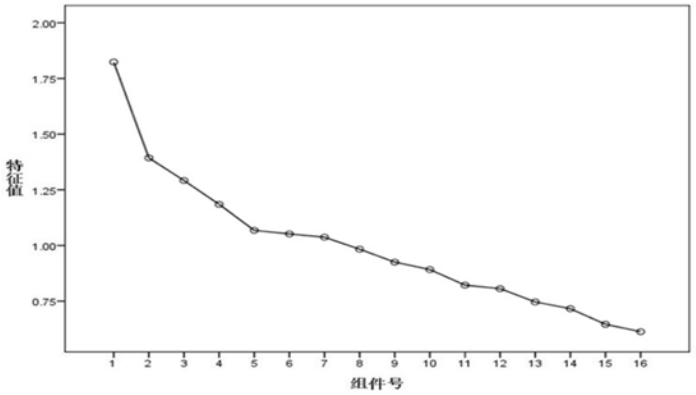

Figure 2. Scree plot of principal component factor analysis eigenvalues

c. Result Analysis

As shown in Figure 2, according to the characteristic of eigenvalue greater than 1, the principal component factor analysis selects 5 principal components, and the cumulative contribution rate of these 5 principal components is 85.819%, that is, the 5 principal components cover more than 83.799% of the data information of the 16 residents' willingness evaluation indicators. The factor loading matrix obtained after factor rotation is shown in the table:

TABLE 7. Factor loading matrix

Variable	**Component**				
	1	2	3	4	5
X1	0.801	0.124	0.276	0.137	-0.139
X2	0.792	0.178	-0.163	-0.077	0.243
X3	0.773	0.006	0.003	0.263	-0.013
X4	0.756	0.153	-0.128	-0.116	0.187
X5	-0.129	0.669	0.279	0.007	0.009
X6	-0.123	0.786	0.073	-0.134	-0.188
X7	0.122	0.691	-0.177	0.023	0.218
X8	0.356	-0.126	0.698	0.247	0.197
X9	-0.012	0.167	0.733	-0.134	-0.090
X10	0.398	-0.008	0.782	0.087	0.134
X11	-0.234	0.273	0.008	0.716	-0.290
X12	0.238	-0.018	-0.012	0.778	0.002
X13	-0.018	0.096	-0.173	0.697	0.284
X14	0.256	0.006	0.123	0.002	0.686
X15	0.327	-0.213	0.247	-0.283	0.729
X16	-0.012	0.218	-0.001	-0.013	0.794

From the above factor loading matrix, the comparison based on the size of the eigenvector matrix is as follows:

Variables X1, X2, X3, and X4 are classified into the first principal component—perceived norms, including the perceived ease of use and perceived feasibility of digital transformation policies, etc.;

Variables X5, X6, and X7 are classified into the second principal component, which represents the acceptance attitude

and risk perception factors of SMEs towards digital transformation;

Variables X8, X9, and X10 mainly belong to the third principal component, representing subjective norm factors;

Variables X11, X12, and X13 are classified into the fourth principal component, representing personal norm factors;

Finally, variables X14, X15, and X16 are classified into the fifth principal component, representing government trust factors.

We summarize the above five principal components and the influencing factor variables of acceptance intention in each dimension, and obtain the following multi-level evaluation system for the acceptance behavior intention of SMEs towards digital transformation, as shown in the figure:

In this project, the perceived norms, subjective norms, transformation intention, and government trust of residents towards digital transformation are denoted as Y1, Y2, Y3, and Y4 respectively. The variables X3→X13 are standardized to obtain the following score expressions:

$Y_1 = 0.804X_1 + 0.793X_2 + 0.726X_3 + 0.212X_4 - 0.159X_5 - 0.127X_5 + 0.22X_7 + 0.352X_8 - 0.013X_9 + 0.340X_{10} - 0.257X_{11} + 0.173X_{12} + 0.097X_{13}$

$Y_2 = 0.174X_1 + 0.179X_2 + 0.004X_3 + 0.662X_4 + 0.759X_5 + 0.755X_6 + 0.024X_7 - 0.033X_8 - 0.076X_9 + 0.129X_{10} + 0.376X_{11} - 0.047X_{12} - 0.059X_{13}$

