

Research on Influencing Factors of Local Digital Government Construction under the TOED Framework

Tianyi Zheng

*International Economics and Trade, Henan University of Economics and Law, Zhengzhou, China
3279229975@qq.com*

Abstract. Data factors are gradually becoming the core driving force for the construction of digital government. The traditional TOE (Technology-Organization-Environment) theoretical framework is difficult to highlight the independent value of data as a new factor of production. Therefore, this paper introduces the data dimension on the basis of the classic TOE framework, constructs a four-dimensional TOED analysis framework combining technology, organization, environment and data, and conducts an empirical test with panel data of 31 provincial-level administrative regions in China from 2021 to 2024 as samples. Aiming at the multicollinearity problem among indicators of various dimensions, this paper adopts principal component analysis to reduce the dimensionality of indicators, synthesize a comprehensive index of influencing factors of digital government construction, and then construct a two-way province-year fixed effect model for regression estimation. The results show that the TOED comprehensive index has a significant positive impact on the level of local digital government construction, and the conclusion remains robust after incorporating control variables and adopting province-level clustered robust standard errors, which verifies the research hypothesis that the four-dimensional factors of technology, organization, environment and data can synergistically drive the digital transformation of local governments. This paper expands the theoretical analysis framework of digital government construction, enriches large-sample quantitative empirical evidence in related fields, and provides practical references for all regions to promote digital government construction in an overall manner.

Keywords: digital transformation, digital government, TOED theoretical framework, principal component analysis

1. Introduction and literature review

In the field of research on digital government and government digital transformation, the TOE theoretical framework serves as the mainstream analytical paradigm in academic circles. Scholars such as Gong Wei and Ruan Jiyang [1] systematically analyze the influencing mechanisms of digital government construction and government digital transformation based on the three dimensions of technology, organization, and environment. In these studies, the influence of the data dimension is mostly embedded within the TOE framework: the technology dimension covers the construction level of data platforms, data technical capabilities and other contents, while the organizational

dimension includes organizational readiness, data openness and other factors, without treating data as an independent influencing factor. With the deepening of research on digital governance, the core driving value of data as a new factor of production has become increasingly prominent, and many studies have begun to focus on the independent role of data factors in government digital transformation and digital government construction. Qi Zhiwei [2] points out that data resources are the key element promoting the shift of the Chinese-style modern digital government system from concept to practice, and data resources, data sharing and data governance are core issues in digital government construction. Ning Qi and Tan Jiachao [3] also emphasize that digital government construction needs to address the in-depth integration of digital technology and the digital transformation of government functions, and data factors are an important starting point for promoting the deep coupling of the two. In addition, scholars such as Zhao Juan and Meng Tianguang [4] further propose that digital government construction involves multi-level interactions among technology embedding, organizational restructuring, environmental optimization and data empowerment. Therefore, drawing on the theoretical frameworks of scholars such as Cao Haijun [5] and Yan Linzhi, Zhou Ying [6], this paper incorporates "data" as the fourth independent dimension into the analytical framework, forming an improved TOED theoretical framework to discuss its impact on digital government construction.

The marginal contributions of this paper are as follows. First, the expansion and deepening of the theoretical framework. Most existing studies conduct digital government-related research based on the traditional three-dimensional TOE framework, or embed data factors into the dimensions of technology, organization and environment. Although scholars such as Yan Linzhi and Zhou Ying [6] have constructed a four-dimensional TOED analytical framework for discussion, relevant empirical support still needs to be enriched. On the basis of existing research, this paper further improves the TOED analytical framework, incorporates data factors as an independent dimension into the research system, systematically examines their driving effects on local government digital transformation from four aspects of technology, organization, environment and data, enriches the theoretical research system in the field of digital government, and provides further empirical support for the application of the TOED framework. Second, the supplementation and innovation of research methods. At present, most studies analyzing digital government construction based on the TOED framework adopt qualitative and semi-qualitative research methods such as LDA topic modeling and fsQCA configurational analysis, while large-sample quantitative empirical studies based on panel data are relatively scarce. This paper adopts a panel data regression model for quantitative analysis, quantitatively tests the effects of the four-dimensional factors of technology, organization, environment and data on digital transformation from a large-sample empirical perspective, makes up for the deficiencies of existing qualitative research, and improves the universality and robustness of the research conclusions.

