

The Impact of Supply Chain Digital Transformation on Performance

-- Based on fsQCA Approach

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Abstract

In order to explore the factors affecting the performance situation and performance mode of digital transformation of enterprise supply chain, fuzzy set qualitative comparative analysis (fsQCA) is adopted, and 32 listed companies are taken as the research samples for the grouping path analysis, and this paper puts forward the multifactorial grouping model affecting the performance situation and mode of digital transformation of enterprise supply chain based on the theoretical framework of TOE. The study shows that the performance situation and mode is a complex and systematic project, and individual factors do not constitute the necessary conditions to influence the high performance situation and mode of enterprises; there are five paths leading to the high performance mode and situation of enterprises, which can be summarised as "organisational culture-competitive environment dominant", "digitalisation-technology single-factor dominant", "digitalisation-technology single-factor dominant" and "digitalisation-technology single-factor dominant". technology single-factor dominant", "organisational culture-digital technology depth and breadth dominant".

Keywords

TOE Theoretical Framework; Fuzzy Set Qualitative Analysis Method; Digital Transformation; Supply Chain Performance.

1. Introduction

In recent years, along with the rapid development of China's economy, the scale of China's industry is gradually expanding, but at the same time, it faces the problems of time-consuming information transmission and excessive circulation costs. These problems not only hinder the enterprise's own benefits, but also directly affect the improvement of the overall supply chain performance. At the same time, the popularity and application of cloud computing, big data and other digital technologies have a far-reaching impact on various industries, and all kinds of enterprises have begun to try digital transformation in order to solve the above developmental drawbacks. In such a context, a large number of scholars within China, began to conduct a large number of studies. Liu Haijian, Hu Huaguang ¹ examined the impact of supply chain on enterprise performance in the context of digital transformation by analysing the data of A-share listed companies from 2013 to 2020, and they found that management empowerment and innovation empowerment are the path mechanisms to achieve supply chain performance improvement. Kong Chui Ching, Hu Lingyu² studied and analysed the relationship of digital competence on sustainable supply chain performance, and the results showed a positive effect, and adverse competition has a positive moderating effect between digital competence and supply chain quality. Zheng Jianzhuang, Tan Jiajia, Zhou Linan ³ in their paper explored the mechanism of digital transformation capability on enterprise performance, the mediating role

of supply chain synergy, and empirical research found that digital transformation capability has a positive influence ability on enterprise performance improvement, and supply chain synergy plays an obvious mediating effect between digital transformation capability and enterprise performance.

After combing through the existing literature, it is found that at this stage, a large number of studies have focused on the necessary conditions for digital transformation on enterprise supply chain performance and transformation paths, and the question of whether it can really promote the improvement of supply chain performance remains to be explored. In view of the above, this paper takes the impact of enterprise digital transformation on supply chain performance as the research object, and introduces the digital technology adoption process, the breadth and depth of digital technology, organisational culture, organisational digital capabilities and the competitive environment into the research, so as to clarify the intrinsic connection between enterprise digital transformation and supply chain performance.

2. Theoretical Framework and Modelling

This paper borrows the TOE (Technology-Organisation-Environment) theoretical framework to sort out the antecedents of digital transformation affecting the supply chain performance of enterprises, and uses the fuzzy set qualitative comparative analysis (fsQCA) method to study and explore the role paths and grouping configurations that affect the supply chain performance of enterprises, so as to find out the grouping paths of the performance patterns and the performance situations, which can help the enterprises maintain their competitive advantages and improve their competitive position in the market in the digital transformation. competitive advantage and improve their competitive position in the market. In this paper, with the help of research data from 32 listed companies, the study the antecedents of performance situations and performance patterns that affect supply chain performance and how these antecedents dynamically match to finally find the supply chain performance patterns and situations of enterprises in digital transformation. The samples of this study are mainly collected from the CSMAR database, and mainly use the digital transformation data in the CSMAR database and the data in the supply chain research database. In this study, use the data from CSMAR database and Supply Chain Research Database. 32 listed companies in the manufacturing industry are obtained after eliminating the companies with missing data.