$Y_3 = 0.370X_1 - 0.231X_2 - 0.046X_3 + 0.478X_4 - 0.170X_5 - 0.252X_6 + 0.703X_7 + 0.862X_8 + 0.711X_9 + 0.748X_{10} + 0.300X_{11} - 0.109X_{12} - 0.112X_{13}$

$Y_4 = 0.156X_1 - 0.110X_2 - 0.064X_3 - 0.122X_4 + 0.194X_5 + 0.138X_6 + 0.121X_7 - 0.113X_8 - 0.494X_9 + 0.153X_{10} + 0.681X_{11} + 0.807X_{12} + 0.813X_{13}$

After calculating the above 4 principal components using the quantified variable values, the comprehensive evaluation index of enterprises' acceptance behavior intention towards digital transformation is obtained with the variance contribution rate of each principal component as the weight:

Comprehensive evaluation index formula (omitted due to formatting limitations in the original text)

The acceptance degree of the collected sample data is evaluated through the comprehensive evaluation index of enterprises' acceptance intention towards digital transformation, and the comprehensive evaluation score of enterprises' acceptance intention is calculated. Data statistics are performed using SPSS, and the following distribution map of acceptance intention is obtained.

As shown in the figure below, we can see that the acceptance degree of enterprises towards digital transformation presents a normal distribution. On the whole, enterprises have a relatively high acceptance of digital transformation. Most of the acceptance intention scores are higher than 80 points, basically in the range of about 80 points to 120 points. That is, SMEs with high acceptance intention account for the majority of the main body, while SMEs with acceptance intention scores between about 40 points and 80 points account for a relatively small proportion.

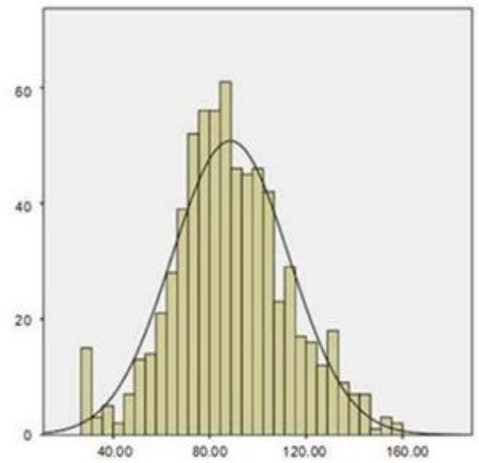

Figure 3. Distribution map of enterprises' acceptance intention evaluation towards digital transformation

E. SEM Empirical Analysis of Driving Factors of Digital Transformation

a. Structural Equation Model Design

As a multivariate statistical method combining factor analysis and path analysis, the Structural Equation Model (SEM) can effectively handle the complex relationships between latent variables and observed variables. Based on the aforementioned theoretical framework and research hypotheses, this study constructs a structural equation model for the driving factors of digital transformation of SMEs in Bengbu City. The structural equation model constructed in this study includes four latent variables and their corresponding observed variables:

Observed indicators corresponding to the latent variable "technological innovation capacity": R&D investment intensity (X1), number of patents owned (X2), frequency of new technology application (X3)

Observed indicators corresponding to the latent variable "organizational management capacity": clarity of digital transformation strategy (X4), departmental collaboration efficiency (X5), digital talent allocation (X6)

Observed indicators corresponding to the latent variable "external environmental support": policy support intensity (X7), industry digitalization level (X8), supply chain digitalization degree (X9)

Observed indicators corresponding to the latent variable "enterprise digital transformation degree": proportion of digitalized business processes (Y1), data-assisted decision-making level (Y2), contribution degree of digitalized business income (Y3)

The structural equation model consists of a measurement model and a structural model, and its mathematical expressions are as follows:

