Research on the Green Transformation Path of Manufacturing Enterprises

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Abstract. In today's advocacy of green and sustainable development, the green transformation of manufacturing enterprises is an inevitable choice for the manufacturing industry to seek new development in the context of Industry 4.0. As a pillar industry of China's economy, the green transformation of the manufacturing industry is of great significance for the high-quality and sustainable development of the Chinese economy. In order to explore the specific path of green transformation of manufacturing enterprises, this paper collected the relevant information about green transformation from different channels of two leading manufacturing enterprises, and used Grounded theory to conduct three-level coding analysis on them, and obtained seven factors that affect green transformation of manufacturing enterprises. A survey questionnaire was designed and distributed to several manufacturing enterprises, and 40 samples of green transformation cases were collected. The fuzzy set qualitative comparative analysis method (fsQCA) was used to explore the mechanism of different configurations on green transformation, and the final research conclusion was drawn based on the empirical results. The research results indicate that: (1) The green transformation of the manufacturing industry is influenced by seven factors: "willingness and responsibility for transformation", "collaboration mechanism", "resource investment", "development concept", "model innovation", "technological innovation", and "green products and solutions"; (2) There are three green transformation paths.

Keywords: manufacturing enterprise · Green transformation · Influencing factors · Configuration research

1 Introduction

With the increasingly severe impact of global climate change, countries around the world are actively researching various plans and measures to resist and adapt to the impacts of climate change. Enterprises are the lifeblood of a country, among which manufacturing enterprises are the main body of the national economy, the foundation of establishing a country, the tool of rejuvenating the country, and the foundation of a strong country. For Chinese manufacturing enterprises, the "dual carbon" goal is always a big test that cannot be overcome. The realization of carbon neutrality and carbon peak for manufacturing enterprises is the internal requirement for implementing the new development concept, building a new development pattern and promoting high-quality economic development.

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Therefore, how Chinese manufacturing enterprises actively integrate into the "dual carbon" development strategy and accelerate the green transformation process is currently an important issue to be solved. At present, paying attention to and exploring the green transformation behavior of manufacturing enterprises has important guiding significance for improving China's ability to cope with climate change.

2 Journals Reviewed

At present, there is relatively little research on the green transformation path of manufacturing enterprises both domestically and internationally, and existing research mainly focuses on the enterprise transformation path. In terms of research on the path of enterprise transformation, Lv Tie (2016) [1] proposed that enterprise transformation needs to rely on technology and take the path of innovative development by studying the path of manufacturing industry transformation. He also proposed transformation strategies such as industry transformation, business transformation, and technology transformation. Xie et al. (2021) [2] studied how to promote green transformation in enterprises and proposed a transformation path from external policies to enterprise actions and then to enterprise performance. Wang Chunying (2023) [3] and others used the method of case analysis to study the Digital transformation of manufacturing enterprises. The conclusion shows that the effective path of enterprise Digital transformation is to change the business model, connect the whole chain of digitalization, apply digital twin technology and build a Industrial Internet platform. Yi Shaohua et al. (2023) [4] conducted a study on the innovation and transformation path of traditional commercial enterprises and found that borrowing the advantages of digital technology and data resources can effectively promote enterprise innovation and transformation. Wei Chen (2023) [5] studied the path of green transformation of enterprises in Jiangsu Province and pointed out that green finance can promote green transformation of enterprises in three aspects: policy transmission, financial support and resource allocation.

3 Analysis of Influencing Factors

Because the research on the influencing factors of green transformation of manufacturing enterprises is qualitative, and the core idea of Grounded theory is to discover theories from data, rather than preset or hypothetical theories, which is consistent with the requirements of qualitative research aimed at in-depth understanding of phenomena, exploring the meaning and dynamics behind phenomena. Therefore, the Grounded theory is applicable to the research on the influencing factors of green transformation of manufacturing enterprises. This study collected data from 20 manufacturing enterprises, conducted Grounded theory analysis on them, and obtained the influencing factors of green transformation of manufacturing enterprises. The results are shown in Table 1.

