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# System Identification of Enterprise Innovation Factor Combinations—A Fuzzy-Set Qualitative Comparative Analysis Method

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**Abstract:** High-tech manufacturing enterprises, as innovative entities, are a key focus of national attention. Currently, such enterprises are facing both internal governance pressure and external institutional pressure. Unlike traditional studies that mostly use regression equations, this article uses the fuzzy-set qualitative comparative analysis method to examine how high-tech manufacturing enterprises can coordinate their internal governance mechanisms and external institutional pressures to achieve optimal innovation. This improves the complex mechanism of the multiple factors jointly explaining corporate innovation, and also helps to elucidate the nonlinear relationship between internal governance factors, external institutional factors, and corporate innovation, effectively enriching research methods and results. However, there has not been any research on the issue of enterprise innovation from the perspective of coordinating the two, which urgently needs to be addressed. This article examines how high-tech manufacturing enterprises can reconcile their internal governance mechanisms with external institutional pressures to achieve optimal innovation. The results showed that (1) a single factor cannot constitute the necessary conditions for innovation in high-tech manufacturing enterprises, but executive and shareholder governance have universality in the innovation in high-tech manufacturing enterprises; (2) in the absence of political advantages, high-tech manufacturing enterprises should focus on the coordinated development of internal governance, making board, executive, and shareholder governance the core conditions for innovative development; (3) with political advantages as the main focus and market attention as a supplement, high-tech manufacturing enterprises promote innovative development by combining executive and shareholder governance. This finding indicates a significant substitution effect between government legitimacy and board governance, and confirms that the importance of obtaining government legitimacy for high-tech manufacturing innovation is higher than market legitimacy. This article enriches the research on enterprise innovation by linking internal corporate governance with external institutional pressure, expands the research on the coordination relationship between institutional pressure and corporate governance, and has enlightening significance in revealing the collaborative path for innovation in high-tech manufacturing enterprises.

**Keywords:** system identification; corporate governance; institutional pressure; enterprise innovation; fuzzy-set qualitative comparative analysis



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## 1. Introduction

The manufacturing industry is the lifeline and pillar industry of the national economy. It should be driven by economic factors and transformed into innovation, which is an inevitable choice for China in order to move towards being a manufacturing powerhouse (Dou et al., 2023) [1]. High-tech enterprises are economic entities that rely on continuous research and development and technological transformation to form independent intellectual property rights. They can be either knowledge-intensive and technology-intensive economic entities. As a micro entity in the industry, high-tech enterprises have the characteristics of high innovation efficiency and low innovation cost. They are a national source

of innovation and a key focus of national attention. The cultivation and enhancement of independent innovation capabilities, mainly focused on high-tech enterprises, is closely related to the micro foundation of sustainable economic growth in China. At the same time, the characteristics of high-tech manufacturing enterprises (HTMEs), such as high knowledge density, great development potential, and strong comprehensive capabilities, have a positive effect on the overall value chain climb of China's manufacturing industry, which is crucial for achieving the sustainable development of the manufacturing industry. Therefore, studying which factors promote the innovative development of HTMEs is of great significance.

Technological innovation is the necessary path for the development of HTMEs, but due to the joint influence of different stakeholders, the innovation process is complex and uncertain, full of difficulties. Subsequently, some scholars have pointed out that good corporate governance can effectively alleviate the difficulties faced in innovation, thereby stimulating the willingness of enterprises to innovate and increasing innovation investment (Yang et al., 2007; Liu et al., 2019) [2,3]. Therefore, the relationship between corporate governance and innovation has received widespread attention, such as shareholder supervision (Zhu et al., 2016) [4], board structure (Xiao et al., 2016) [5], and management incentives (Liang et al., 2015) [6]. Specifically, shareholders have supervisory power, but the different interests of different shareholders lead to differences in their consideration of corporate innovation, resulting in a greater impact of equity structure on corporate innovation. Therefore, corporate innovation cannot be separated from effective shareholder governance, and it is necessary to exercise their right to reasonable supervision. Secondly, as the core leadership, the board of directors is responsible for formulating strategic decisions. Therefore, effective decision-making by the board of directors can reduce innovation risks and improve innovation output. Furthermore, salary incentives, as an important means of stimulating management's willingness to innovate, are an important part of corporate governance and can effectively alleviate agency problems. Due to the long-term nature and uncertainty of innovation, it cannot bring short-term benefits to management. They will avoid innovation activities for personal gain in order to maintain short-term profitability and obtain performance rewards. Therefore, providing reasonable compensation incentives to management can help increase their willingness to innovate. Although relevant research has confirmed the effectiveness of corporate governance, most of the existing literature on the impact of corporate governance on innovation uses econometric models to consider whether a single factor is significant. On this basis, some research has begun to explore how different modes of corporate governance can synergistically affect corporate innovation (Huang et al., 2023) [7], but researchers have only considered how to improve corporate innovation investment and performance through internal governance. However, does corporate governance, which belongs to the internal factors of the enterprise, work together with external factors to influence enterprise innovation? It is worth discussing.