2.1. Research Model

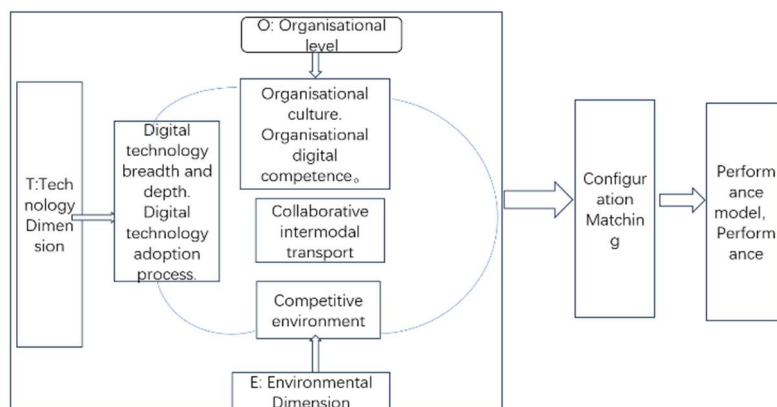


Fig. 1. Framework for group research on digital transformation of enterprises on supply chain performance under TOE theory

Based on the previous literature combing, five antecedent variables affecting the digital transformation of enterprises on supply chain performance are summarised and refined, including the digital technology adoption process, the breadth and depth of digital technology, the organisational culture, the organisation's digital competence and the competitive environment, and the theoretical framework of this study is constructed with the help of the TOE theory (see Fig. 1) in order to explore the supply chain performance pattern and situation of the enterprises in the case of digital transformation.

3. Research Design

3.1. Research Methodology.

QCA is an approach that examines how the interaction between components affects the whole from a configurational perspective, rather than analysing the components in isolation. fsQCA methodology has been used to investigate the complex causal mechanisms between supply chain diversification, digital transformation, firm size and supply chain resilience. At the same time, the fsQCA approach combines the strengths of both qualitative and quantitative research, which not only solves the problem of generalisation inherent in the qualitative analysis of a few cases, but also compensates to a certain extent for the lack of qualitative change and phenomenological analysis inherent in purely quantitative analysis of a large sample

Basic fsQCA expressions:

$$P(Y) = \sum_{i=1}^n [f(X_i) \cdot P_i] + \sum_{j=1}^m [f(Z_j) \cdot Q_j] + \sum_{k=1}^p [f(W_k) \cdot R_k] + \epsilon \tag{1}$$

Of which :Y is an indicator of performance.

X_i Z_j W_k is the factors that may affect the performance.

$f()$ is the fuzzy set factor for each factor.

P_i Q_j R_k is the weight of each factor corresponding to the fuzzy set.

ϵ is the error term.

3.2. Measurement of Prerequisites

Table 1. Result and antecedent condition names and meanings

	Name	Meaning
Result	Performance	Revenue from new product development sales
	Performance model	Changes in the business landscape as a result of digital transformation
Antecedent conditions	Digital technology adoption process	Types of digital keywords appearing in the Management Discussion and Analysis section per year
	Breadth and depth of digital technologies	Sum of five digitisation-related technologies and frequencies
	Organisational culture	Digital capital investment plan Number of investment projects
	Organisation's digital capabilities	Number of digital infrastructure builds
	Competitive environment	Intensity of digital capital investment in the industry in which it operates

In this study, it focus on the multiple causal relationships between digital technologies, organisations and environments involved in digital transformation. Digital transformation technologies are divided into the dimensions of digital transformation breadth and digital

transformation depth as well as digital technology adoption processes, organisations are further divided into organisational culture and organisational digital capabilities, and environments are classified as competitive environments. In the figure below, a detailed definition of each dimension is provided.