The rest of this paper is arranged as follows: Part II is the theoretical framework; Part III is the research design, which introduces the institutional background, model specification, variable selection and data sources; Part IV presents the empirical results and analysis, reporting the results of correlation analysis, multicollinearity test, principal component analysis, as well as benchmark regression and robustness test in sequence; Part V is practical implications.

2. Theoretical framework

The TOE (Technology-Organization-Environment) theoretical framework is a classic paradigm in academic research for analyzing technology adoption, digital transformation, and innovation behavior. This theory systematically explains the driving mechanisms for entities to adopt new

technologies and advance digital reform from three dimensions: technology, organization, and environment. It has been widely applied in studies of digital government construction, enterprise digital transformation, government data governance, and other fields. Although the traditional TOE framework demonstrates strong theoretical universality, it has certain limitations in research scenarios of digital governance and data-factor-driven development. On the one hand, the three dimensions can hardly highlight the independent driving value of data as a new factor of production; core connotations such as data resources, data sharing, and data governance are mostly embedded in the technological or environmental dimension, and their unique action paths are not fully reflected. On the other hand, the three dimensions struggle to adapt to the complex governance context of the digital era and lack explanatory power for the in-depth mechanisms of data-driven digital transformation. With the continuous deepening of digital governance research, scholars such as Qi Zhiwei [2], Zhao Juan, and Meng Tianguang [4] have begun to focus on the independent value of data factors. Based on the traditional TOE framework, scholars including Cao Haijun [5] and Yan Linzhi [6] have incorporated Data as the fourth dimension into the analytical system, constructing the integrated TOED (Technology-Organization-Environment-Data) analytical framework. This framework breaks through the boundary limitations of traditional TOE theory and expands its extension and application scenarios. It conforms to the realistic logic of multi-dimensional collaboration among technology empowerment, organizational adaptation, environmental constraints, and data-driven governance in the digital governance context, and can systematically depict the differentiated action paths of each dimension on government digital transformation. Drawing on the above research ideas, this paper takes the TOED theoretical framework as the core analytical paradigm, builds a theoretical model from the four dimensions of technology, organization, environment, and data, deeply analyzes the influencing factors of government digital transformation, and carries out subsequent empirical analysis accordingly.

Based on the four-dimensional connotations of the TOED theoretical framework and the findings of existing literature, the mechanism of each dimension on local government digital transformation is shown in Figure 1. First, the technological dimension serves as the fundamental support for digital transformation. This dimension mainly covers the construction of digital infrastructure and the reserve of digital talents. Sound digital infrastructure provides a hardware carrier for online government processes and intelligent governance scenarios, while high-quality digital talents offer intellectual support for digital construction. Together, they lower the technical barriers to digital development and enable governments to efficiently promote digital transformation. Second, the organizational dimension focuses on the internal organizational adaptability of the government. This dimension mainly includes elements such as fiscal expenditure allocation, organizational management models, and inter-departmental coordination mechanisms. Rational allocation of fiscal resources guarantees funding for digital construction, and adaptive organizational structures and management systems ensure the effective implementation of digital technologies and data resources, thereby improving the implementation efficiency of digital governance and providing organizational and financial support for government digital transformation. Third, the environmental dimension mainly refers to the external constraints and support faced by government digital transformation. This dimension mainly includes public demand for digital services, local economic development level, regional digital economy development level, and other factors. Strong public demand for digitalization forms external driving pressure, while a sound regional economy and digital economy foundation provide a favorable environment for digital construction. Both jointly create favorable external conditions for digital transformation. Fourth, the data dimension is the core driver of governance transformation in the digital era. This dimension mainly covers multi-dimensional

connotations related to data openness and data governance, including basic guarantees, data volume, data quality, and utilization effectiveness. As a new factor of production, data can break down government information barriers, integrate governance resources, and optimize the supply of public services. It is a key instrument driving the digital transformation of government functions and deepening digital governance, directly empowering local government digital transformation. Based on the above analysis, the four-dimensional factors of technology, organization, environment, and data form a complete system driving local government digital transformation. All dimensions work synergistically to promote government digital development. Accordingly, this paper proposes the following hypothesis:

H1: The four dimensions of technology, organization, environment, and data collectively exert a significant promoting effect on local government digital transformation.