At the same time, technological innovation has intensified the institutional pressure and challenges brought by HTMEs. Due to the novelty and breakthrough characteristics of technological innovation, HTMEs will face institutional pressure from the government and the market. At the government level, the Chinese government being the actual controller and key resource provider of HTMEs has led to a high degree of dependence on the government. If HTME innovation cannot gain government recognition and acceptance, then the legitimacy of such enterprises is lacking, and they cannot obtain new resources and government support for innovation. At the market level, due to the novelty and breakthrough characteristics of technological innovation, the degree of information asymmetry between HTMEs and market investors has increased. As important stakeholders in the enterprise, investors face legitimacy constraints due to information asymmetry, which affects their investment in HTMEs. This reduces the acquisition of innovation resources in the HTME market, thereby affecting innovation efficiency. Therefore, it is necessary, for HTMEs, to alleviate the pressure of government and market legitimacy.

In summary, an HTME faces internal governance pressure and external institutional legitimacy pressure. On the one hand, an HTME needs to seek innovation through effective internal governance, to differentiate itself significantly from competing enterprises. On the other hand, innovation puts legitimacy pressure on HTMEs from both the government and the market, which require recognition and support from both the government and the market (Zimmerman et al., 2002) [8]. However, there is often conflict between governance differentiation and legal convergence when implementing innovation in HTMEs. This has sparked new thinking: how to unite governance and legitimacy has become a strategic decision-making issue for HTMEs. However, reviewing the existing literature, this article finds that although there is a large amount of research on the impact of corporate governance and institutional theory on innovation, the intersection between these two themes is not substantial. In other words, previous studies have overlooked the synergistic effect of corporate governance and institutional pressure on HTME innovation, and have separated their impacts on innovation.

Therefore, studying the synergistic effects of corporate governance and institutional legitimacy on HTME innovation can complement existing research in this field and is of great significance. To address these knowledge gaps, this article conducts research from the perspective of a corporate governance and institutional analysis framework, using the fuzzy-set qualitative comparative analysis (fsQCA) method to analyze 1282 HTME companies listed in 2021 and attempting to reveal the influencing mechanisms behind different factor combinations. The main findings are as follows:

- (1) A single factor cannot constitute a necessary condition for HTME innovation, but executive and shareholder governance are common in HTME innovation. That is, regardless of the configuration, both exist as core conditions. The HTME requires collaborative governance between the two to suppress management's innovation risk aversion and alleviate the principal-agent conflict between shareholders and management.
- (2) In the absence of political advantages, HTMEs should focus on the coordinated development of internal governance, making the board of directors, executives, and shareholder governance the core conditions for innovative development. Also, there is a significant substitution effect between government legitimacy and board governance. When a company lacks legitimacy, it cannot obtain government support and can only use its own resources to maintain a competitive advantage. At this point, the company needs more board members to use collective thinking to ensure minimal decision-making risk.
- (3) With political advantages as the main focus and market attention as a supplement, HTMEs promote innovative development by combining executive and shareholder governance. This finding confirms that the importance of obtaining government legitimacy for HTME innovation is higher than market legitimacy. In other words, government legitimacy can not only directly compensate for the shortage of innovation resources in enterprises, but can also indirectly help them obtain more market resources through government endorsement.

This article provides a reference for the development of HTME innovation by exploring how corporate governance and institutional pressure legitimacy can synergistically affect HTME innovation.

The remaining parts of this article are as follows: Section 2 is a literature review. The next section is the methodology, including data sources and research methods. Subsequently, there are the experimental results, including a correlation analysis, data calibration, antecedent conditions, configuration analysis, and robustness testing. In Section 5, the configuration results are discussed. Finally, conclusions are proposed.

## 2. Literature Review

### 2.1. Corporate Governance and Enterprise Innovation

Corporate governance has a significant impact on corporate innovation. Corporate governance is achieved through the mutual checks and balances of the rights and responsibilities of shareholders, board of directors, and executives (Bai et al., 2005; Lu et al., 2014) [9,10]. For example, shareholders reduce innovation decision-making errors through effective supervision, the board of directors helps companies build innovation strategies through scientific decision making, and executives are motivated to focus on maximizing long-term profits and innovation value. An HTME's governance through shareholders, the board of directors, and executives can assist its own innovation and development, thereby achieving optimal value for itself. The specific board, shareholders, and executive governance are as follows.

#### 2.1.1. Board Governance

Due to its strategic decision-making power, the board of directors has always been regarded as the core of the enterprise, and its size directly affects the decision-making governance structure of the enterprise. Existing research suggests that a larger board size is beneficial for broadening the board's decision-making perspective, breaking away from fixed thinking, increasing its ability to identify innovation opportunities, and reducing decision-making risks. Accordingly, a smaller board size can easily lead to one-sided decision making (Daniel et al., 2007) [11]. In other words, as the size of the board of directors increases, there is diversity in the functions of its members and a wider range of knowledge coverage. They can scientifically and accurately evaluate corporate innovation behavior through complementary experience and skills, effectively identifying innovation projects, and promoting the implementation of corporate innovation strategies and innovation activities (Muhammad et al., 2022) [12]. Some relevant scholars have confirmed this conclusion. For example, Xu et al. (2013) found that a reasonable board structure is helpful for scientific decision making in enterprises, and its size can significantly affect innovation output [13]. Lai et al. (2017) found that a larger board size can significantly affect innovation investment [14]. However, it is worth noting that the above conclusion does not necessarily mean that the larger the size of the board of directors, the better. When the number of people exceeds an appropriate range, board members will become more inefficient when making decisions, which will affect the quality of their decision making. Therefore, enterprises need to control their personnel to within a certain range (Daniel et al., 2007) [11].

