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Understanding the Sustainable Competitive Advantages of China's Private Manufacturing Enterprises: An Empirical Study Based on the Dynamic Capabilities of Supply Chain

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ABSTRACT This study aims to explore the impact of supply chain dynamic capabilities on the construction of sustainable competitive advantage. This paper takes Chinese private manufacturing enterprises as the research object, and we also use statistical methods such as correlation analysis and hierarchical regression for empirical testing. Research shows that supply chain sensing has a positive impact on supply chain agility and supply chain adaptability; supply chain agility and supply chain adaptability have a positive impact on the sustainable competitive advantage of enterprises; environmental dynamics does not have a significant regulating effect on the relationship between supply chain sensing and supply chain adaptability. This research guides Chinese private manufacturing companies to focus on cultivating supply chain dynamic capabilities to reasonably respond to changes in the market environment, thereby promoting sustainable competitive advantages.

INDEX TERMS Supply chain dynamic capability, short-term financial performance, sustainable competitive advantage, environmental dynamics.

I. INTRODUCTION

In 2015, the State Council of China issued the “Made in China 2025”, a guiding document for the development of the manufacturing industry, which put forward the basic principles of strategic development of “based on the current and looking to the long-term,” and required to effectively improve the core competitiveness and sustainable development capabilities of the manufacturing industry to adopt significant changes in the economic development environment [1]. As an essential part of the socialist market economy, Chinese private manufacturing enterprises are inherently sensitive to the market environment and have flexible mechanisms. They have invested heavily in optimizing industrial structure, promoting technological innovation, and promoting transformation and upgrading. However, unlike China's state-owned and foreign-funded manufacturing companies,

many private manufacturing companies started late, have not yet accumulated strong technical capabilities, and face issues such as poor management and operational experience and serious brain drain [2]. Under this circumstance, studying how Chinese private manufacturing companies can perceive the changes in the market environment and effectively adopt response mechanisms to promote sustainable growth and development of the company is one of the important research topics for achieving the strategic goals of “Made in China 2025” [3].

With the rise of emerging technologies such as the Internet of Things and artificial intelligence, China's private manufacturing enterprises face unprecedented pressure from many aspects, such as intensified competition in the global market and rising resource costs [4]. The originally scattered enterprises gradually realize that it is difficult to survive in such a large environment only by their ability. How to dynamically manage the internal resources of each enterprise in the supply chain, identify and obtain the corresponding external

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resources of the supply chain, effectively adjust the overall structure and process of the supply chain to quickly identify and respond to the market demand in the dynamic environment, build the dynamic ability to cope with environmental changes, and make the whole supply chain play a $1 + 1 > 2$ collaborative role. It is increasingly becoming the key for manufacturing enterprises to obtain sustainable competitive advantage and improve enterprise performance [5], [6].

As one of the critical capabilities of the whole supply chain to maintain competitive advantage, supply chain dynamic capability is indispensable in developing enterprises [7]. In recent years, more and more scholars have introduced supply chain dynamic capability into the research of Chinese enterprises. After combing the literature at home and abroad, found in the past the study of dynamic capability theory mainly embodied in the definition and constituent elements of dynamic capability, the forming mechanism and construction mechanism, the relationship between dynamic capability and performance, the dynamic capability theory in production operation, marketing, international business, organizational change, social responsibility and public management in the areas of application, etc. [8]–[10]. In addition, contingency theory holds that organizational behavior (market perception, resource selection behavior) can produce higher performance only when matched with the corporate environment (environmental dynamism). Still, previous studies have ignored the role of environmental factors in creating sustainable competitive advantage.

Therefore, this study takes “how Chinese private manufacturing enterprises obtain a sustainable competitive advantage by building the dynamic capability of the supply chain” as the starting point, focuses on the performance mechanism of dynamic capability, takes the research of Day and Wensley [11] as the theoretical basis, and draws on the views of Teece [12] and Aslam *et al.* [13] for reference. This paper identifies three types of supply chain dynamic capabilities: perception, agility, and adaptability. Environmental dynamics are introduced as a moderating variable, and empirical research is conducted to investigate the mechanism and path for enterprises to improve short-term financial performance and sustainable competitive advantage by building supply chain dynamic capabilities under a dynamic environment.

II. REVIEW AND HYPOTHESES

A. DYNAMIC CAPABILITY THEORY

Dynamic capability is defined as the ability of an enterprise to integrate and reconstruct resources to adapt to changes in the external environment to reasonably explain how an enterprise can identify and understand market changes in the rapidly accelerating environment to obtain and maintain competitive advantages [14], [15]. This is an important driving force for companies to adapt to changes in the fast and dynamic business environment and to perceive new opportunities and threats. Since the “dynamics” embodied in the dynamic capability theory are consistent with the “unpredictable” and “rapidly turbulent” characteristics of

today's super-competitive environment. Therefore, dynamic capabilities have opened up new and beneficial ways for companies to avoid market risks and enhance the sustainability of competitive advantages by integrating internal and external resources under the continuous changes of the market and institutional environment [16], and have gradually become a research hotspot in the current strategic management field [17]. And it has been further developed and improved by scholars [18].

Dynamic capabilities are different from basic capabilities. They are high-level capabilities embedded in the daily organizational process of an enterprise and act based on basic capabilities. They can promote the improvement of essential capabilities, thus driving enterprises to update, adjust and reconfigure their resources and core capabilities to continuously obtain the core competitive advantages of an enterprise [19].

Dynamic capability theory focuses on converting the enterprise's resources (knowledge/technology, etc.) into products or services and paying excess value to customers. On the one hand, this transformation encourages companies to adapt to industry changes in a faster, more accurate, and creative way, reflecting the “dynamic” characteristics, that is, matching the dynamic changes of the external environment [20]; On the other hand, this transformation is also conducive to enterprises to obtain sustainable competitive advantages, highlighting the meaning of “ability,” that is, how a company can maintain core competitiveness for a long time. Dynamic capabilities explain the essence of enterprise capabilities and ability evolution affected by environmental changes, and determine the decisive factors and processes affecting the survival and development of enterprises, which effectively make up for the lack of resource-based theory [21].