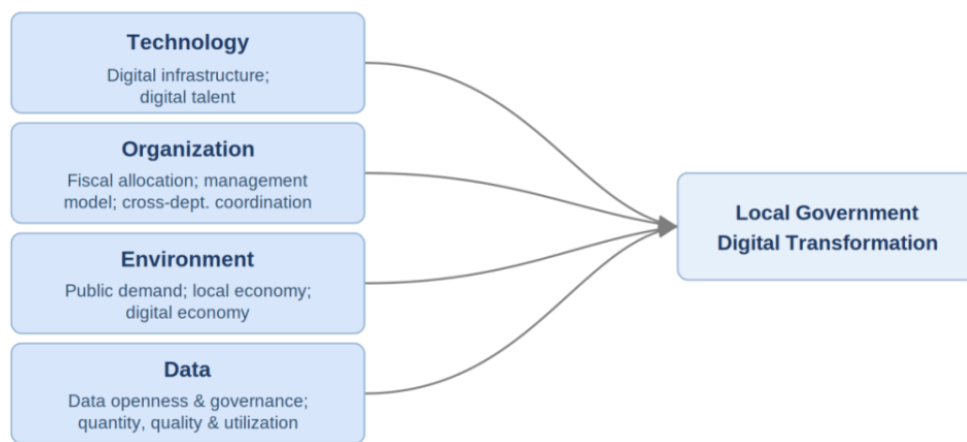


Figure 1. Influencing factors of local government digital transformation based on the TOED theoretical framework

3. Research design

3.1. Institutional background and model specification

Digital government construction is a key instrument for promoting the modernization of China's national governance system and governance capacity. Since the launch of the Digital China strategy, the central government and local governments have successively issued policies to advance digital government construction. Significant differences exist in the progress and implementation intensity of digital infrastructure development, data opening and sharing, and improvement of digital governance capacity across provinces, providing a realistic scenario for this paper to conduct empirical research using panel data. Since 2021, the state has successively issued top-level design documents such as the *14th Five-Year Plan for Digital Economy Development and the Guiding Opinions on Strengthening Digital Government Construction*, clarifying phased goals for local digital government construction. Provinces have formed differentiated construction paths and outcomes based on their own resource endowments and development foundations.

To systematically examine the comprehensive impact of the four dimensions of Technology, Organization, Environment, and Data (TOED) on local digital government construction, this paper conducts research based on panel data of 31 provincial-level administrative regions in China from 2021 to 2024. Considering unobservable individual differences in resource endowments and

development foundations across provinces, and that digital government construction is jointly affected by macro policies and time trends, this paper adopts a province-year two-way fixed-effects model as the baseline regression specification to simultaneously control for province-specific fixed effects that do not vary with time and time fixed effects that do not vary with provinces. The model is specified as follows:

$$\text{Score}_{it} = \alpha_0 + \beta_1 \text{Index} + \beta_2 X + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Where Score_{it} is the dependent variable, representing the comprehensive score of government digital transformation in province i in year t ; μ_i is the province-specific fixed effect included in the regression; λ_t is the time fixed effect; and ε_{it} is the random disturbance term. The core explanatory variable *Index* is synthesized from relevant indicators under the four TOED dimensions using Principal Component Analysis (PCA). Specifically, the technology dimension selects internet broadband access ports (*port*) to measure the level of digital infrastructure, and urban employees in information transmission, software and information technology services (*soft*) and scientific research and technical services (*sci*) to measure digital talent reserves. The organization dimension selects fiscal expenditure on science and technology (*org*) to measure the government's scientific and technological investment capacity. The environment dimension uses the number of mobile phone users (*mobile*) and broadband users (*broadband*) to measure public digital demand, and per capita regional GDP (*PGDP*) to measure the economic development environment. The data dimension selects the data openness index (*Data*) to measure the level of government data governance and application. X is a set of control variables; drawing on the practices of existing scholars, industrial structure (*structure*) and fiscal strength (*financial*) are included. Table 1 reports the descriptive statistics of each variable.