#### 2.1.2. Shareholder Governance

Shareholders, as the guardians of corporate resources, are able to effectively supervise the operation of the enterprise and are the foundation of internal governance. In terms of shareholders, the supervision mechanism of equity balance has been widely discussed by scholars. As the degree of equity balance increases, the intensity of shareholder supervision increases. This can not only constrain the management's short-sighted resistance to innovation, but also reduce the self-interest behavior of major shareholders who infringe on the interests of the enterprise to satisfy their own desires, thus scientifically and reasonably allocating enterprise funds (Luo et al., 2014) [15]. Finally, the innovation efficiency and competitive advantage of enterprises can be improved. Some relevant scholars have confirmed this conclusion. For example, Chen et al. (2016) found that equity balance can effectively alleviate agency conflicts in companies, thereby promoting innovation investment [16]. Zhu et al. (2016) found that equity balance can supervise and constrain the behavior of shareholders and management, thereby promoting their active action and significantly improving the efficiency of corporate innovation [4].

#### 2.1.3. Executive Governance

As executors of corporate innovation activities, management usually serves the overall interests of the enterprise, and their performance and compensation are linked to the com-

pany's profits. However, due to the uncertainty, long cycle, and high-risk characteristics of innovation (Zhai et al., 2016) [17], the performance of enterprises may decrease in the short term, which seriously affects the compensation of management. Existing research suggests that management tends to avoid innovation investment in order to reduce the impact of innovation failure on their compensation (Holmstrom, 1989) [18]. Therefore, motivating management compensation is crucial for corporate governance. By ensuring returns for management, it is possible to increase their innovation risk tolerance and enhance their motivation for innovation investment, achieving maximum long-term returns for the enterprise. Some relevant scholars have confirmed this conclusion. For example, Liang et al. (2015) found that salary incentive governance can effectively improve innovation efficiency. Yin et al. (2018) found that salary incentive governance can significantly affect innovation investment [19]. Balkin et al. (2000) found that as manager salaries increase, a company's R&D investment and patent numbers also increase [20].

## 2.2. Institutional Pressure and Enterprise Innovation

The legitimacy brought about by institutional pressure helps enterprises obtain innovation resources, thereby their improving innovation efficiency, including in government and market dimensions. HTMEs can obtain timely government policy information and innovation support by obtaining government legitimacy (An et al., 2021) [21]. The market legitimacy helps HTMEs obtain market innovation resources and avoid the innovation risks caused by information asymmetry. Specifically:

### 2.2.1. Government Legitimacy

The government plays an important role in helping enterprises obtain innovative resource allocation (Peng et al., 2000) [22], especially for enterprises that rely on government support. In terms of direct impact, government departments can help enterprises obtain policy dividends (Su et al., 2014) [23], such as research and development subsidies and project financing (Wu et al., 2009; Xiao, 2018) [24,25], effectively alleviating their financial difficulties. In terms of indirect impact, the government usually endorses a company to prove its good reputation and reliability. This will make it easier for the company to attract the attention of market investors, thereby helping enterprises obtain market resources (Yang et al., 2008) [26]. Therefore, enterprises should maintain close contact with government departments to gain government recognition and legitimacy to make up for their shortage of innovation resources, and thereby gain competitive advantages and improve their innovation performance. Some relevant scholars have confirmed this conclusion. For example, Chen et al. (2018) and Yu et al. (2020) found that government legitimacy has a positive promoting effect on corporate innovation activities [27,28].

### 2.2.2. Market Legitimacy

Driven by innovative business models, the market is gradually forming new ways of operating and competition regulations. To better carry out business activities, enterprises need to constrain their own behavior and comply with the regulatory requirements of stakeholders, that is, to obtain a legitimate identity and avoid being excluded from the market. In addition, market legitimacy can help companies establish good business relationships and facilitate their information acquisition from partners (Sun, 2011) [29]. This can effectively alleviate the problem of information asymmetry in transactions (Zhao et al., 2014) [30], and further deepen cooperation between enterprises, which is conducive to knowledge sharing and exchange (Jie et al., 2019) [31], thus forming a good atmosphere for innovation. When positive feedback is obtained through external communication, it will stimulate enterprises to increase their innovation investment, thereby improving their innovation performance. Some relevant scholars have confirmed this conclusion. For example, Santos et al. (2020) found that market legitimacy can effectively promote the innovative development of enterprises [32]. Sulkowski et al. (2018) found that businesses can promote collaborative relationships and jointly create sustainable value shared with

stakeholders [33]. Murcia (2022) found that strong stakeholder orientation alleviates the impact of shareholder orientation on corporate innovation [34].