B. RESEARCH MODEL

The resource-based theory emphasizes that resources are the source for enterprises to obtain competitive advantages; that is, diversified resources are distributed in various degrees among enterprises, and the heterogeneity of each enterprise is solidified over time. For China's private manufacturing enterprises, the demand for products is increasingly diversified and personalized. The dynamic change of the market environment may lead to the rapid consumption of excess profits brought by enterprise resource sharing. Therefore, private manufacturing enterprises must focus on building and cultivating resilience to adapt to changes in the external environment, namely dynamic capability, to promote enterprises to build new competitive advantages. Strong dynamic ability can drive enterprises to continuously reuse, integrate and configure enterprise resources and processes, and quickly respond to and meet customer market demand to coordinate and match with the turbulent market environment. At the same time, the complexity and variability of the external market constantly erode the equilibrium stability previously achieved by enterprises, so the static interpretation of the resource-based theory of enterprises should be organically combined

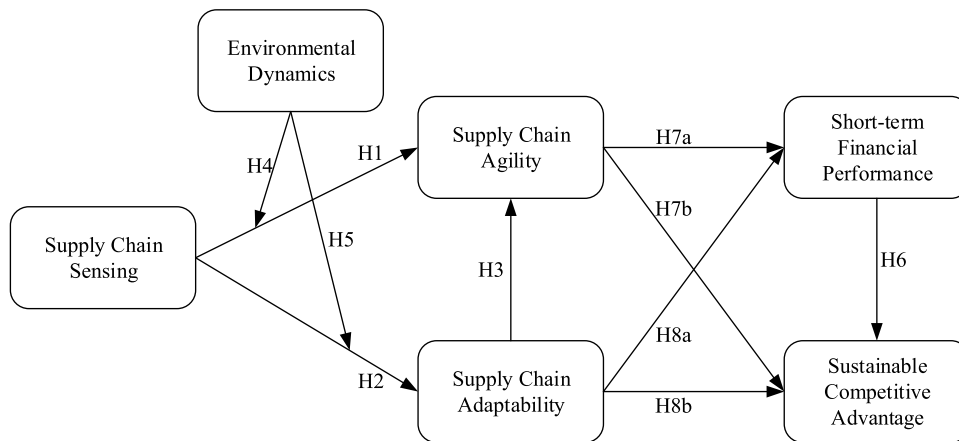


FIGURE 1. The research model.

with dynamic capability theory after being fully extended. Therefore, Chinese private manufacturing enterprises must constantly update their resources and optimize dynamic capabilities to obtain sustainable competitive advantages to remain invincible in the market competition. Because of this, following the research logic of “supply chain dynamic capability – a sustainable competitive advantage of enterprises” and combining fundamental theories such as resource-based theory and dynamic capability theory, the research model, as shown in Figure 1 below, is constructed to deeply reveal the function relationship and influence mechanism of supply chain dynamic capability on the sustainable competitive advantage of enterprises. This paper analyzes the necessity of supply chain node enterprises to maintain sustainable competitive advantage from the perspective of the dynamic capability to make up for the deficiency of existing theoretical research.

C. SUPPLY CHAIN DYNAMIC CAPABILITY, ENVIRONMENTAL DYNAMICS, AND COMPETITIVE ADVANTAGE

1) SUPPLY CHAIN DYNAMIC CAPABILITY

The application management of dynamic capabilities in supply chain strategic decision-making is becoming more common. The dynamic capability of a supply chain is regarded as the changeability of the supply chain. Blome *et al.* [22] viewed the flexibility and agility capabilities of each node of the supply chain as two aspects of the dynamic capabilities of the supply chain. Defee and Fugate [23] defined the dynamic capability of the supply chain as the capability that the upstream and downstream enterprises in the supply chain have common learning and innovation capabilities to improve the original supply chain structure configuration. Cao [24] pointed out that the theory of enterprise dynamic capability can be extended to supply chain management in the supply chain environment. Still, there is little research on the dynamic capability of the supply chain. Based on the information obtained from the critical events in supply chain management, the essential factors of the dynamic

capability formation of the supply chain are analyzed using the grounded method. Beske *et al.* [25] stated that the dynamic capability of a supply chain is the ability of the complex network chain structure of the supply chain to turn adverse situations into advantages when facing external market changes and to deal with inter-enterprise relations.

Through combing, it is found that although scholars have explained the basic meaning of supply chain dynamic capabilities based on their research purposes, there is a consensus among many definitions that supply chain dynamic capabilities integrate the dynamic capabilities of upstream and downstream enterprises and play an essential role in responding to future demand [26]. This study defines the concept of supply chain dynamic capabilities as starting from the overall benefits of the supply chain, through mutually beneficial incentive strategies to enable multi-stakeholders to participate in cooperation, integrate and configure corporate resources and processes to ensure that each sub-capability is consistent with the initial strategy. At the same time, the ability to rapidly identify and respond to market requirements in a dynamic environment ensures that the supply chain continues to gain a competitive advantage.

From the perspective of supply chain response to market environment change, this paper divides the essential components of supply chain dynamic capability into three aspects: supply chain sensing, supply chain agility, and supply chain adaptability. Among them, supply chain sensing helps the node enterprises of the supply chain identify and explore the external market information, which is the basic ability of the dynamic ability of the supply chain and the prerequisite for the rapid construction of other sub-abilities. After the supply chain has an insight into the market situation, it needs to quickly integrate and reorganize internal and external resources according to the environmental situation to seize opportunities. Supply chain agility is the core ability to enhance the competitiveness of the supply chain. Supply chain adaptability mainly guides the supply chain to adjust in organizational structure and internal process, to give full play to the role of internal and external resources of enterprise

integration on the fundamental structural change of supply chain, and is the endogenous driving force of the dynamic capability of the supply chain.