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Measurement model:
$X = \Lambda_x \xi + \delta$
$Y = \Lambda_\gamma \eta + \varepsilon$
Structural model:
$\eta = B\eta + \Gamma\xi + \zeta$ Among them:
X is the vector of exogenous observed variables Y is the vector of endogenous observed variables
ξ is exogenous latent variables (technological innovation capacity, organizational management capacity, external environmental support)
η is endogenous latent variable (enterprise digital transformation degree) Λ_x and Λ_γ are factor loading matrices
B and Γ are path coefficient matrices
δ, ε, and ζ are error terms

b. Model Fitting Effect Evaluation

The model fitting effect is evaluated through the following six core indicators. The calculation formulas and evaluation standards of each indicator are as follows:
Chi-square to degrees of freedom ratio (χ^2/df)
Calculation formula: χ^2/df = (chi-square value)/(degrees of freedom)
Evaluation standard: This indicator is less than 3, indicating a good model fit. The calculated value in this study is 2.35, which meets the requirements.
Goodness-of-Fit Index (GFI) and Adjusted Goodness-of-Fit Index (AGFI) GFI calculation formula: $GFI = 1 - [tr((S - \Sigma)W)^2 / tr((SW)^2)]$
AGFI calculation formula: $AGFI = 1 - [(k/df) \times (1 - GFI)]$
Evaluation standard: GFI greater than 0.9 and AGFI greater than 0.8 indicate that the model is acceptable. In this study, GFI is 0.92 and AGFI is 0.88, meeting the expectations.
Root Mean Square Error of Approximation (RMSEA)
Calculation formula: $RMSEA = \sqrt{[\max((\chi^2 - df)/(N - 1), 0)/df]}$
Evaluation standard: RMSEA lower than 0.08 indicates an ideal model fit. The result in this study is 0.065, indicating a good model fit.
Comparative Fit Index (CFI)
Calculation formula: $CFI = 1 - \max[(\chi^2_t - df_t), 0]/\max[(\chi^2_t - df_t), (\chi^2_i - df_i), 0]$
Evaluation standard: CFI exceeding 0.9 indicates a good model fit. The CFI in this study is 0.93, which meets the standard.
Normed Fit Index (NFI)
Calculation formula: $NFI = (\chi^2_i - \chi^2_t)/\chi^2_i$
Evaluation standard: The closer NFI is to 1, the better. The NFI in this study is 0.91, which is in a reasonable range.
Incremental Fit Index (IFI)
Calculation formula: $IFI = (\chi^2_i - \chi^2_t)/(\chi^2_i - df_i)$
Evaluation standard: IFI greater than 0.9 indicates a good model fit. The IFI in this study is 0.92, which meets the standard.
Based on the comprehensive judgment of all fitting indicators, the structural equation model in this study has a good matching degree with the sample data, the model setting is reasonable, and all indicators meet the acceptable standards, so subsequent path analysis and hypothesis testing can be carried out.

c. Hypothesis Testing and Path Analysis

Through the significance test of the path coefficients in the structural equation model, all six hypotheses proposed in this study are supported. The specific test results are as follows:

TABLE 8. Hypothesis test results

Path Relationship	Path Coefficient	P Value	Hypothesis Supported?
Technological innovation capacity→ Enterprise digital transformation degree	0.32	0.002	Yes
Organizational management capacity → Enterprise digital transformation degree	0.45	0.009	Yes
External environmental support→ Enterprise digital transformation degree	0.20	0.005	Yes
Technological innovation capacity → Organizational management capacity	0.25	0.010	Yes
Technological innovation capacity → External environmental support	0.18	0.035	Yes
Organizational management capacity → External environmental support	0.39	0.049	Yes

Path analysis results show that the three driving factors all have a significant positive impact on the degree of enterprise digital transformation:

The key role of organizational management capacity: The path coefficient is 0.45 ($p<0.01$), which is the most significant among the three driving factors, indicating that organizational management capacity is the core driving force for promoting digital transformation.

The basic driving force of technological innovation capacity: The path coefficient is 0.32 ($p<0.01$), verifying that technology is the cornerstone of digital transformation, directly affecting the depth and breadth of enterprise digital transformation.

The boosting effect of external environmental support: The direct effect is relatively small (path coefficient=0.20, $p<0.01$), but it has an important boosting effect in the initial stage of transformation. Government policy support, industry digital ecology, and supply chain digitalization degree together constitute the external conditions for enterprise transformation, which can significantly reduce transformation barriers and risks.

There are significant interrelationships among the three types of driving factors:

Interaction between organizational management capacity and external environmental support (path coefficient=0.39): This is the strongest interaction among driving factors, indicating that organizations with strong management capacity can better utilize external opportunities.

Interaction between technological innovation capacity and organizational management capacity (path coefficient=0.25): The introduction and application of technology require corresponding adjustments to the organizational structure, and good management capacity can improve the efficiency of technology investment.