### 2.3. Research Breakthrough Points and Contributions

In the context of innovation, HTMEs face particularly significant internal and external pressures. Previous research has separated the internal and external antecedents of enterprise innovation. On the one hand, most discussions have explored the internal impact of corporate governance on enterprise innovation. In terms of shareholder governance, this means promoting reasonable innovation activities through mutual supervision and restraint among shareholders. In terms of board governance, by complementing the experience and skills of board members, innovative projects can be effectively identified, enabling the scientific formulation of enterprise innovation strategies. In terms of executive governance, by bundling executives with corporate profits, they can avoid avoiding innovative projects due to self-interest issues.

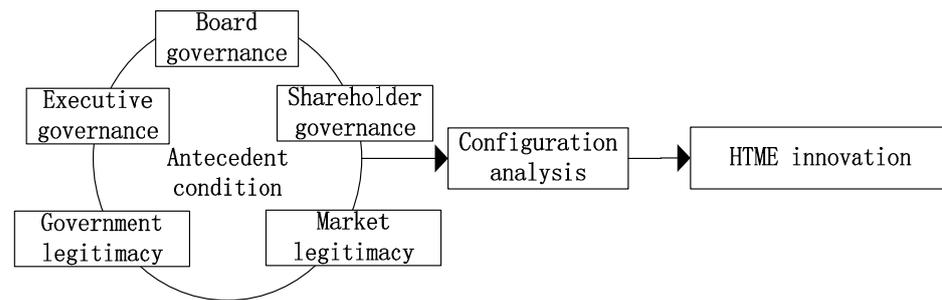
On the other hand, existing research has verified that institutional pressure has a significant impact on enterprise innovation. In terms of government legitimacy, most studies believe that enterprises should comply with government policies and adjust their business activities accordingly. If they resist policies, they will lose their legitimacy and cannot receive government innovation resource support and subsidies. In terms of market legitimacy, enterprises need to constrain their own behavior and comply with the regulatory requirements of stakeholders in order to improve their innovation models to cater to investor attention and gain a competitive advantage in the market.

However, in real-life scenarios, factors that affect HTME innovation interact rather than exist in isolation, and it is difficult to fully explain the HTME innovation process solely based on institutional pressure or corporate governance factors. Therefore, it is necessary to study the synergistic effects of corporate governance and institutional pressure on HTME innovation, which could fill the existing research gap in the field.

In addition, this article explores the combined synergy of multiple factors on enterprise innovation using the fsQCA method, filling the gap left by traditional quantitative methods that cannot explore the impact of multiple-factor combination synergy on a dependent variable. This supplements the multiple synergistic effects of internal and external factors on high-tech enterprises, which is conducive to leveraging the synergy between governance and institutional mechanisms and promoting the effective implementation of HTME innovation.

### 3. Methodology

In the context of innovation, an HTME faces particularly significant multiple pressures. On the one hand, with the continuous development of technology and the intensification of market competition, an HTME needs to establish a competitive advantage through internal governance and differentiation from its competitors. On the other hand, breakthroughs in technological innovation bring uncertainty, increasing the information asymmetry between the government and market entities towards the HTME, which cannot be recognized and accepted. HTMEs should strive to obtain legitimacy and reduce the resource constraints caused by a lack of legitimacy. Therefore, how to reconcile internal governance and external legitimacy acquisition is the key to this research. In this article, corporate governance and institutional legitimacy reflect two important strategies of HTME differentiation and convergence, with different dimensions. As shown in Figure 1, this specifically includes five antecedent variables: board governance, executive governance, shareholder governance, government legitimacy, and market legitimacy.



**Figure 1.** Research framework.

### 3.1. Data Sources and Variables

The 13th Five-Year Plan for National Economic and Social Development of the People's Republic of China (13th Five Year Plan Regulations) points out that, by 2020, the foundation of intelligent manufacturing development in China will be significantly strengthened, and significant progress will be made in the transformation of the traditional manufacturing industry. Since the 13th Five-Year Plan, China has made significant progress in the development of intelligent manufacturing through multiple measures. In 2021, the "14th Five-Year Plan" was proposed. It pointed out that it is necessary to strengthen the position of enterprises as the main body of innovation, rather than focusing on the government and the market. This indicates that, in 2021, as a turning point in the development of the manufacturing industry, HTMEs have achieved significant improvements compared to the past, moving towards new goals and considering themselves the main body of innovation, thus increasing their willingness and motivation for innovation. Therefore, this article selects HTMEs in 2021 as its research object.

This article uses HTME data from Guotai An Data and the Intellectual Property Office. To ensure the sample size and unified caliber of indicators, companies with missing key variables were excluded to reduce errors caused by missing values. Finally, 1282 samples were selected as experimental data.