The change perception of supply chain enterprises to the environment includes reflecting the change of consumer demand and competitors' strategy. Enterprises can get the corresponding business opportunities by perceiving environmental changes in the supply chain or dealing with the turbulence more calmly. The perception content of each node enterprise of the supply chain to external market changes includes the responses of suppliers and stakeholders, the structural changes of the industry and the market, the evolution and development trend of industrial competition and cooperation, and the changing trends of customer demand [27]. In the face of market changes, supply chain enterprises with good market perception ability are more likely to make a positive response quickly. Market perception helps enterprises prepare for market changes and formulate structure, technology, and policies to respond to market changes effectively [28]. In the input of raw materials, fuel, and power, the manufacturing industry has significant natural monopoly characteristics and a high market entry threshold [29], which shows that market perception is essential for enterprises. At the same time, market perception encourages companies to understand the development trend of technology and the market to adjust the supply chain in time to respond to the rapid changes in the environment. Therefore, to improve the supply chain's agility in the short term, companies at each supply chain node need to be aware of the business opportunities and challenges in the market environment for the first time. The supply chain's insight and perception of the market environment can help companies tap potential market demand and development trends. Suppose core companies cannot capture industry and market information trends as soon as possible. It is difficult for the supply chain to adjust its structure in time to achieve effective operation when opportunities and challenges come. Schoenherr and Swink [30] believe that supply chain adaptability reduces the constraints of companies on changing product or service demand through insight into new resources, product commercialization, and listing activities, thereby responding to the "structural changes" of the market. To achieve this transformation, Sheel and Nath [31] believe that it is necessary to search for and perceive this structural transformation in advance and then adjust the supply chain structure to achieve long-term supply chain design decisions. Bharadwaj and Dong [32] proposed that systematic market perception activities can keep pace with market changes by capturing market data, identifying key patterns and other activities, which can help each node enterprise in the supply chain to improve and configure the supply chain structure reasonably according to the external environment, to achieve the state of "sharing weal and woe" between the enterprise and the environment, to adapt to long-term and fundamental changes. Therefore, we believe that the ability of supply chain managers to perceive and scan the market, interpret and respond

to change signals is the key trigger factor for long-term supply chain restructuring (supply chain applicability).

The speed of informationization reform gradually accelerates, leading to sharp fluctuations of the economic system, which makes the traditional focus of supply chain management migrate with the market environment changes. Only when the supply chain has the flexible function to adapt to the continuous shift of the focus of supply chain management can it make the real-time structural adjustment to cope with the fundamental changes of the environment. Eckstein *et al.* [33] believe that supply chain adaptability contributes to supply chain agility. Specifically, supply chain agility requires enterprises at each node of the supply chain to quickly deal with changes in demand, such as customer preferences, and changes in supply, such as delivery failures [22]. If a business is involved in the ongoing development of its suppliers and logistics infrastructure, it can cope with delivery failures. Similarly, if a company monitors changes in customer demand over time, it can respond to changes in consumer preferences. Through adaptability, enterprises create tension in the supply chain [34] to more actively adapt to and reasonably respond to changes in the system and the environment, that is, to enhance the agility of the supply chain. We believe that the ability to reconfigure the supply chain structure according to the market demand (supply chain adaptability) is the basis for enterprises to develop supply chain agility. Based on the above analysis, the following hypotheses are proposed:

Hypothesis 1 (H1). Supply chain sensing has a positive effect on supply chain agility.

Hypothesis 2 (H2). Supply chain sensing has a positive effect on supply chain adaptability.

Hypothesis 3 (H3). Supply chain adaptability has a positive effect on supply chain agility.

2) ENVIRONMENTAL DYNAMICS

With the support of information technology, the decision-making level of private manufacturing companies has been dramatically improved, but the impact of environmental uncertainty has not been reduced. Therefore, the environment is a variable that small and medium-sized private manufacturing enterprises must consider, and it is an essential regulatory variable of supply chain management [35]. Environmental dynamism describes the change degree and predictability of the external environment faced by enterprises [36]. The highly turbulent environment makes companies face rapid changes in industry technology, constant changes in customer preferences, continuous and large fluctuations in product demand and material supply, and endless emergence of competitors [37]. To gain a firm foothold in the industry, enterprises need to realize real-time control of the external dynamic environment by perceiving the dynamic changes of their environment. The enhancement of environmental dynamics makes companies feel the changes in the external environment more strongly, which also dramatically promotes companies to constantly review themselves and

consolidate the basis of supply chain perception capabilities to achieve timely insights into the external environment. At the same time, the highly volatile environment is more likely to generate market opportunities and stimulate enterprises to enhance their awareness of self-innovation [37]. The emergence of environmental dynamics has stimulated the construction of supply chain sensing, and the development of supply chain sensing has collected more information for enterprises. The enterprise absorbs the external information collected by the supply chain sensing and transforms it into enterprise thinking to provide supply chain agility [38]. Therefore, when the highly volatile external environment appears, the supply chain sensing can assist each node company in the timely awareness of the business opportunities and challenges in the external environment. It is convenient for the company to adjust strategic measures in time to make a more agile and positive response and make forward-looking preparations for the long-term development of enterprises in the future [28].

A highly turbulent environment is more likely to produce more market development opportunities. It is an important way for the forerunners of enterprises to obtain benefits from the market or technology [37]. Based on sufficient insight into environmental dynamics, supply chain sensing can help companies at various nodes search and perceive the development opportunities in the market environment in advance. Under the influence of environmental dynamics, enterprises can absorb the available knowledge related to the external environment, promote enterprises to improve the adaptability of the supply chain in a short time, and effectively configure the supply chain structure to provide stable support for enterprises to make full use of market development opportunities [39]. In addition, with the increasing degree of scarce resources and the intensification of environmental dynamics, to seize more market shares, enterprises will give full play to their perception ability to grasp and predict the external environment in time and improve their adaptability to technological change and market uncertainty, to enhance their market position. Based on the above analysis, the following hypotheses are proposed:

Hypothesis 4 (H4). Environmental dynamics positively affect the relationship between supply chain sensing and supply chain agility; in a highly dynamic environment, supply chain sensing has a more significant impact on supply chain agility than in a less dynamic environment.

Hypothesis 5 (H5). Environmental dynamics have a positive regulatory effect on the relationship between supply chain sensing and supply chain adaptability. In a highly dynamic environment, supply chain sensing has a more significant impact on supply chain adaptability than in a less dynamic environment.