3.3. Calibration of Results and Preconditions

The most important issue in using the QCA method is to calibrate the measurement conditions in order to convert them into pooled concepts, as uncalibrated data have no general meaning. In this study, mainly used quartiles for calibration; that is, 95%, 50%, and 5% of the preconditions and outcomes were used to represent anchors that fell completely within the threshold, crossover points, and completely out-of-threshold anchors that fell completely outside the threshold.

4. Analysis of Data Results

4.1. Necessity Analysis of Preconditions

The formulaic approach to consistency calculation is:

$$\text{Consistency}(C) = \frac{N_{\text{observed}}}{N_{\text{possible}}} \quad (2)$$

The coverage formula approach is:

$$\text{Coverage}(C) = \frac{N_{\text{observed}}}{N_{\text{consistent}}} \quad (3)$$

The necessity formula is:

$$\text{NESS}(A \Rightarrow B) = \frac{\sum_x \min(A(x), B(x))}{\sum_x A(x)} \quad (4)$$

Table 2. Necessity analysis of sample variables

Antecedent condition	Performance situation		Performance model	
	Consistency	Coverage	Consistency	Coverage
Digital technology adoption process	0.681005	0.801973	0.619241	0.601316
~ Digital technology adoption process	0.583798	0.622024	0.623306	0.547619
Breadth and depth of digital technologies	0.688267	0.850241	0.632791	0.644583
~ Breadth and depth of digital technologies	0.603910	0.617362	0.618563	0.521416
organisational culture	0.505586	0.722844	0.563008	0.663738
~ organisational culture	0.672066	0.617556	0.697154	0.528234
Organising digital capabilities	0.726814	0.711318	0.638211	0.515036
~ Organising digital capabilities	0.637988	0.832969	0.647019	0.696572
competitive environment	0.675977	0.930054	0.666666	0.756341
~ competitive environment	0.532401	0.501843	0.506097	0.393365

In the fuzzy set qualitative comparative analysis method, the necessity of each antecedent variable needs to be analysed first, and the consistency(2) is the criterion for measuring the necessity of antecedent variables, and it is usually considered that the consistency of the

necessity(4) should be higher than 0.9. The necessity of antecedent variables in this paper is analysed by using fsQCA software, and the results are shown in Table 2. The consistency level of all the antecedent variables is lower than 0.9, indicating that none of the individual antecedent variables in this paper constitutes a necessary condition leading to the supply chain performance model and performance situation. This result also confirms the systematic and complex nature of supply chain performance situations and performance patterns, and the need for all factors to work together to improve enterprise performance.

4.2. Conditional Grouping Analysis

In this part, the grouping effect will be achieved through truth table construction and standardisation analysis. Referring to the research of Zhang Ming and Du Yunzhou, the minimum acceptable standard of consistency will be set to 0.8, and the value of PRI above 0.8 will be assigned as "1" to represent the existence of the PRI, and then the standardisation analysis will be carried out, and the intermediate solution will be used as the main solution in the QCA research.

The intermediate solution was used as the main solution in the QCA study, the supply chain performance situation was used as the outcome variable, the supply chain performance model was used as the outcome variable, and the antecedent condition grouping results generated by the software are shown in Table 3.

Table 3. Configuration results analysis table

Antecedents	High Performance Scenario Grouping Results				Performance Model Grouping Results		
	path1	path2	path3	path4	path1	path2	path3
Digital technology adoption process	•		⊗	⊗	•		⊗
Digital technology breadth and depth	•	⊗	•		•	⊗	•
Organisational culture	⊗	•	•	•	•	•	•
Organisational digital capability		•	•	⊗	⊗	•	•
Competitive environment	⊗	•	⊗	•		•	⊗
Consistency	0.941	0.996	0.949	0.971	0.873	0.835	0.854
Original coverage	0.244	0.271	0.189	0.187	0.271	0.275	0.206
Unique coverage	0.037	0.010	0.009	0.002	0.015	0.011	0.018
Overall Consistency	0.895105				0.823346		
Overall Coverage	0.715083				0.716802		