The specific variables involved in this article are as follows:

- (1) Board governance variables. As the core of the enterprise, the board of directors has strategic decision-making power. The diversity of board members can help companies break through existing technological fields, and board members with different functional backgrounds can help ensure that decision-making perspectives are fully supported. Through group thinking, relevant decision-making risks will be minimized. That is to say, the size of the board of directors varies, and the capital of the board also varies. Therefore, this article takes the size of the board of directors as a variable of board governance, which is usually defined as the total number of directors in a company (Lu et al., 2014) [10].
- (2) Executive governance variables. The management plays a leading role in enterprise innovation, leading them to face the biggest negative impact of innovation failure and develop a dislike for innovation. To enhance the management's engagement in innovation activities, companies may choose to link their interests with the company's development through salary incentives. In other words, the increase in management compensation can promote their pursuit of maximizing corporate value (Coles et al., 2006) [35], which is an important measure to promote the innovative development of enterprises. Therefore, this article takes executive compensation as a variable of executive governance, which is usually measured by the total amount of compensation (Crilly et al., 2012) [36].
- (3) Shareholder governance variables. Shareholders usually have the power to exercise supervision over the board of directors and management, but lack self-supervision. The proposal of equity balance effectively solves this problem. By enabling mutual supervision among major shareholders, not only is the relative concentration of equity ensured, which can effectively supervise the board of directors and management,

- but this also prevents major shareholders from harming the interests of the company through the internal constraints among shareholders. This is a scientifically reasonable method of shareholder governance. Therefore, this article takes the degree of equity balance as a variable of shareholder governance, which is usually measured by the sum of the shareholding ratios of the 2nd to 10th largest shareholders and the shareholding ratio of the 1st largest shareholder (Sun et al., 2015) [37].
- (4) Government legitimacy variables. The legitimacy of the government means that enterprises deeply understand policy information and comply with policy guidelines, keeping up with the government's pace. In other words, when there is a correlation between a company and the government, the company is more likely to receive government recognition and support. Existing research suggests that political affiliation is a description of the network relationship between enterprises and government departments, which can bring policy dividends to enterprises and promote their business development (Yu et al., 2012; Tang et al., 2014) [38,39]. Therefore, this article uses dummy variables by setting the HTMEs previously or currently working with government departments to 1 and those not to 0, as a variable of government legitimacy.
  - (5) Market legitimacy variables. Market legitimacy refers to the degree of recognition and information symmetry of market entities such as investors towards enterprises. In other words, the more investors pay attention to a company, the higher their recognition and the legitimacy of the company. Existing research indicates that the Baidu search index of listed companies can effectively reflect the level of investor attention (Wang et al., 2021) [40]. As investor attention increases, the stock price of the company is positively impacted (Zhang et al., 2014) [41]. Therefore, this article defines the total Baidu index as a variable of market legitimacy.
  - (6) HTME innovation. At present, corporate innovation behavior can usually be summarized into two types (Li et al., 2016) [42]. One is strategic innovation. Enterprises implement strategic innovation activities not for the purpose of technological progress, but to seek other benefits (Tong et al., 2014) [43]. They focus on pursuing simple innovation, which is a one-sided pursuit of innovation quantity, in order to comply with government regulations and innovation policies (Hall et al., 2012) [44], to obtain more subsidies from government departments. The other is substantive innovation, which is where enterprises engage in "high-quality" innovation behavior with the aim of promoting their own technological progress, thereby enhancing their independent innovation capabilities and gaining competitive advantages. In order to seize a share of the market and maintain a leading position in market competition, enterprises will have a strong willingness to innovate and drive technological research and development. They will actively enhance their technological innovation capabilities and improve innovation quality, seeking technological progress and product iteration upgrades. To reflect the quality of HTME innovation, this article uses dummy variables. If the invention patent is greater than or equal to the utility model patent, the variable is defined as 1; otherwise it is defined as 0.

### 3.2. Research Question and Purpose

The qualitative comparative analysis method has gradually become an important management method (Misangyi et al., 2017) [45]. This study uses the fsQCA method to explore how the aforementioned five variables synergistically affect HTME innovation.

Firstly, based on internal governance and external institutional pressures, the five antecedent conditions have been established, and their interdependence and joint action determine HTME innovation. However, traditional regression analysis methods can only handle the interactions of three variables at most, and cannot handle the complex causal relationship of interdependence and synergy between five variables. The fsQCA has a holistic perspective and can identify the causal relationships between conditional combinations and outcomes through a comparison between cases. It is particularly suitable for

handling the synergistic causal relationships of multiple variables (Lerner et al., 2007) [46]. It can effectively answer “What combinations of variables can lead to the expected results?”

Secondly, finding the configuration and core conditions to achieve HTME innovation is the goal of this article. Multiple regression cannot distinguish between the core conditions of an antecedent variable and the size of the combined sample coverage. The fsQCA method can distinguish between core conditions and auxiliary conditions. This article enriches the research on enterprise innovation by linking internal corporate governance with external institutional pressure, expands the research on the coordination relationship between institutional pressure and corporate governance, and has enlightening significance in revealing the collaborative path for innovation in HTMEs.