3) COMPETITIVE ADVANTAGE

In the constantly changing market competition environment, an enterprise can't have a certain competitive advantage for a long time [40]. Under the threat and attack of peers, its

dominant position will eventually dissipate gradually [41]. Suppose an enterprise wants to obtain a sustainable competitive advantage. In that case, it must be based on its resources and capabilities to exchange energy with the outside world to continuously accelerate the speed of innovation and make up for and replace the original gradually dissipating competitive advantage by continually creating new competitive advantages during its development period [42]. However, enterprises hope to make a competitive advantage with more excess profits than their peers in the short term and hope to keep creating new competitive advantages by using their resources and capabilities to resist competitors' attacks in a long time [43]. The actual content of sustainable competitive advantage is that enterprises can provide more consumer surplus and producer surplus in the long-term development process. In the ever-changing product market environment, enterprises can have different forms of competitive advantage that can create excess profits for a long time. The essence of sustainable competitive advantage is that enterprises can provide more consumer surplus and producer surplus in the long-term development process. In the constantly changing product market environment, they can have different forms of competitive advantage that can create excess profits for enterprises for a long time. Therefore, sustainable competitive advantage is a wavy link chain composed of competitive advantage groups with various manifestations and cyclic superposition within a certain period. In the long-term development process of an enterprise, only through the continuous integration, reconfiguration, and energy exchange of internal and external resources and capabilities can the enterprise create a new round of competitive advantage to replace the original uncompetitive competitive advantage that is dissipating. And finally, form the sustainability of maintaining competitive advantage [44]. Figure 2 shows the process of creating a sustainable competitive advantage for enterprises.

It can be seen from the figure that with the changes in the external environment, through the continuous creation of competitive advantages and the realization of a virtuous circle of corporate competitive advantages, companies can maintain their current competitive advantages. Therefore, companies should start to create a new round of competitive advantage when the previous competitive advantage is about to dissipate. In this way, when the original competitive advantage dissipates, the latest round of competitive advantage has begun to enter the forming period, and this cycle continues to create new ones. Only with a competitive advantage can an enterprise obtain a natural, sustainable competitive advantage. Therefore, we believe that short-term performance is the basis of long-term competitive advantage. Based on the research results of Fang and Zou [45], we use financial performance to measure the short-term performance of enterprises. Based on the above analysis, the following hypotheses are proposed:

Hypothesis 6 (H6). Short-term financial performance has a positive effect on Sustainable competitive advantage.

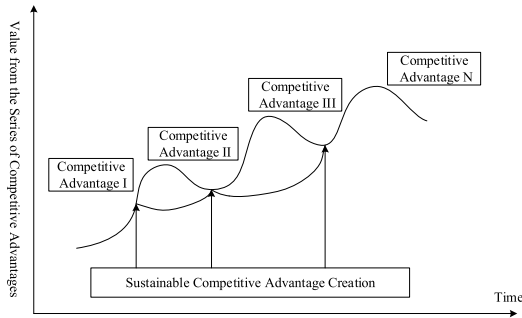


FIGURE 2. Creation model for enterprise sustainable competitive advantage.

Irfan *et al.* [46] believe that excellent enterprises need the upstream and downstream enterprises of the supply chain to respond quickly to short-term demand changes, that is, relying on the agility of the supply chain as support. Blome *et al.* [22] defined supply chain agility as an enterprise's ability to respond to market changes, such as changes in demand patterns (quality, quantity, diversity, etc.) and shortages or interruptions in supply patterns. The primary focus of supply chain agility is to maximize customer efficiency, that is, service level and product or service quality, which will directly affect the organization's financial performance. Husada *et al.* [47] point out that enterprises can respond to external changes efficiently, quickly, and responsibly, called "supply chain agility." In this paper, supply chain agility is defined as the ability of supply chain node enterprises to respond to the changes of market supply and demand quickly through business process integration or reorganization across enterprises under the unpredictable and uneven external environment to effectively avoid risks and reduce the occurrence of some uncertain events. It is believed that improving the agility of the supply chain is helpful to realize the cooperation and coordination between the upstream and downstream partners of the supply chain, to respond to the changes of the market environment before the competitors, provide customers with higher quality and more unique products/services, and enhance the competitive advantages of the upstream and downstream enterprises and the whole supply chain.

Affected by the dynamic fluctuation of the external environment, the supply chain is aware of the need to deal with this fluctuation more positively [48], [49]. As a result, more and more supply chain scholars pay attention to supply chain agility, which becomes an essential ability to help organizations quickly and effectively adjust strategies to respond to short-term changes [50]. Through rapid and accurate response to market changes, supply chain agility can effectively shorten the development cycle of new products, improve the launch frequency of new products, and improve the reliability of product delivery. It can help enterprises achieve the synchronization of supply and demand in the turbulent market environment and even achieve the scale effect of large-scale customized production to bring good revenue for enterprises in the short term [51]. Gligor *et al.* [52]

proposed that supply chain agility has a direct relationship with return on assets, while Inman *et al.* [53] linked profitability (return on investment and return on sales) with supply chain agility under the guidance of experience. In addition, supply chain agility can also help enterprises identify threats and opportunities in the market environment in a timely and accurate manner, which is conducive to improving the adaptability of enterprises with the advantage of small cost [22], [54]–[56], to effectively avoid unknown risks in the market, seize potential opportunities in the market, and obtain competitive advantages in the turbulent market environment [57]. It can be said that supply chain agility can effectively improve the ability of enterprises to adapt to market development and further help enterprises to build sustainable competitive advantage. Based on the above analysis, the following hypotheses are proposed:

Hypothesis 7. Supply chain agility can promote competitive advantage.

Hypothesis 7 (H7a). Supply chain agility has a positive effect on short-term financial performance.

Hypothesis 7 (H7b). Supply chain agility has a positive effect on Sustainable competitive advantage.

Teece [12] pointed out that high-level adaptive ability shows dynamic ability. Eckstein *et al.* [33] defined supply chain adaptability as the ability of an enterprise to make supply chain design changes. It needs to restructure the supply chain to adapt to long-term market changes, which is much more thorough and long-term than the change pursued under the concept of supply chain agility. Aslam *et al.* [13] believe that adaptability usually involves the evolution of organizational form. The key to the improvement of adaptability is that the internal elements of the organization should adapt to the external environmental factors. In this paper, supply chain adaptability is defined as the ability of the supply chain to respond to the perceived long-term and fundamental changes in a time. Specifically, it can make the upstream and downstream enterprises of the supply chain keep a coping state at all times to fully adjust and reconstruct the original configuration, structure, and process of the supply chain according to the external situation. Fundamentally change the nature of the supply chain to build a more stable structure to obtain a sustainable competitive advantage.