5. Discussion of Results

5.1. Analysis of the Grouping of Supply Chain Performance Scenarios of Digital Transformation

By combining Eq. (1) one can derive: First technology path The digital technology adoption process, the breadth and depth of digital technology as the core condition exists, the organisational culture exists as the marginal condition, and the competitive environment marginal condition is missing. Enterprises through the use of digital technology, for the future development of strategic policy and R & D direction to lay the foundation for the enterprise,

strengthen the stability of the enterprise supply chain, so that the supply chain can better resist the risk, supply chain performance situation has a better cycle. From the original coverage of 0.244 and the unique coverage of 0.037, it can be seen that this grouping path can explain about 24.4% of the enterprises' high supply chain performance situation, and about 3.7% of the enterprises can only be explained by this path.

Organisational-Environmental Path When organisational culture and competitive environment are the core conditions present, non-organisational digital capabilities and non-digital technology workforce breadth and depth can be substituted for each other. In this path organisational culture encourages employees to actively participate in digital transformation and provides training support to adapt to new technologies and processes, supports inter-departmental collaboration and information sharing, and plays a crucial role in digital transformation. Secondly the interaction, cooperation and degree of digitisation with supply chain partners and the external environment positively affects the overall performance profile. The technology-organisation path exists with the breadth and depth of digital technology, organisational culture as a core condition, the digital technology adoption process exists as a peripheral condition, and the organisational digital capabilities and competitive environment are missing. The frequency of AI, blockchain technology, cloud computing technology, big data technology, and digital technology usage in the organisation has a big impact in carrying out digital transformation, wider digital coverage provides more data and insights, improves overall visibility and synergies, and helps to reduce inventories, improve customer service levels, and reduce costs. Deeper digitisation increases efficiency, reduces errors, accelerates decision making and improves supply chain agility and responsiveness. From the original coverage of 0.189 and the unique coverage of 0.009, this grouping path explains 18.9% of the high digital transformation mid-performance scenarios, and about 0.9% of the firms can be explained by this path only.

5.2. Group-state Analysis of Digital Transformation Performance Patterns in Supply Chains

Organisational Culture and Digital Breadth and Depth Interaction-Driven Type With the breadth and depth of digital technology and organisational culture as core conditions under this path, a more comprehensive digital ecosystem can be created when digital technology is widely applied to different departments and business processes. This contributes to improved cross-departmental collaboration, data sharing and decision support. Organisational culture can facilitate or limit the success of digital transformation. An open, innovative culture may adapt more easily to digitalisation, while a traditional, old-fashioned culture may hinder change. Ensure that the breadth and depth of digital technologies are aligned with the organisational culture to achieve an optimal performance model.

Organisational Culture and Competitive Environment Interactive, in which organisational culture and competitive environment exist as core conditions under this path, with the breadth and depth of digital technologies and the organisation's digital capabilities as missing conditions. The organisational culture encourages innovation, open information sharing, and companies need to develop adaptive performance goals and strategies based on the industry and market environment in which they operate to ensure success in a competitive environment. The changing competitive environment also requires organisations to be flexible and adapt their performance models to new challenges and opportunities. Even though there is a lack of digitisation related technology, certain good performance patterns can be achieved. Raw Coverage 0.275 and Unique Coverage 0.011. This shows that the path explains 27.5% of high performance patterns and about 1.1% of firms can be explained by the path only.