Table 1. Descriptive statistics of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Score	124	73.173	8.78	53.76	93.22
soft	124	17.186	23.082	.8	101.2
sci	124	14.835	14.202	1.1	66.9
port	124	3570.006	2353.692	254.2	10664.2
Org	124	2313438.7	2473815.2	83100	9837800
mobile	124	5531.809	3694.023	329.9	18281.3
broadband	124	1960.943	1307.582	115.3	5049.5
PGDP	124	8.864	4.034	4.251	22.817
Data	124	25.73	21.71	1.2	78.47
structure	124	.549	.079	.43	.854
financial	124	.257	.175	.105	1.16

3.2. Data description

The data in this paper are primarily drawn from three sources. The dependent variable is the composite score for the digital capabilities of Chinese local governments, derived from the *Report*

on the Development of Internet Service Capabilities of Chinese Local Governments. The indicators for the data dimension (D) are taken from the *Report on Data Openness of Chinese Local Governments*. The three-dimensional variables—technology, organization, and environment—as well as the control variables are all sourced from the *China Statistical Yearbook*.

4. Empirical results and analysis

4.1. Correlation analysis

Table 2 reports the Pearson correlation coefficients among variables. It can be observed that some indicators within the same dimension are highly correlated; for instance, the correlation coefficient between digital talents and digital infrastructure reaches 0.981. Significant correlations of varying degrees also exist among indicators of the organizational, environmental, and data dimensions, as well as between control variables and some core indicators. This indicates a strong risk of multicollinearity among variables, and direct inclusion in regression would likely lead to estimation bias.

Table 2. Correlation analysis of variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) soft	1.000									
(2) sci	0.981*	1.000								
	(0.000)									
(3) port	0.481*	0.549*	1.000							
	(0.000)	(0.000)								
(4) Org	0.772*	0.783*	0.774*	1.000						
	(0.000)	(0.000)	(0.000)							
(5) mobile	0.522*	0.588*	0.978*	0.766*	1.000					
	(0.000)	(0.000)	(0.000)	(0.000)						
(6) broadband	0.380*	0.465*	0.976*	0.722*	0.959*	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)					
(7) PGDP	0.748*	0.745*	0.159	0.561*	0.140	0.097	1.000			
	(0.000)	(0.000)	(0.078)	(0.000)	(0.122)	(0.286)				
(8) Data	0.471*	0.501*	0.410*	0.461*	0.382*	0.355*	0.517*	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
(9) structure	0.699*	0.685*	-0.050	0.357*	-0.015	-0.117	0.731*	0.473*	1.000	
	(0.000)	(0.000)	(0.583)	(0.000)	(0.870)	(0.196)	(0.000)	(0.000)		
(10) fiscal	-0.345*	-0.416*	-0.535*	-0.445*	-0.531*	-0.533*	-0.338*	-0.414*	-0.114	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.208)	

*** p<0.01, ** p<0.05, * p<0.1

4.2. Multicollinearity test

To further determine the degree of collinearity, this paper calculates the variance inflation factor (VIF) for each variable. The results show that the VIF values of multiple variables far exceed the empirical threshold of 10, with a maximum of 59.09 and an average of 27.01, indicating severe multicollinearity among variables. To alleviate collinearity while retaining the core information of each variable, this paper adopts Principal Component Analysis (PCA) to reduce the dimensionality of the four-dimensional indicators of technology, organization, environment, and data, and synthesizes the comprehensive index Index of digital government construction as the core explanatory variable for subsequent regression.

4.3. Principal component analysis

4.3.1. Applicability test

Before dimensionality reduction, it is necessary to test whether the data are suitable for principal component analysis. The KMO test value is 0.774, higher than the empirical critical value of 0.7, and the Bartlett sphericity test is also significant at the 1% level, indicating strong correlations among variables and that the data are suitable for principal component analysis.

4.3.2. Extraction of principal components

After standardizing the eight variables under the TOED framework, principal component analysis is performed, and principal components are extracted according to the principle that eigenvalues are greater than 1. As shown in Table 3, the eigenvalues of the first two principal components are 5.155 and 1.761 respectively, with a cumulative variance contribution rate of 86.44%. The scree plot (Figure 2) shows an obvious inflection point after the second principal component and then tends to be gentle. Accordingly, the first two principal components are retained for subsequent analysis.