As one of the attributes of the supply chain, supply chain adaptability can understand the long-term and fundamental changes of the supply chain and the market environment. Through the flexible adjustment and effective exploration of the supply chain configuration, adaptability can be used to identify and capitalize on the market opportunities [6]. Based on the effective response to the external environment and the timely reception of customer demand changes, supply chain adaptability can help enterprises steadily expand market share and provide strong support for the short-term financial performance of enterprises. In addition, enterprises can balance internal resources and customer demand through the adaptability of the supply chain to adapt to the change of environment. Bharadwaj and Dong [32] propose that

fast-paced thinking and innovation will bring more significant challenges to enterprises in an uncertain environment. The stronger the adaptability of enterprises, the stronger the competitive advantage of enterprises. We believe that supply chain adaptability enables supply chain members to adjust according to the situation to obtain the expected competitive advantage [53]. Based on the above analysis, the following hypotheses are proposed:

Hypothesis 8. Supply chain adaptability can promote a competitive advantage.

Hypothesis 8 (H8a). Supply chain adaptability has a positive effect on short-term financial performance.

Hypothesis 8 (H8b). Supply chain adaptability has a positive impact on sustainable competitive advantage.

III. METHODOLOGY

A. SAMPLE AND PROCEDURES

In order to ensure the quality of the data from the source, based on the research questions and the results of the interview research, the research sampling standards have been established. First of all, because the research question is to explore how the supply chain of Chinese private manufacturing companies actively adapt to changes in the environment, the sample companies are generally required to be in an environment that is not too stable, or at least to face challenges in this regard. Secondly, because the dynamic capabilities of the supply chain need to be cultivated and activated in the enterprise, the sample enterprises are formally established and operated normally for at least one year. The questionnaire is filled in by the relevant personnel who are familiar with the situation of the enterprise, such as the president, general manager and other senior managers of the enterprise.

In this study, field survey and e-mail were used to conduct questionnaire survey and obtain data. With the help of the social relations of tutors, relatives and friends, questionnaires were sent to the top managers of private manufacturing enterprises in Beijing, Shandong and Liaoning province in China. From June to July 2021, 457 questionnaires were collected. Excluding the incomplete and extremely regular invalid questionnaires, 333 valid questionnaires were obtained, and the overall effective rate was 72.9%. The characteristics of sample enterprises are shown in Table 1.

B. MEASURES

In order to improve the validity of the questionnaire, we mainly refer to the relevant mature scales and interview data at home and abroad when designing the questionnaire, and on this basis, combined with the actual situation of China's private manufacturing industry, we adjust the scale slightly. All the variables were evaluated by Likert 5 scale. 1-5 represents the degree of recognition of the subjects for the content described in the measurement items. 1 means totally disagree, 5 means totally agree. According to Aslam and other research results [13], the dynamic capability of supply chain is divided into supply chain sensing, supply chain agility and supply chain adaptability.

The specific measurement scale combines the research of Mathivathanan *et al.* [26] and Hamid *et al.* [44]. The scale of supply chain perception includes 5 items, the scale of supply chain agility includes 4 items, and the scale of supply chain adaptability includes 5 items. Using the method of Jaworski and Kohli [58], the environmental dynamism is measured from the aspects of the overall market variability, the speed of technology and demand change, with a total of four items. Performance mainly refers to the research of Li and Atuahene-Gima [59], and is measured from two aspects of short-term financial performance and long-term competitive advantage, with a total of 8 measurement items.

IV. DATA ANALYSIS

A. SCALE VALIDITY AND RELIABILITY

First, this study uses SPSS 26.0 and AMOS 23.0 statistical analysis software to test the reliability and structural validity of the scale. It can be seen from Table 2 that the Cronbach's α value and CR value of all scales are greater than 0.7, which indicating a good measurement reliability. Secondly, the convergent validity and discriminant validity of each study variable were investigated. As can be seen from Table 2, the standardized factor load of all the measurement items is greater than 0.6, and all of them are significant at the level of 0.01. At the same time, the average variation extraction amount AVE of each variable is greater than 0.5, showing a good convergent validity, and the square root of AVE is basically greater than the absolute value of the correlation coefficient of each latent variable, indicating a good discriminative validity.

B. RESULTS OF GENERAL DESCRIPTIVE ANALYSIS

Pearson two-sided test was used as descriptive statistics and correlation analysis. The analysis results of the mean, standard deviation and correlation coefficient of the related variables are shown in Table 4. The correlation coefficients among the variables are all less than the critical value of 0.75, which basically eliminates the problem of multicollinearity, and provides a preliminary basis for subsequent hypothesis testing.

C. HYPOTHESES TESTS

We tested our hypotheses via hierarchical regression analysis. Table 5 shows the hypothesis test results among the three dimensions of supply chain dynamic capabilities and the moderating effect of environmental dynamics. First of all, the supply chain agility is taken as the dependent variable, and the enterprise's size, the age of establishment and the industry as the control variables are used to construct Model 1, and the overall fitting effect of the model is poor. On this basis, after adding the supply chain sensing as an independent variable, namely Model 2, the model explanatory power is greatly improved, and the fitting effect is better. At the same time, Model 2 shows that there is a significant positive correlation between supply chain sensing and supply chain agility ($r = 0.468, p < 0.001$). Model 3 shows that there is a significant positive correlation between supply chain adaptability and

supply chain agility ($r = 0.492, p < 0.001$). Model 6 shows that there is a significant positive correlation between supply chain sensing and supply chain adaptability ($r = 0.597, p < 0.001$). Therefore, Hypothesis 1, Hypothesis 2, and Hypothesis 3 are all supported. According to model 4 in Table 5, the interaction between supply chain sensing and environment dynamics has a significant positive impact on supply chain agility ($r = 0.143, P < 0.01$), while Model 7 shows that environment dynamics does not play a significant regulating role in the relationship between supply chain sensing and supply chain adaptability ($r = 0.063, P > 0.05$). Therefore, Hypothesis 4 is supported, and Hypothesis 5 is not confirmed. In order to explain the role of environmental dynamics more clearly, the regulating effect of environmental dynamics on the effect of supply chain sensing on supply chain agility is drawn. It can be seen from Figure 3 that compared with a less dynamic environment, in a highly dynamic environment, the positive correlation between supply chain sensing and supply chain agility is higher, which once again supports Hypothesis 4.

Table 6 shows the hypothesis test results between short-term financial performance and sustained competitive

advantage, as well as between supply chain agility and supply chain adaptability to short-term financial performance and sustainable competitive advantage. Model 14 shows that there is a significant positive correlation between short-term financial performance and sustained competitive advantage ($r = 0.433, p < 0.001$), so Hypothesis 6 is supported. Model 9 and model 10 show that supply chain agility ($r = 0.428, P < 0.001$) and supply chain adaptability ($r = 0.407, P < 0.001$) are positively correlated with short-term financial performance. Similarly, Model 12 and Model 13 show that supply chain agility ($r = 0.345, p < 0.001$) and supply chain adaptability ($r = 0.393, p < 0.001$) are significantly positively correlated with sustainable competitive advantage. Therefore, Hypothesis 7 and Hypothesis 8 are supported.