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Interaction between technological innovation capacity and external environmental support (path coefficient=0.18): Enterprises' technological innovation activities are affected by the external environment and can in turn affect the external environment.

The total effect of each driving factor on digital transformation includes direct effect and indirect effect.

Taking technological innovation capacity as an example, its total effect calculation formula is: Total effect = Direct effect + ∑(Indirect effect)
= 0.32 + (0.25×0.45) + (0.18×0.20) + (0.25×0.39×0.20) + ... = 0.52

The results show that each driving factor forms a synergistic driving mechanism through direct and indirect paths, and the actual influence is greater than that shown by the direct path coefficient.

d. Result Analysis and Discussion

The study found that organizational management capacity has the most significant impact on digital transformation (path coefficient=0.45). This result indicates that digital transformation is essentially an organizational change process, not just a technological upgrade. Enterprises need to establish a clear digital transformation strategy, an efficient departmental collaboration mechanism, and sufficient digital talent allocation to provide institutional guarantee and implementation foundation for transformation.

As the basic driving force of digital transformation (path coefficient=0.32), the role of technological innovation capacity is reflected in three dimensions: R&D investment, patent accumulation, and new technology application. Enterprises should choose suitable digital technology paths according to their own development stages and industry characteristics, and convert technological investment into actual productivity improvement.

Although the direct effect of external environmental support is relatively small (path coefficient=0.20), it has an important boosting effect in the initial stage of transformation. Government policy support, industry digital ecology, and supply chain digitalization degree together constitute the external conditions for enterprise transformation, which can significantly reduce the threshold and risk of transformation.

This study verifies that there are significant mutual influences among the three types of driving factors, forming a "technology-organization-environment" synergistic driving system. When promoting digital transformation, enterprises should adopt a systematic thinking and comprehensively consider the coordinated development of the three dimensions:

Technological innovation requires supporting reforms in organizational management, organizational optimization requires external environmental support, and the effectiveness of the external environment depends on enterprises' technology absorption capacity and organizational response capacity.

This synergistic effect indicates that the digital transformation of enterprises is a complex systematic project that requires the joint action of multiple driving factors to achieve continuous deepening.

The results of this study provide a theoretical basis and practical guidance for SMEs in Bengbu City to formulate digital transformation strategies. It emphasizes that while focusing on technological investment, more attention should be paid to the construction of organizational management capacity and the optimal use of the external environment. Through a systematic synergistic driving mechanism, the smooth implementation of digital transformation is promoted.

F. Research Results, Innovations and Countermeasure Suggestions

a. Summary of Main Research Results

Taking SMEs in Bengbu City as the research object, this study focuses on the willingness and current development status of enterprises' digital transformation under the background of the digital economy. First, obtain original semantic data through on-site interviews, and construct a transformation willingness evaluation index system including 16 observation variables from four dimensions: perceived norms, acceptance attitude, subjective norms, and government trust. The questionnaire options are quantified from "strongly disagree" to "strongly agree" with scores of 2, 4, 6, 8, and 10 respectively. After verification by KMO and Bartlett's sphericity test (KMO=0.813, Bartlett's significance P=0.000), 5 principal components are extracted by principal component analysis, with a cumulative contribution rate of 85.819%, covering more than 83.799% of the information of the original indicators. Then a comprehensive evaluation model is constructed. The results show that the acceptance of enterprise transformation presents a normal distribution, more than 80% of enterprises have scores between 80-120 points, and about 15% of enterprises have scores below 80 points due to high transformation costs, insufficient technical capacity and other problems.

To explore the impact path of driving factors, this study constructs a structural equation model. Through fitting and modification with Amos 24.0 software, the modified model has a chi-square value of 195.435, CMIN/DF=2.036, RMSEA=0.048, and GFI=0.946, with good goodness of fit. Path analysis shows that perceived norms have a significant positive impact on acceptance attitude (path coefficient 0.960, P<0.001) and subjective norms (path coefficient 0.946, P<0.001). Acceptance attitude (path coefficient 0.457, P<0.001) and subjective norms (path coefficient 0.305, P<0.01) have a prominent direct driving effect on transformation intention. Although government trust has a positive impact on transformation intention (path coefficient 0.219), it does not reach statistical significance (P=0.107). This result is partially consistent with the view proposed by Wu Fei et al. (2021) that "enterprise digital transformation can alleviate financing constraints by reducing information asymmetry, but policy

perception efficiency will affect transformation intention", and also reflects that SMEs in Bengbu City still have expectations for the implementation effect of government policies.