### 3.3. Research Hypothesis

#### 3.3.1. Shareholders and Executives Need to Govern Collaboratively

The principal–agent conflict between shareholders and management in listed companies to some extent restricts HTME innovation. Innovation activities require strong professionalism and a long lag time, making it difficult to estimate short-term innovation benefits. Management will avoid innovation risks, leading to a serious underestimation of the value of innovative projects and affecting the long-term development of the enterprise. In this process, the interests of shareholders are infringed upon, and conflicts between shareholders and management regarding agency arise accordingly when proxy conflicts are severe. Although the cost of shareholder governance is high, once the governance structure is established it will bring about an increase in the company’s value (Renders et al., 2012) [47]. Shareholders hope to see innovative achievements from the enterprise, and through supervision and governance, they can constrain the management’s short-sighted behavior in resisting innovation. In addition, equity balance can also prevent major shareholders from abusing their power, thus scientifically and reasonably allocating corporate funds. Ultimately, strengthening shareholder supervision can enhance a company’s value (Anderson et al., 2022) [48]. In addition, under the influence of salary incentives, management will take the initiative to innovate in order to seek economic benefits. This can reduce the problem of agency. Zhao et al. (2023) found that providing compensation incentives to management can increase their willingness to innovate [49]. Atallah et al. (2021) found a positive correlation between innovation and incentive measures [50]. This indicates that incentive measures can help adjust the interests of management, thereby promoting long-term decision making. Based on this, our research hypothesis is as follows:

**H1:** *HTMEs need shareholders and executives’ collaborative governance to effectively suppress management’s innovation risk aversion, in order to alleviate the principal–agent conflict between shareholders and management.*

#### 3.3.2. Innovative Development Relies on the Decision Governance of the Board

Decision governance is of great importance. Generally speaking, the board, as the core leadership, can determine the direction of an enterprise’s innovation and development. The high-order echelon theory is also applicable to explain this phenomenon, where the composition of internal board members is mapped to decision-making strategies, becoming a key factor affecting innovation decision making. Berries et al. (2021) found that board composition can have an impact on different types of innovation in enterprises [51]. Genin et al. (2023) found that an experienced diversified board can promote corporate innovation by better meeting company needs [52]. Chatjuthamar et al. (2023) found that a larger board can provide additional resources and expertise for businesses to better develop a culture of innovation [53]. Zhu et al. (2024) found that corporate decision making and government form a game. To some extent, enterprises can rely on their own decisions for technological innovation while ignoring government regulations [54]. In other words, when a company lacks legitimacy and cannot receive government support, it can only use its own resources to maintain a competitive advantage. To pursue economic efficiency

and seize their market share, it is necessary to establish an innovation orientation through scientific decision making, and then break through task boundaries. Based on this, our research hypothesis is as follows:

**H2:** *When the legitimacy of corporate systems is insufficient, their innovative development relies on the decision governance of the board.*

### 3.3.3. Government and Market Legitimacy Should Jointly Influence Innovation

In the context of China, the innovation and development of enterprises face dual pressures from the government and the market, making the innovation process of enterprises full of complexity. Institutional theory emphasizes that enterprise innovation should be integrated into the institutional environment. The legitimacy of the government stems from its policy leadership. The government has introduced a series of policies to punish and incentivize small and medium-sized enterprises (Zhu et al., 2023) [55]. By perceiving and weighing different government measures, enterprises can appropriately cater to preferential government policies based on their own development situation (Zhu et al., 2023) [56], which therefore promotes the technological development of manufacturing enterprises (Zhu et al., 2023) [57]. Secondly, institutional pressure often accompanies the introduction of competition, such as bidding, which indirectly promotes enterprises to enhance their competitiveness to meet government requirements. Thirdly, institutional pressure can lead companies to allocate innovation resources reasonably, such as increasing their innovation investment, recruiting technology personnel, and producing patents. Finally, institutional pressure can also send positive signals to the market, attracting more investors and consumers.

Market legitimacy stems from the expectations of market stakeholders. It can help companies establish good business relationships. Firstly, adhering to market legitimacy standards helps companies establish and maintain a good brand reputation. A strong brand reputation can bring more market opportunities and resources to enterprises, thereby supporting innovation. Secondly, legality requires companies to publicly disclose relevant information, which helps alleviate information asymmetry and attract investors. Finally, market legitimacy can promote cooperation and communication. Legitimacy standards are often the foundation of cooperation. When a company meets these requirements, it is easier for it to establish cooperative relationships and engage in communication and cooperation with companies from other countries and regions, which provides a platform for enterprise innovation. Based on this, our research hypothesis is as follows:

**H3:** *Institutional legitimacy is an important influencing factor on corporate decision making, and government and market legitimacy should jointly to influence HTME innovation.*

### 3.4. Research Method

The fsQCA method uses the sufficient relationship between the set of antecedent variables and the set of outcome variables as the basis for causal inference, thus demonstrating different causal inference concepts and explanatory methods (Du et al., 2017) [58]. Compared to the traditional statistical testing methods that emphasize “net effects”, it focuses more on the configuration path formed by the combination of multiple antecedent conditions on the outcome variable, and has sufficient explanatory power. Specifically, the fsQCA method is based on fuzzy-set member scores and can solve the problem of sample data types by extending its set Boolean functions. It can be applied not only to categorical sample data, but also to continuous data. The fuzzy membership calibration method used in this method can convert the data into any value representation dataset within the [0–1] interval, avoiding the loss of data information during processing. At present, this method has been widely applied in the field of management (Du et al., 2017; Zhang et al., 2019) [58,59].