A summary of the results for all hypotheses is shown in Table 7.

V. DISCUSSION

A. GENERAL RESULTS DISCUSSION

In recent years, more and more companies regard the implementation of supply chain management as a strategic measure to enhance their core competitive advantages [66], [67].

TABLE 1. Statistics of sample characteristics (N = 333).

Enterprise characteristics	Type	Number of samples	%
Firm size	Below 50	42	12.6%
	51~200	77	23.1%
	201~500	94	28.2%
	501~1000	74	22.2%
	Above 1000	46	13.8%
Firm age	1~2 years	57	17.1%
	2~5 years	69	20.7%
	5~8 years	75	22.5%
	8~10 years	78	23.4%
	10 years or more	54	16.2%
Industry	Communication equipment, computer and other electronic equipment manufacturing industry	32	9.6%
	Instrument and machinery manufacturing industry	73	21.9%
	Furniture, printing and other textile manufacturing industry	62	18.6%
	Pharmaceutical manufacturing industry	75	22.5%
	Metal, plastic and rubber products manufacturing industry	56	16.8%
	Other industries	35	10.5%

TABLE 2. Reliability, aggregation and discriminant validity of research variables.

Variable	Cronbach's α	Load factor	CR	AVE	Discriminant validity						
					SS	SA	SD	ED	FP	CA	
Supply chain sensing (SS)	0.896	0.823~0.856	0.925	0.71	0.843						
Supply chain agility (SA)	0.822	0.790~0.821	0.882	0.652	0.472**	0.807					
Supply chain adaptability (SD)	0.83	0.764~0.779	0.881	0.596	0.599**	0.500**	0.772				
Environmental dynamics (ED)	0.926	0.893~0.913	0.947	0.818	0.393**	0.351**	0.372**	0.904			
Short-term financial performance (FP)	0.813	0.790~0.809	0.877	0.641	0.487**	0.425**	0.407**	0.376**	0.801		
Sustainable competitive advantage (CA)	0.829	0.788~0.843	0.887	0.662	0.458**	0.353**	0.402**	0.334**	0.448**	0.814	

Note: The bold diagonal is the square root of AVE; the lower triangle is the Pearson correlation coefficient of the variable; ** means $p < 0.01$.

TABLE 3. Results of confirmatory factor analysis.

Model	Factor	χ^2/df	IFI	TLI	CFI	RMSEA
Model 1 (Six factors)	SS, SA, SD, ED, FP, CA	2.162	0.93	0.919	0.929	0.059
Model 2 (Five factors)	SS, SA, SD, ED, FP+CA	2.933	0.881	0.865	0.88	0.076
Model 3 (Four factors)	SS+SA+SD, ED, FP, CA	3.665	0.833	0.813	0.832	0.09
Model 4 (Three factors)	SS+SA+SD, ED, FP+CA	4.412	0.784	0.761	0.782	0.101
Model 5 (Two factors)	SS+SA+SD, ED+FP+CA	7.798	0.566	0.524	0.563	0.143
Model 6 (Single factors)	SS+SA+SD+ED+FP+CA	8.718	0.505	0.459	0.503	0.152

Note: "+" means that the former and the latter factors are combined into one factor.

TABLE 4. Mean, standard deviation and correlation matrix of each variable (N = 333).

Variable	Mean	Standard Deviation	1	2	3	4	5	6	7	8	9
1. Firm size	3.015	1.231	1								
2. Firm age	3.009	1.334	0.071	1							
3. Industry	3.465	1.496	-0.053	0.036	1						
4. supply chain sensing	3.797	0.561	0.043	0.07	0.052	1					
5. supply chain agility	4.418	0.432	-0.04	0.106	0.064	0.472**	1				
6. supply chain adaptability	4.016	0.449	-0.023	0.073	0.069	0.599**	0.500**	1			
7. Environmental dynamics	3.215	0.756	0.034	0.063	-0.036	0.393**	0.351**	0.372**	1		
8. Short-term financial performance	4.368	0.47	0.088	0.056	0.028	0.487**	0.425**	0.407**	0.376**	1	
9. Sustainable competitive advantage	4.492	0.436	0.122*	0.119*	0.113*	0.458**	0.353**	0.402**	0.334**	0.448**	1

Note: **p<0.01, Pearson correlation coefficient adopts two-tail test.

supply chain sensing can provide core companies with opportunities for the exchange and sharing of internal and external resources and information to promote the effective development and smooth implementation of the entire supply chain activities. Its application in management practices has attracted more and more scholars' attention. Under this research background, this paper takes Chinese private manufacturing enterprises as the research object, based on the resource-based view and dynamic capability theory, and uses various research methods such as literature analysis, interview and empirical analysis to deeply explore how the dynamic capability of supply chain can promote the construction of sustainable competitive advantage. The main conclusions are as follows:

Supply chain awareness is a prerequisite for supply chain agility and adaptability. This finding resonates with

Aslam *et al.* [8] emphasizing the importance of market perception for supply chain agility and supply chain adaptability. Only when supply chain managers can first perceive market opportunities and threats, the agility and adaptability of the supply chain are necessary. After perceiving opportunities and threats, managers can react in two ways. In the short term, supply chain agility enables companies to quickly change their products and services according to the number and diversity of customers' requirements. From a long-term perspective, supply chain adaptability can help companies understand end customers, understand product life cycles, and continue to develop new suppliers. Therefore, market perception not only helps supply chain companies quickly understand market changes, but also helps them improve their decision-making regarding execution and reconfiguration capabilities. At the same time, the empirical test results

TABLE 5. Multiple regression results for supply chain agility and supply chain adaptability.

Variables	Supply chain agility				Supply chain adaptability		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
<i>Control variables</i>							
Firm size	-0.045	-0.064	-0.032	-0.062	-0.025	-0.049	-0.05
Firm age	0.107	0.076	0.071	0.071	0.073	0.034	0.028
Industry	0.058	0.033	0.026	0.042	0.065	0.034	0.042
<i>Main effects</i>							
SS		0.468***		0.391***		0.597***	0.532***
SD			0.492***				
ED				0.269***			0.196***
<i>Interaction effects</i>							
SS*ED				0.143**			0.063
R ²	0.017	0.234	0.257	0.282	0.01	0.363	0.389
Adj R ²	0.008	0.224	0.248	0.269	0.001	0.355	0.378
Model F	1.873	24.982***	28.308***	21.312***	1.149	46.769***	34.591***

Note: *p < 0.05; **p < 0.01; ***p < 0.001.