Table 1. Influencing Factors

Main category	Category connotation
Transformation willingness	The willingness of enterprises to undergo green transformation refers to whether they are willing to undergo green transformation, that is, their attitude towards green transformation
Collaboration mechanism	Interenterprise collaboration refers to the commercial activity of enterprises jointly developing products or markets and sharing benefits through a certain form of collaboration to gain overall advantages
Resource investment	Refers to the investment of a certain amount of funds by a company into activities such as technology research and development
Development concept	Refers to whether the enterprise has a green and ecological development concept
Model Innovation	Innovation in the production, management, or profit acquisition methods of enterprises
technological innovation	Refers to the innovation of green or digital technologies in enterprises
Green Products and Solutions	Green products refer to products with energy-saving, low pollution and other functions. Green solutions refer to solutions that solve problems such as high energy consumption and high pollution

4 Research Process Based on fsQCA

In the previous chapter, seven major influencing factors for green transformation in manufacturing enterprises were extracted, but we have not yet known the configuration relationship and role of the influencing factors. Therefore, in order to study the configuration relationship and role path of the influencing factors, this study mainly uses fsQCA for case analysis.

Firstly, this study collected 40 valid data on green transformation cases of manufacturing enterprises through a questionnaire survey. Then, the case specific set membership is assigned through calibration. Due to the qualitative nature of the data collected through questionnaire surveys in this study, it is more suitable for the indirect calibration method. The conditional variables in this study are all measured by the five point Likert scale, and the data are calibrated based on the mean value of each measure, so we directly give them five scores of 0.0, 0.25, 0.5, 0.75, and 1.0.

After completing the pre work, the author used fsQCA4.0 software for configuration analysis. We obtained three solutions: parsimonious solution, intermediate solution, and complex solution. This study referred to the combination of intermediate and reduced solutions recommended by Fiss (2007) [6], and ultimately decided to use intermediate solutions to determine the number of configurations that led to the results and the

Table 2. Multiple Paths for Green Transformation of Manufacturing Enterprises

condition	Transformation achievements		
Configuration	1	2	3
Transformation willingness	•	•	⊗
Collaboration mechanism	•		•
Resource investment	•	•	⊗
Development concept	●	●	●
Model Innovation		•	•
technological innovation	⊗	•	•
Green Products and Solutions	•	•	•
Configuration combination	wis*coo*ide*mod*~tec*Pro	wis*inp*ide*mod*tec*Pro	~wis*coo*~inp*ide*mod*tec*Pro
consistency	0.91541	0.936637	0.936673
raw coverage	0.425789	0.581613	0.386054
unique coverage	0.0529801	0.170238	0.0389559
solution coverage	0.673549	0.673549	0.673549
solution consistency	0.894928	0.894928	0.894928

Note: "●" indicates the condition that appears simultaneously in both the intermediate solution and the simplified solution, which exists as a core causal condition, "⊗" indicates the absence of a core causal condition, "⊗" indicates the existence of auxiliary causal conditions, "•" indicates the absence of auxiliary causal conditions, and "blank" indicates that the condition is irrelevant.

conditions contained in these configurations. Then, the reduced solution was used to determine the core conditions in the configuration. The results are shown in Table 2.

5 Conclusions

From Table 2, it can be seen that there are three paths that can positively promote the green transformation of manufacturing enterprises; The only variable that appears in both the minimalist solution and the intermediate solution is “development concept”, so development concept exists as the core factor for green transformation of manufacturing enterprises.

Based on the development concept occupying the core position of the combination, manufacturing enterprises can supplement other categories according to their own situation. When manufacturing enterprises have a collaborative mechanism between enterprises, they can borrow the technological or management advantages of other enterprises, thus the importance of their own mode and technological innovation decreases; Similarly, when enterprises can collaborate, their investment in technology can be appropriately reduced. And even if one’s own transformation intention is not strong and lacks transformation motivation, in order to match the project progress of the cooperative enterprise, under the supervision of the cooperative enterprise, one has to highly invest in green projects; When there is a lack of collaboration among enterprises, they need

to rely on their own efforts to complete green transformation. At this time, enterprises must have a strong willingness to transform and invest a large amount of resources in scientific research, independently completing mode innovation and technological innovation; No matter which path is taken for transformation, one must ultimately transform their own investment and innovation into concrete results, namely green products and solutions. Based on this, reducing emissions and saving energy will be implemented, thereby promoting the green transformation of manufacturing enterprises.

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