A Study on the Grouping of Factors Influencing the Green Transformation of Heavy Polluting Enterprises under the "Double Carbon" Target

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Abstract: Promoting the green transformation of enterprises and helping to achieve the dual carbon goal. Based on the theoretical framework of "technology-organization-environment". The paper constructs a model of the influencing factors of green transformation of heavy polluting enterprises. this uses the necessary conditions analysis method and qualitative comparative analysis method to explore the group effect of green transformation of heavy polluting enterprises with a sample of 514 listed enterprises. The results demonstrate that the green transformation of heavy polluting enterprises is not only a result of the green transformation, but also of the green transformation of heavy polluting enterprises. The results demonstrate that the green transformation of heavy polluting enterprises is not driven by a single antecedent condition. There are six groups of conditions for high level green transformation of heavy polluting enterprises, which are categorized as "scale-driven technology development", "large-scale dynamic development" and "all-factor driven". There are seven groups of conditions for the low-level green transformation of heavy polluting enterprises, and the two groups show asymmetry. There are obvious differences between the green transformation paths of state-owned enterprises and non-state-owned enterprises. The research findings provide a reference for the path of green transformation practice of enterprises.

1. Introduction

In recent years, green transformation has increasingly received widespread attention from domestic and foreign enterprises and has become a hot topic of world attention [1]. 2020, China proposed in the United Nations General Assembly that "China will increase its national autonomous contribution to achieve carbon peaking by 2030 and carbon neutrality by 2060." In addition, the "Action Plan for Achieving Carbon Peaks by 2030" issued by the State Council in 2021 repeatedly puts forward the concept of green transformation based on the "double carbon" target, and clearly states that green technological innovation should be vigorously developed to promote the green transformation of key industries and important fields. [2] Therefore, the "double carbon" target is an important cornerstone of national development, a major political task for the government, and an important guide for heavy polluting enterprises to carry out green transformation. However, in the face of resource and environmental constraints, how to achieve green transformation has become a real dilemma for heavy polluters. From the practical point of view of enterprises, a part of enterprises actively carryout green transformation, combining their own actual exploration of green transformation path in line with the development of enterprises, and have achieved good results. However, there are also many enterprises that are subject to the cost, environmental protection, and other pressures, and cannot take the initiative to achieve the green transformation of enterprises. The exploration of heavy polluting enterprises green transformation factors, processes and so on for China to achieve a comprehensive green transformation for important practical significance. Therefore, based on the goal of "double carbon", it has become an urgent problem to explore how to realize green transformation and the influencing factors of heavy polluting enterprises in China.

Throughout the available research, literature on the influencing factors of green transformation, a part of scholars explored the influencing factors of corporate green transformation from internal or external dimensions. For the internal perspective, different digital inputs are used as the main line to study how digital technology empowerment of enterprises affects the green transformation of enterprises and the existence of heterogeneity among industries with different energy consumption intensities [3]; and the dissection of factors affecting the green transformation of heavy polluting enterprises of different sizes based on the existence of interactive properties among green innovation influencing factors[4]. In terms of external perspective, whether heavy polluting firms can achieve substantial green transformation by implementing green M&A under media pressure [5]; and the use of double difference model to study the specific channels of environmental regulation on

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the green transformation of firms [6]. Another part of scholars explores the factors influencing corporate green transformation from macro, mesh, and micro dimensions. The macro level studies the role of environmental dynamics in promoting green transformation of enterprises [7]; the mesh level network relationship and industrial transformation are the focus of research on green transformation influencing factors [8][9]. At the micro level, factors such as resources, organization, and technology are decisive factors for enterprises to accelerate green transformation [10]. However, existing studies have largely focused on a single perspective, using regression analysis for empirical studies. Few have explored the factors influencing the green transformation of heavy polluters from a multidimensional histological perspective. Therefore, this paper intends to explore the antecedents of green transformation in the framework of "technology-organization-environment" theory.

This paper takes 514 heavily polluting listed enterprises as an example, based on the TOE theoretical framework, from three dimensions of technology, organization and environment, using the Necessary Conditions Analysis (NCA) and Fuzzy Set Qualitative Comparative Analysis (fs QCA) methods to explore the influence of internal and external dimensions of antecedent conditions on the green transformation of enterprises from the group state, focusing on answering the following questions: the key factors affecting the green transformation of heavily polluting enterprises are What are they? Are there individual factors that constitute the necessary conditions for the green transformation of enterprises? Which groupings can more effectively promote the green transformation of enterprises? Are the paths consistent when green transformation of enterprises with different property rights nature?

In summary, this paper will expand the research from the following aspects to make innovations: First, under the "double carbon" strategy objective, we explore the green transformation of heavy polluting enterprises in China, and refine the internal and external factors of the green transformation of enterprises from the TOE theoretical framework. It is different from previous studies that only focus on the impact of some internal or external conditions on the green transformation of heavily polluting enterprises. In this paper, the "technology organization environment" is divided into three levels. Six conditions are extracted: digital technology, R&D capability, dynamic capability, enterprise scale, resource constraints and competitive pressure. In this paper, we discuss the impact of different conditions on the green transformation of heavily polluting enterprises from a more systematic and comprehensive perspective. Secondly, NCA and QCA were used to analyze the common and mutual effects of different conditions on transformation. This paper combines quantitative and qualitative analysis to effectively deal with the impact of multiple antecedents on transformation. It makes up for the lack of single condition research. This study helps to deepen the knowledge related to the green transformation of heavy pollution enterprises. Provide guidance for managers to develop green transformation routes suitable for their own conditions.