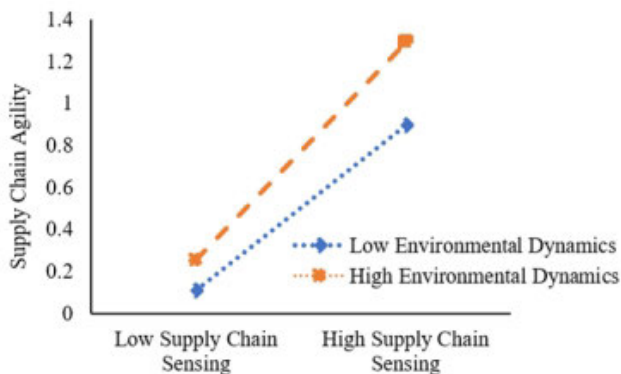


FIGURE 3. Moderating effect of environmental dynamics on the relationship between supply chain sensing and supply chain agility.

also show that supply chain adaptability can also effectively promote the improvement of supply chain agility. This conclusion shows that the adaptability of the supply chain can maintain long-term response to market changes by changing the resource base and structure of the supply chain. Furthermore, when the enterprise is facing the changing market demand, the adaptability of supply chain can promote the agility of supply chain and bring short-term response with immediate results, so that the enterprise can grasp the market opportunity in time and further meet the customer demand.

The empirical results show that the positive effects of supply chain agility and supply chain adaptability on short-term financial performance and sustainable competitive advantage are verified. Supply chain dynamic capability helps enterprises to provide real-time and reliable supply chain operation resources, breaking the original “resource island”, so as to provide a basis for enterprises to make supply chain management decisions. Supply chain agility and supply chain adaptability help enterprises adapt to changes in the external

environment and provide opportunities for related information resources to be synchronized and integrated on their supply network. This is conducive to enterprises at all nodes of the supply chain in responding to market demands, thereby improving short-term financial performance. Based on the agile response and rapid adaptation to the external environment, it provides support for enterprises to establish sustainable competitive advantages in line with development trends. At the same time, the improvement of short-term financial performance levels also lays the financial foundation for subsequent enterprises’ sustainable competitive advantages.

Environmental dynamics play a positive regulating role between supply chain perception and supply chain agility. Dynamic environmental changes are more likely to inspire enterprises to strengthen the awareness of building perception capabilities, thus promoting enterprises to improve their ability to timely respond to customer needs in the short term, actively make rapid responses to opportunities and challenges in the market, and respond to various changes in a reasonable and effective way. This also means that environmental dynamics enhance the dependence of supply chain agility on supply chain sensing. Environmental dynamics has no significant positive adjustment effect between supply chain sensing and supply chain adaptability. The main reason may be: highly turbulent environmental conditions have higher requirements for supply chain awareness. When the supply chain sensing is enhanced, it means that the enterprise can obtain more external information technology resources at the same time, which puts forward higher requirements on the supply chain adaptability. However, there is limited space for enterprises to improve their adaptability in a short period of time, which is easy to cause more pressure on enterprises, resulting in limited space for them to play their adaptability. Therefore, environmental dynamics cannot play its regulatory

TABLE 6. Multiple regression results for short-term financial performance and sustainable competitive advantage.

Variables	Short-term financial performance			Sustainable competitive advantage			
	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
Control variables							
Firm size	0.086	0.105*	0.096	0.121*	0.136*	0.131**	0.083
Firm age	0.049	0.003	0.019	0.106*	0.07	0.078	0.085
Industry	0.031	0.006	0.004	0.115*	0.096	0.09	0.102*
Main effects							
SA		0.428***			0.345***		
SD			0.407***			0.393***	
FP							0.433***
R2	0.011	0.191	0.175	0.04	0.157	0.193	0.226
Adj R2	0.002	0.181	0.165	0.032	0.147	0.184	0.216
Model F	1.241	19.404***	17.433***	4.626**	15.296***	19.654***	23.882***

Note: *p < 0.05; **p < 0.01; ***p < 0.001.

TABLE 7. Summary of the results for all hypotheses.

Hypotheses	Results
Hypothesis 1. Supply chain sensing has a positive effect on supply chain agility.	supported
Hypothesis 2. Supply chain sensing has a positive effect on supply chain adaptability.	supported
Hypothesis 3. Supply chain adaptability has a positive effect on supply chain agility.	supported
Hypothesis 4. Environmental dynamics have a positive regulatory effect on the relationship between supply chain sensing and supply chain sensing and supply chain agility, that is, in a highly dynamic environment, supply chain sensing has a greater effect on supply chain agility than in a less dynamic environment .	supported
Hypothesis 5. Environmental dynamics have a positive regulatory effect on the relationship between supply chain sensing and supply chain adaptability, that is, in a highly dynamic environment, supply chain sensing has a greater effect on supply chain adaptability than in a less dynamic environment .	not supported
Hypothesis 6. Short-term financial performance has a positive effect on sustainable competitive advantage.	supported
Hypothesis 7. Supply chain agility can promote competitive advantage.	supported
Hypothesis 7a. Supply chain agility has a positive effect on short-term financial performance.	supported
Hypothesis 7b. Supply chain agility has a positive effect on sustainable competitive advantage.	supported
Hypothesis 8. Supply chain adaptability can promote the competitive advantage.	supported
Hypothesis 8a. Supply chain adaptability has a positive effect on short-term financial performance.	supported
Hypothesis 8b. Supply chain adaptability has a positive effect on sustainable competitive advantage.	supported

role between supply chain sensing and supply chain adaptability. In addition, the reason why this conclusion is not confirmed may also be that enterprises need to have more mature agile capabilities. Only by adjusting the supply chain structure well, can an enterprise actively respond quickly and flexibly to various short-term external changes, can the speed of enterprise adaptability be improved, so that timely feedback under the influence of environmental dynamics can be realized. Therefore, this conclusion once again confirms the importance of supply chain agility.