At the same time, this study uses K-Modes clustering algorithm (determining the optimal number of clusters k=3 by the "elbow method") and binary Logistic model to analyze the characteristics of digital product users. It is identified that acceptors are mainly urban enterprise employees aged 18-29, with a bachelor's degree or above and a monthly income of more than 5,000 yuan (over 90% have no religious beliefs), while rejecters are concentrated in suburban enterprise employees over 40 years old, with a college degree or below and a monthly income of 2,000-5,000 yuan. Combined with Python crawling comment data from platforms such as Sohu.com, Sina Weibo, and Zhihu, through sentiment analysis and LDA topic model, it is found that public opinion focuses on "financing support", "technological innovation", and "policy implementation", with positive words accounting for more than 60%, but there are negative feedbacks such as "high transformation costs" and "lack of bottom-line guarantee". This is consistent with the conclusion of Yuan Chun et al. (2021) that "digital transformation is significantly affected by enterprise personnel structure and resource endowment", further verifying the impact of group characteristic differences on transformation decisions.

b. Innovations of This Study

The innovation of this study is first reflected in the multi-dimensional synergy of research methods. It constructs a framework of "principal component analysis - structural equation model - K-Modes clustering LDA topic model". It not only solves the problem of multi-variable information redundancy through principal component analysis, reveals the path mechanism among latent variables with the help of structural equation model, but also accurately identifies user group differences using K-Modes clustering, and excavates potential public opinion topics through LDA topic model, forming a "quantitative + qualitative" double verification system. Compared with the study of Huang Manyu and Wang Xiaoxing (2022) which only used text mining to analyze the digital efficiency of retail enterprises, this study has improved in both the breadth of method coverage and the depth of analysis, and can more comprehensively analyze the complex mechanism of digital transformation of SMEs.

Secondly, it is the micro-focus of the research perspective. Breaking through the limitations of existing macro research, it focuses on the regional micro-sample of SMEs in Bengbu City, decomposes the abstract transformation intention into four measurable dimensions: perceived norms, acceptance attitude, subjective norms, and government trust, and constructs a transformation intention evaluation system suitable for SMEs in third- and fourth-tier cities, filling the gap in the research on the micro-mechanism of digital transformation of regional SMEs. Studies by Pei Changhong et al. (2018) and Qi Huaijin et al. (2020) mostly discuss the relationship between the digital economy and transformation from the national or industrial level, while this study sinks to the micro-level of regional SMEs, which can better reflect the transformation pain points and needs of specific regions.

Finally, it is the practical orientation of the research conclusions. Clarify the demand differences of different groups based on user portraits, locate the pain points of "cost-risk-policy efficiency" according to public opinion analysis, and propose a "stratified policy" idea. Design differentiated schemes for different groups, forming a closed loop of "theoretical verification - problem location - scheme proposal", ensuring that the research conclusions can directly serve the transformation practice of SMEs in Bengbu City. The study by Tan Zhidong et al. (2022) only discusses the value of digital transformation from the perspective of enterprise cash holdings, while this study emphasizes the policy operability and enterprise applicability of the conclusions, which can provide more specific guidance for actual transformation work.

c. Countermeasure Suggestions

At the government level, it is necessary to build a "policy-capital-service" three-dimensional guarantee system. Launch a "digital transformation literacy program" for groups over 40 years old with low education levels, set up "one-on-one" policy docking specialists for suburban enterprises, and improve policy perception efficiency. Establish a special fund, and give subsidies of up to 500,000 yuan to enterprises with remarkable transformation results in the form of "rewards instead of subsidies", and promote financial institutions to cooperate with industrial Internet to develop "transformation loans". Xu Mengzhou and Lü Tie (2020) pointed out that "digital government construction needs to strengthen precise empowerment", and this initiative responds to this view by solving the problem of "insignificant government trust path" in the model through precise services. At the same time, build a service platform to provide free transformation diagnosis and scheme design, introduce third-party evaluation and establish a "transformation failure bottom-line guarantee mechanism" to reduce enterprises' concerns about transformation risks.