2. TOE Framework

Tornatzky (1990) et al. first proposed the TOE theory for analyzing corporate innovation, arguing that organizational adoption of innovation is influenced by a combination of technological, organizational, and environmental factors [11]. It is applicable to several research areas [12]. The green transformation of heavy pollution enterprises is influenced by a combination of antecedent conditions in the dimensions of technology, organization, and environment, and it is necessary to explore the relationship between antecedent groupings and green transformation of heavy pollution enterprises from a grouping perspective to provide a reference for the decision of green transformation of heavy pollution enterprises.

The technology dimension, which emphasizes the characteristics of technology itself and its relationship to the firm, examines whether technology is compatible with the structural characteristics of the firm and whether technology is compatible with the firm's management capabilities [13]. In this paper, two antecedent groupings, digital technology and R&D capability, are selected to measure the technology dimension, which is an important force driving the green transformation of heavy polluting enterprises. The existing literature shows that digital technology is one of the important influencing factors for the green transformation of enterprises. Relying on digital technology, enterprises are able to achieve green transformation by reducing energy consumption intensity and pollution emissions [14]. Digital technology contributes to green transformation by alleviating corporate financing constraints, weakening corporate agency conflicts, and stimulating corporate growth potential[15]. R&D capability is an important factor to promote enterprise technological innovation and an effective driving force to promote green transformation. Enterprises enhance green transformation by strengthening technological R&D capability and optimizing energy consumption structure [16].

Organizational dimensions, which are important factors affecting the level of digital technology adoption in enterprises, include attention allocation, organizational size, financial security, and resource redundancy, etc. [17]. In this paper, dynamic capability and enterprise scale are selected to measure the organizational dimension. This is an effective way to promote the green transformation of heavy pollution enterprises. The high levels of dynamic capability will help the top management team to make green strategy and green innovation behavior decisions more scientifically and efficiently, and advance the green transformation implementation process [18]. The dynamic capability of the enterprise can drive the green strategy and green innovation behaviors. Dynamic capabilities can drive the development and implementation of green strategies [19].The dynamic capabilities of enterprises can facilitate the development and implementation of green strategies. Enterprises of different scales differ in terms of resource allocation and organizational structure, and their innovation performance capabilities are very different. Some scholars believe that different size enterprises also differ in innovation, and there is an inverted U-shaped

relationship between enterprise size and innovation [20].

Environmental dimension, mainly based on external perspective, examines the impact of market structure, industry competition, regional infrastructure, institutional policies and other factors [21]. This paper selects resource constraints and competitive pressures as two prerequisites to measure the environmental dimension. This is an important opportunity to accelerate the green transformation of heavy pollution enterprises. Resource constraint refers to the restriction of resources for enterprise development. Heavy polluting enterprises are mainly affected by natural resources, and when they face increased resource constraints, they will seek their own development with external resources[22] .Vorfolomeiev concludes that resources are the basis of the green transformation of enterprises, and the key is to improve resource utilization, further emphasizing the important role of resources and their flow in the green transformation of enterprises[23].Competitive pressure is the level of pressure felt by firms from their business competitors that forces them to adopt new technologies to maintain a competitive advantage[24]. Research shows that when more competitors adopt new technologies, enterprises will feel competitive pressure. And rapidly transform technology into strategic needs.

3. Conclusions

This paper is based on the TOE theoretical framework. The research sample is 514 heavily polluted enterprises. Use NCA and fs-QCA methods. The influence of digital technology, R&D capability, dynamic capability, enterprise scale, resource constraints, competition and pressure on enterprise green transformation is analyzed. The main findings of the study are as follows.

First of all, there is no single necessary condition for green transformation. The necessity test of NCA and fs-QCA shows that all antecedents cannot constitute the necessary conditions for green transformation of enterprises alone. However, there are multiple antecedents working together, with the characteristics of "multiplicity" and "concurrency"[25].

Second, this paper identifies 6 antecedent histories of high green transformation of firms. According to the theoretical framework of TOE, it can be further divided into three types: scale driven type, technology development type, large-scale dynamic development type, and all-factor driven type. The research results show that there is no single optimal path for the green transformation of enterprises, and the paths to produce unified results are diverse.

Thirdly, this paper identifies seven leading groups for enterprises' non-high green transformation. There is a significant asymmetric relationship between these two groups. Cross-sectional comparative analysis shows that enterprise scale plays an indispensable role in the process of green transformation.

Fourth, the heterogeneity analysis found that there are significant differences between the green transformation paths of state-owned and non-state-owned enterprises. This may be the result of the difference between the size of the industry and the decision of the senior executives.

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