Based on the research question and specific scenario considerations in this article, the fsQCA method is fully matched with research on the impact of multiple factors on HTME innovation. Specifically, the board of directors, shareholders, and executives in terms of corporate governance, as well as government and market factors in terms of institutional legitimacy, cannot reveal innovation alone, and conventional measurement methods are unwieldy to apply to the interaction of two or more factors. The fsQCA method can detect multiple concurrent causal relationships and reveal complex relationships such as the impact of various corporate governance and institutional legitimacy factors on HTME innovation from a holistic perspective. Based on this, this method can effectively identify the conditional configuration that constitutes HTME innovation, and ultimately achieve the optimal path to it.

In summary, the fsQCA method differs from previous studies on the linear relationship between single factors and outcomes. One reason is that the fsQCA method is based on set theory rather than using traditional linear relationships to explain the antecedent variables, believing that a set of conditional variables rather than individual conditions plays a role in HTME innovation, thus explaining the conditional configuration that leads to the outcome variables. The second reason is that the fsQCA method can be applied not only to categorical sample data, but also to continuous data. In addition, it can analyze the explanatory power of conditional configurations on outcome variables.

## 4. Experimental Result

### 4.1. The Correlation Analysis

By testing the correlation coefficients of each variable, it was observed from Table 1 that X1–X5 have a positive correlation with Y, confirming their promoting effect on the core variable. In addition, the variance inflation factor test for all variables was below the threshold of 10, and there was no multicollinearity among the variables.

**Table 1.** Correlation test.

	X1	X2	X3	X4	X5	Y
Board governance (X1)	1					
Executive governance (X2)	0.2579 *	1				
Shareholder governance (X3)	0.0661 *	0.0664 *	1			
Market legitimacy (X4)	0.1550 *	0.4337 *	−0.0753 *	1		
Government legitimacy (X5)	0.0220	0.0168	0.0005	0.1234 *	1	
HTME innovation (Y)	0.0694 *	0.1262 *	0.0137	0.0751 *	0.0022	1

Note: \* means the significance between variables.

### 4.2. The Data Calibration

Based on the idea of set theory, existing data should be calibrated before running the fsQCA method, and the corresponding membership score of the set needs to be assigned to the research case (HTME). This is a process that reflects the membership scores of the antecedent variables (X1–X5) and the outcome variable (Y) in the variable set in a research case (Schneider, 2012) [60]. Specifically, data calibration involves treating X1–X5 and Y as single sets of variables, respectively. Among them, each research case has a membership score in the set of variables mentioned above. It is necessary to convert variables into a continuous set between 0–1 and select an appropriate threshold to convert the data. This article draws on the three calibration points proposed by Fiss (2011) [61], namely complete membership (membership score of 0.75), intersection (membership score of 0.5), and complete non-membership (membership score of 0.25), to calibrate X2, X3, and X4 data. It is worth noting that the fsQCA will automatically delete cases with a membership score of 0.5 after data calibration. Therefore, to retain the research cases, this article refers to the practical experience obtained from previous studies and finetunes 0.5 to 0.501. In addition, board sizes exceeding 11 and below 7 will have a negative impact on corporate innovation. Therefore, this article will use (11,9,7) as the threshold for data calibration to convert X1

(Huang et al., 2023) [7]. On the other hand, since X5 and Y are binary variables, there is no need for data calibration and they can be used directly. The results are shown in Table 2.

**Table 2.** Variable calibration.

	Fully Attached Point	Intersection Point	Completely Unrelated
Board governance (X1)	11	9	7
Executive governance (X2)	6,781,325	4,259,000	2,759,675
Shareholder governance (X3)	1.49136175	0.88677035	0.493980425
Market legitimacy (X4)	329,081	185,848.5	72,645
Government legitimacy (X5)	1	/	0
HTME innovation (Y)	1	/	0

#### 4.3. Necessary Condition Analysis

Testing whether a single conditional variable is necessary for the outcome variable is an important prerequisite of conducting a configuration adequacy analysis. Zhang et al. (2019) believe that when the outcome occurs, the necessary condition variable always exists with the outcome variable [62], but the necessary condition may not lead to the generation of the outcome variable. Most studies typically measure the necessity of conditions based on consistency, and when the consistency threshold of a conditional variable reaches 0.9, it can be considered a necessary condition that leads to the generation of the outcome variables (Greckhamer et al., 2018) [63]. In this article, the single necessity of five antecedent variables is tested to identify which factors are necessary institutional conditions for HTME innovation, as shown in Table 3.

**Table 3.** Necessary condition analysis results.

	Consistency	Coverage
Board governance (X1)	0.315475	0.691037
~Board governance (~X1)	0.684528	0.645388
Executive governance (X2)	0.537387	0.720487
~Executive governance (~X2)	0.462613	0.599789
Shareholder governance (X3)	0.500050	0.670833
~Shareholder governance (~X3)	0.499950	0.647819
Market legitimacy (X4)	0.530868	0.701023
~Market legitimacy (~X4)	0.469133	0.617374
Government legitimacy (X5)	0.191716	0.661224
~Government legitimacy (~X5)	0.808284	0.658631

Table 3 presents the analysis results of five antecedent conditions and their non-set and outcome variables. The results show that the consistency of the antecedent conditions is all less than 0.9, indicating that X1–X5 have a weak explanatory power for the outcome variable and do not have the ability to affect Y. In addition, the absence of five antecedent conditions does not constitute a necessity for the outcome variable. The above results indirectly indicate that the conditions that affect HTME innovation are not singular, but complex outcomes influenced by the interaction of multiple conditions. Therefore, it is necessary to further examine all antecedent conditions and explore which conditions collectively constitute the configuration path for HTME innovation.