6. Robustness Testing

In this paper, the robustness of the outcome variables is analysed by adjusting the degree of affiliation of the condition variables from "fully affiliated (0.95)" and "fully unaffiliated (0.05)" to "fully affiliated (0.75)" "Fully affiliated (0.95)" and "Fully unaffiliated (0.05)" were adjusted to "Fully affiliated (0.75)" and "Fully unaffiliated (0.25)", and the simulation showed that the core conditions, paths as well as the consistency and coverage of the conditional grouping did not change substantially, which indicated that the results of this paper had a high degree of robustness.

7. Conclusion

7.1. Conclusion of the Study

This study analyses the group effects of digital technology adoption process, digital technology breadth and depth, organisational culture, organisational digital capability, and competitive environment on the performance of digital transformation of enterprise supply chain under the framework of TOE theory, with the help of fuzzy set qualitative comparative analysis, in order to find out group paths leading to the high performance situations and performance patterns of enterprises, with the following results:

There is no single necessary condition for the effect of supply chain digital transformation on performance. faqca's necessary condition test shows that there is no single variable among the antecedent conditions such as digital technology adoption process, digital technology breadth and depth, organisational culture, organisational digital capability, competitive environment, etc., which is necessary for the performance of supply chain digital transformation, and that supply chain performance is a systematic work which is the result of the synergistic linkage of multiple factors.

The five paths leading to high performance mode and high performance situation can be summarised as "organisational culture-competitive environment dominant", digital technology element dominant, organisational culture-digital technology depth and breadth dominant. The five paths are dominated by the first path, which indicates that the majority of companies fully consider the importance of digital technologies in supply chain digital transformation, and that a high level of adoption usually promotes a wider and deeper use of digital technologies, as organisations are more willing to invest in and implement more technologies to improve performance. At the same time, the breadth and depth of digital technologies can increase opportunities for performance improvement by providing more data and tools to optimise supply chain operations. But Path 2 also shows that organisational culture plays a clear role in supply chain digital transformation and can influence the acceptance, speed and success of digital projects. In order to improve digital transformation performance, organisations need to actively shape their culture to contribute to the success of digital transformation and ensure that the culture is aligned with the digital strategy.

When considering performance patterns and performance situations, the same antecedent conditions will also lead to uncertain outcomes, for example, when generating high performance situations, the digital technology adoption process, the breadth and depth of digital technology, the organisational culture and the competitive environment book important conditions for high performance situations of digital transformation in the supply chain of the organisation, whereas when generating high performance patterns, the organisational culture plays an important role in the supply chain digital transformation performance patterns The.

7.2. Suggestions for Countermeasures

Enterprises undertaking supply chain digital transformation should ensure that the digital transformation plan has a clear strategic vision and well-defined objectives, including all aspects of the supply chain, such as procurement, production, inventory management and logistics, and assess various digital technologies in the supply chain, including IoT, big data analytics, artificial intelligence, blockchain, etc., in order to understand how they can be applied to the specific situation of the enterprise. Regularly analyse the competitive environment to understand competitors' digital progress and trends, as well as market opportunities and threats. By developing a clear plan, building digital capabilities, encouraging cultural change, and being sensitive to the competitive environment, organisations can improve performance and achieve successful digital transformation.

7.3. Research Outlook

This paper quantifies the factors affecting the performance of digital transformation of enterprise supply chains, and the antecedents selected are based on existing literature and CSMAR, statistical annual reports, etc., and there is a lack of clear theories and a unified viewpoint to adequately identify and explain these influencing factors; in terms of research this paper is based on the TOE theoretical framework, and focuses on only five elements of the three dimensions of technology-organisational-environmental to carry out the study, but the elements affecting the performance situation and patterns are not clear and consistent. However, there are many more elements that affect the performance situation and patterns, and more relevant factors can be added in the future to achieve more rigorous and comprehensive conclusions. In terms of research method selection, the fsQCA method combines qualitative and quantitative research with superiority, but it is not perfect, and it fails to reflect the proportion and importance of each factor in the grouping of antecedents affecting the performance situation and mode of enterprises, so it can be combined with other research methods to carry out joint research in the future.

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