B. MANAGERIAL IMPLICATIONS

The diversification and individuation of consumer demand and the application of the Internet and information technology have made market competition gradually developed from traditional competition between enterprises to competition between enterprise alliances, that is to say, the competition among supply chains in the industry. Dynamic supply chain capability can accelerate the continuous integration and reconstruction of available resources for enterprises to plan a more reasonable and efficient operation scheme to

respond to the rapid changes in market, technology and other environmental aspects, so as to catch up with the development of other related enterprises' supply chains. However, in this highly volatile and changing environment, we found that many small and medium-sized private manufacturing enterprises have relatively weak ability to rationally allocate internal and external resources to cope with market changes, leading to cases of near bankruptcy everywhere. The research results of this paper provide reference and guidance for supply chain managers to assist private manufacturing enterprises to build sustainable competitive advantage by strengthening dynamic capabilities. The specific management implications are as follows:

Pay attention to the construction and investment of supply chain dynamic capability. Many Chinese private manufacturing enterprises started relatively late, have not yet accumulated strong technical capabilities, lack of sufficient management experience, financial support and competitive advantage support. Under the competition between supply chains in the industry, the construction of supply chain agility and supply chain adaptability is crucial for private manufacturing companies at each node of the supply chain to improve short-term financial performance and sustainable competitive advantage. To realize the effective construction of dynamic capabilities among enterprises also depends on the discovery of supply chain sensing. Supply chain sensing is an effective tool for companies at each node in the supply chain to "receive information antennas." the application of supply chain perception ability helps each enterprise to identify external changes and gather heterogeneous resources, so as to ensure that each node enterprise can achieve timely feedback in the resource transmission process, and improve the cooperation level and the efficiency and quality of resource information transmission [64]. Therefore, private manufacturing companies need to be aware of the importance of accelerating the process of resource internalization, provide substantial assistance to the development of corporate resource internalization, guide companies to increase the construction of supply chain perception capabilities, and promote the effective cultivation of inter-company perception capabilities. And strive to provide supporting support from policy, personnel, and physical objects, so that enterprises can influence the realization of organizational goals through implementation, improvement of perception ability foundation and management skills.

Strengthen the understanding of environmental dynamics, cultivate the dynamic ability of supply chain to build sustainable competitive advantage. When facing the dynamic changes of the environment, enterprises should first have a comprehensive understanding and cognition of the external environment, mainly including the market employment environment and situation, the industry development trends, the understanding of the upstream and downstream companies in the supply chain, and even the competitors in the same industry, and timely grasp the update of production technology and the diversified changes of customers' demand for products.

Specifically, companies at each node of the supply chain can predict future development trends of this industry by paying attention to recent relevant policies and theoretical development trends, so as to seize new opportunities that companies may come at any time based on these research trends, and gain more say in the market than competitors. In addition, relevant information can also be obtained in the exchange of activities. Enterprises can actively participate in business activities such as industry associations and economic forums to communicate with each other unsuspectingly, and then grasp the development trends of the industry.

When facing sudden environmental pressure, enterprises need to rely on supply chain agility to play a key role. This ability is a supply chain competition strategy that emphasizes time, and requires them to make rapid and accurate judgment on potential demand with their supply chain. During the operation process of upstream and downstream enterprises in the supply chain, enterprises can adjust the quantity and price of products in a timely manner by observing the supply and demand relationship in the dynamic market environment, so as to keep the whole supply chain in a continuous dynamic state and quickly improve better products / services for customers. In addition, by strengthening the transmission of information and capital flows between upstream and downstream enterprises in the supply chain, real-time monitoring of the operating conditions and transactions of core enterprises can also be realized, and then improve the response speed of the core enterprises of the supply chain to the external market environment.

Supply chain agility can only restructure the resources within the limited conditions to respond to the changes of the external environment quickly, while supply chain adaptability determine the structure of enterprise supply chain in the future, which responds to the "structural transformation" of the market by changing the design of supply chain. Therefore, when adjusting the supply chain structure, enterprises should consider changing the working process between departments through flexible and diverse working modes and communication methods, and constantly update the original business activities to ensure the continuous operation of the supply chain. Secondly, whether the setting of organizational structure mode is reasonable also affects the construction of sustainable competitive advantages of enterprises. According to the operational requirements and characteristics of enterprises, organizational structure can be transformed from functional to process, vertical to flat, and a business process-oriented organizational structure can be established. In addition, enterprises should also reduce constraints on the response to changing demand for products or services by discovering new resources (such as raw materials) and solving problems (such as product commercialization and rollout), mitigate uncertainties in the supply chain and effectively deal with the remaining uncertainties. In addition, the development and implementation of corresponding new strategies to adapt to environmental changes, so that manufacturing enterprises continue to obtain higher than the industry

average level of profit performance, promote the long-term maintenance of sustainable competitive advantage.

C. LIMITATION AND FUTURE RESEARCH

This paper systematically analyzes the relationship between the dynamic capability of supply chain and the construction of sustainable competitive advantage, deeply excavates the internal mechanism between them, makes a certain theoretical contribution, and gives some practical enlightenment. However, due to the complexity of supply chain dynamic capability and the construction of sustainable competitive advantage and the restriction of individual factors, there are still some deficiencies to be further studied in the future.

This paper mainly studies the private manufacturing enterprises in Qingdao, Yantai and Liaoning of China. There may be differences in the cognition of the relationship between supply chain dynamic capability and sustainable competitive advantage among private manufacturing enterprises in different regions. Therefore, whether the conclusions of this study can be applied to the global scope needs further analysis. Future research can expand the effective sample size, so that the collected data is more representative, and the conclusions are more universal.

In this study, the time for collecting questionnaires using the questionnaire method is relatively concentrated, so the data collected are cross-sectional data. In fact, the dynamic capabilities of the supply chain have dynamic characteristics, which cannot reflect the changes in the dynamic capabilities of the supply chain and the sustainable competitive advantage of the enterprise over time. In the future, longitudinal data research can be considered to have a more accurate understanding of the evolutionary laws of dynamic capabilities between enterprises, so as to deeply explore the relationship between the dynamic capabilities of the supply chain and the sustainable competitive advantage of enterprises, and improve the persuasiveness of the research conclusions.

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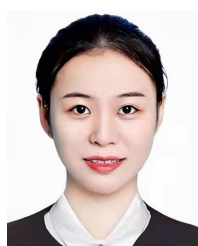
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