Table 3. Eigenvalues and variance contribution

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	5.155	3.394	0.644	0.644
Comp2	1.761	1.095	0.220	0.864
Comp3	0.666	0.429	0.083	0.948
Comp4	0.237	0.101	0.030	0.977
Comp5	0.136	0.115	0.017	0.994
Comp6	0.021	0.006	0.003	0.997
Comp7	0.015	0.007	0.002	0.999
Comp8	0.008	.	0.001	1.000

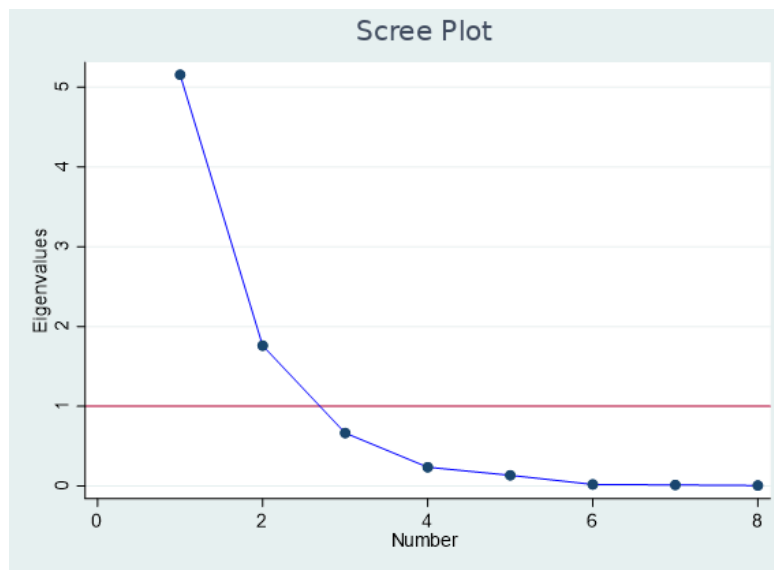


Figure 2. Scree plot

4.3.3. Naming of principal components

Principal Component 1 (Comp1) has a variance contribution rate of 64.4% and is the main source of information. Its loadings on all variables are positive, with high loadings on fiscal expenditure on science and technology, scientific research employees, broadband ports, and mobile users (0.407, 0.386, 0.378, 0.380). It mainly reflects the level of technological infrastructure, digital talents, and government investment in science and technology, and can be named the "technology-organization factor". Principal Component 2 (Comp2) has a variance contribution rate of 22.0%, with the highest loading on per capita GDP (0.551) and negative loadings on broadband ports, mobile users, and broadband users. It mainly reflects regional differences in economic development and digital economic environment, and can be named the "environmental factor".

Table 4. Rotated component matrix

Variable	Comp1	Comp2	Unexplained
std_soft	0.367	0.338	0.103
std_sci	0.386	0.291	0.085
std_port	0.378	-0.375	0.015
std_Org	0.407	0.006	0.144
std_mobile	0.380	-0.366	0.022
std_broadb~d	0.353	-0.431	0.031
std_PGDP	0.259	0.551	0.119
std_Data	0.268	0.192	0.565

4.3.4. Calculation of comprehensive index

Drawing on the practices of Zhang Xiaohui et al. [7] and Du Jun et al. [8], the comprehensive index is synthesized by weighting the variance contribution rates of the two principal components:

$$\text{Index}_1 = 0.745 \text{ Comp}_1 + 0.255 \text{ Comp}_2 \quad (2)$$

Considering that the original score contains negative values, it is shifted by adding a constant 4.7 to obtain the final comprehensive index Index of influencing factors of digital government construction.

4.4. Baseline regression results

Table 5 reports the baseline regression results. Column (1) only includes the core explanatory variable Index and controls for province and year two-way fixed effects. The results show that the regression coefficient of Index is 4.378, which is significantly positive at the 1% level, indicating that the improvement of the comprehensive driving level of the four dimensions of technology, organization, environment and data can significantly promote local digital government construction. Column (2) further incorporates two control variables: industrial structure and fiscal strength. The coefficient of Index is 3.937, which is still significantly positive at the 1% level. After controlling for regional characteristics, the core conclusion remains robust. The coefficients of Index in both columns are significantly positive and consistent in direction, verifying the research hypothesis.