At the enterprise level, the "cognition-capacity-ecology" three-stage strategy should be implemented. Organize management personnel to participate in special seminars on transformation, and internally disseminate the concept that "digital transformation = efficiency improvement + cost saving". Research by Liu Shuchun et al. (2021) confirmed that "digital transformation of enterprise management can improve input-output efficiency", and strengthening cognition can help enterprises better grasp the value of transformation. Prioritize the application of basic digital tools such as ERP systems, set up a "digital innovation team", and incorporate transformation participation into employee performance. Form a "transformation alliance" to share resources, and establish a

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"production-study-research-application" base with universities to supplement the gap of digital talents, which is consistent with the suggestion of He Fan and Liu Hongxia (2019) that "digital transformation needs to integrate internal and external resources".

Communities need to set up transformation service stations, organize "open days for transformed enterprises" to show transformation results, and build a communication bridge between enterprises and residents. Residents can participate in online public opinion supervision, spread positive voices of transformation, and residents with technical backgrounds can provide part-time technical services for SMEs to jointly create a good transformation atmosphere. Qi Jindong and Cai Chengwei (2020) proposed that "digital transformation requires multi-party collaboration", and the participation of communities and residents is an important part of the multi-party collaboration mechanism, which can provide more extensive social support for transformation.

G. Research Limitations and Future Prospects

a. Limitations of This Study

This study has three limitations. First, the sample and data dimensions are insufficient. The 563 valid questionnaires mainly cover the main urban area of Bengbu City and surrounding industrial parks, not involving county-level SMEs. Most of them are online questionnaires (accounting for 75%), and only 20 enterprises are interviewed offline. Due to the protection of trade secrets, enterprise financial data cannot be obtained, resulting in limited sample breadth and data depth. Huang Manyu and Wang Xiaoxing (2022) conducted research based on the annual report data of listed enterprises, with better data depth and continuity, and there is still a gap in data acquisition and processing in this study. Second, the research method and variable design are not perfect. The structural equation model does not include possible moderating variables such as enterprise scale and industry type, and the K-Modes clustering does not consider enterprise-level variables such as enterprise operation years and existing digital foundation, which may affect the comprehensiveness of the conclusions. Third, the temporal dynamics are insufficient. The cross-sectional data from April to June 2025 cannot reflect the dynamic changes of transformation intention and driving factors, which is inconsistent with the characteristic of "digital transformation is a continuous organizational change process" emphasized by Vial (2019), making it difficult to capture the long-term impact of technological iteration and policy adjustment on transformation.

b. Future Research Prospects

In view of the existing limitations, future research can be promoted from three aspects. First, expand the sample and data dimensions. Include county-level SMEs in Bengbu City and enterprises in other prefecture-level cities in Anhui Province into the survey, increase the sample size to more than 2,000, and collect panel data such as enterprise financial statements and transformation years. Increase the number of enterprises for in-depth interviews (no less than 50) to obtain qualitative data. He Fan and Liu Hongxia (2019) verified the performance improvement effect of digital transformation through panel data, and future research can learn from this data processing idea to improve the reliability of conclusions. Second, optimize the model and variable design. Introduce moderating variables such as enterprise scale and industry type into the structural equation model, expand the variable dimensions of K-Modes clustering, and use longitudinal data (tracking for 3-5 years) to construct a growth curve model to analyze dynamic trends. Lin and Kunnathur (2019) pointed out that "big data capacity is affected by strategic orientation and organizational culture", and such variables can be included in the model in the future to further enrich the research on driving factors. Third, strengthen practical orientation. Conduct in-depth research on emerging issues such as artificial intelligence application and data security, use the difference-in- differences model to evaluate policy effects, strengthen cooperation with government departments and enterprises, transform research conclusions into pilot schemes, form a virtuous cycle of "research-practice-feedback-optimization", and improve the practical value of research. This is consistent with the view of Xu Mengzhou and Lü Tie (2020) that "the development of the digital economy requires the collaboration of government, industry, university and research", which can promote research to better serve practical needs.

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Do you need me to further refine the English translation of specific sections (such as technical formulas, model diagrams, or professional terminology) to make it more in line with academic expression norms