Table 5. Baseline regression and robustness test

Dependent Variable	Baseline Regression		Robustness Check	
	(1)	(2)	(3)	(4)
	Score	Score	Score	Score
Index	4.378*** (3.052)	3.937*** (2.656)	4.378** (2.746)	3.937** (2.412)
Industrial Structure		33.443 (0.908)		33.443 (0.674)
Fiscal Capacity		-16.892 (-0.963)		-16.892 (-1.185)
Constant	51.393*** (3.860)	32.993 (1.147)	51.393*** (3.560)	32.993 (0.868)
Province Fixed Effects	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Cluster-Robust Standard Errors	NO	NO	YES	YES
Observations (N)	124	124	124	124
R ²	0.910	0.912	0.910	0.912

Note: t-values are in parentheses; *** p<0.01, ** p<0.05, * p<0.10.

4.5. Robustness test

To alleviate potential heteroscedasticity and intra-group serial correlation in panel data, this paper further re-estimates using province-level clustered robust standard errors, with the results shown in Table 5. The regression coefficients of Index in the two columns remain 4.378 and 3.937 respectively, consistent in direction and significance, and highly consistent with the baseline regression results. This indicates that after correcting the standard error estimation, the core conclusion still holds, and the baseline regression results have good robustness.

5. Conclusions and implications

This paper introduces "data" as an independent dimension into the classic TOE framework and constructs a four-dimensional TOED analysis framework combining technology, organization, environment and data. Using panel data of 31 provincial-level administrative regions in China from 2021 to 2024 as samples, principal component analysis is applied to reduce the dimensionality of the four-dimensional indicators and synthesize a comprehensive index of influencing factors of digital government construction. Then, a province-year two-way fixed effect model is adopted to examine its driving effect. The empirical results show that the TOED four-dimensional comprehensive index has a significant positive impact on the level of local digital government construction, and this conclusion remains valid after incorporating control variables and adopting province-level clustered robust standard errors, indicating that the four-dimensional factors of technology, organization, environment and data can synergistically drive the digital transformation of local governments, thus verifying the research hypothesis. This study theoretically expands the analytical framework of digital government construction, integrates data factors into a unified research system, and enriches the empirical evidence of the TOED framework. In practice, it provides a useful reference for understanding the role of multi-dimensional factors in government digital transformation and for promoting digital government construction in various regions according to local conditions.

Based on the above conclusions, all regions should adhere to multi-dimensional coordination and overall promotion in advancing digital government construction. At the technical level, efforts should be made to continuously improve digital infrastructure and strengthen the construction of professional digital talent teams to consolidate the technical foundation for digital transformation. At the organizational level, fiscal resource allocation should be optimized and cross-departmental coordination mechanisms improved to provide organizational guarantee for the implementation and application of digital technologies and data resources. At the environmental level, government departments should actively respond to public service needs and rely on regional development foundations to create a favorable external environment for the acceptance and participation in digital governance. At the data level, it is necessary to deepen government data governance, enhance the level of data openness and sharing, and fully release the core empowering role of data factors. More importantly, technology, organization, environment and data do not function in isolation but form an interactive organic whole. All regions should avoid one-sided investment in a single dimension, adhere to the integration and coordinated development of the four-dimensional factors, and promote the continuous development of local digital government construction in a standardized, intelligent and efficient direction.

References

- [1] Gong, W., & Ruan, J. (2024). Influencing factors and pathways of digital government development under the TOE and "resource–pressure" frameworks. *Journal of Southwest Minzu University (Humanities and Social Sciences Edition)*, (8).
- [2] Qi, Z. (2025). Digital government development from the technology–organization–environment (TOE) perspective. *Theoretical Exploration*, (2), 85–93.
- [3] Ning, Q., & Tan, J. (2023). Local practices and improvement strategies for digital government development. *Reform*, (1), 144–155.
- [4] Zhao, J., & Meng, T. Digital government's logic of vertical governance: Hierarchical systems and collaborative governance. *Academia Bimestris*.
- [5] Cao, H., & Hou, T. (2021). Digital government development from the perspective of agile empowerment: Practical origins and theoretical construction. *Jilin University Journal (Social Sciences Edition)*, 61(6), 170–178.
- [6] Yan, L., & Zhou, Y. Digital-intelligence-driven digital government: Identifying influencing factors and pathways for high-quality development. *Information Science*.
- [7] Zhang, X., & Kong, S. Optimizing comparable company selection in the market approach to business valuation: A principal component analysis perspective. *Review of Economic Research*.
- [8] Du, J., Ning, L., & Hu, C. An empirical study on the selection of China's strategic emerging marine industries based on principal component analysis. *Ecological Economy*.