#### 4.4. Configuration Analysis

Table 4 shows the adequacy analysis results of the HTME innovation response pathway. From Table 4, it can be seen that under the joint influence of multiple factors, the fsQCA identifies two configurations that can achieve HTME innovation, and the consistency coefficients are both greater than 0.75. This effectively verifies the validity of the configuration results and provides a reference value (Woodside, 2013) [64]. At the same

time, the overall coverage of the combination that led to HTME innovation is 0.16, which explains 16% of the reasons for HTME innovation and has some explanatory power.

**Table 4.** Configuration analysis results.

Antecedent Condition	HTME Innovation (Y)	
	Configuration 1	Configuration 2
Board governance (X1)	●	⊗
Executive governance (X2)	●	●
Shareholder governance (X3)	●	●
Market legitimacy (X4)		●
Government legitimacy (X5)	⊗	●
Consistence	0.769143	0.770533
Original coverage	0.130996	0.130997
Unique coverage	0.0334521	0.0334522
Overall solution consistency		0.769424
Overall coverage		0.164449

Note: ● is a core condition that exists. ● is an auxiliary condition that exists. ⊗ indicates that the core condition does not exist. Blank indicates that the condition may or may not exist.

In the configuration (P1\*P2\*P3\*~P5), three types of corporate governance play a core role, and the lack of government legitimacy also plays a core role. The results indicate that in the absence of political advantages, HTMEs focus on the coordinated development of internal governance, with decision making, incentives, and supervision as the core conditions for enterprise innovation. When enterprises lack legitimacy, they need to rely more on their own board to formulate innovation directions and effectively highlight their innovation advantages by relying on internal governance to drive the closing of the gap with competing enterprises.

In the configuration (~P1\*P2\*P3\*P4\*P5), government legitimacy, executive and shareholder governance, play a core role, while market legitimacy serves an auxiliary role, and the lack of board governance also plays a core role. The results indicate that, with political advantages as the main focus and market attention as a supplement, enterprises promote innovative development by combining executive and shareholder governance. These types of enterprises rely on the government and the market, and their innovation strategies closely follow government policies while also taking into account market investors. They urgently need to alleviate their degree of information asymmetry with the government and market entities.

The above findings indicate the following: (1) Adopting a certain governance factor and institutional legitimacy factor alone cannot constitute a necessary condition for HTME innovation, but the synergistic effect between executive and shareholder governance is universal, and both exist as core conditions regardless of the configuration. (2) In the absence of political advantages, board governance will complement incentives and shareholder governance to drive an HTME's innovative development. This indicates a significant substitution effect between government legitimacy and board governance. (3) In the absence of board governance, government legitimacy is the main focus, supplemented by market legitimacy, and HTME innovation and development are led by executive and shareholder governance. At the same time, this further verifies that there is a significant substitution effect between government legitimacy and board governance. In addition, this phenomenon also indicates that the importance of government legitimacy for HTME innovation is higher than market legitimacy.

#### 4.5. Robust Test

If finetuning the case frequency and consistency during the fsQCA method does not affect the existing explanations, it indicates that the results are robust (Zhang et al., 2019) [62]. Referring to existing research (Zheng et al., 2023) [65], this article tests the antecedent configuration of HTME innovation by adjusting the threshold and case frequency. Firstly,

the consistency threshold is adjusted from 0.75 to 0.74. Secondly, the frequency of the cases is adjusted from 10 to 15. Although there are slight changes in the consistency and coverage values of the solution, the configuration path remains consistent, indicating that the results in this paper have high robustness.

## 5. Discussion

### 5.1. Collaborative Governance between Shareholders and Executives Is Indispensable

In both configurations, shareholder and executive governance factors are important core conditions that play a significant role in HTME innovation. According to the principal–agent theory, our specific analysis is as follows:

The agency problem in listed companies to a certain extent restricts their innovation. Specifically, due to the cyclical and risky nature of innovation activities, there is uncertainty in their outcomes. It is difficult for management to estimate the short-term innovation benefits, which leads to management avoiding innovation risks and weakening innovation willingness. This will lead to a serious underestimation of the value of innovative projects, affecting the long-term development of the enterprise. In this process, the interests of shareholders are infringed upon, and conflicts between shareholders and management regarding agency arise accordingly. On the other hand, innovation activities require strong professionalism and a long lag time, but shareholders hope to see the company produce innovative results as soon as possible. When the expected innovation goals are not achieved, major shareholders are highly likely to use their supervisory power to stifle innovation projects, leading to agency problems for management due to information communication issues, ultimately affecting innovation activities. Therefore, HTMEs require collaborative governance between shareholders and executives to effectively suppress management's innovation risk aversion and alleviate the principal–agent conflict between shareholders and management.

From the perspective of executive governance, when the compensation rewards received by management exceed the cost of innovation failure, it can effectively motivate them to actively engage in product innovation to maintain their maximum compensation. Under an incentive effect, management will inevitably take the initiative to innovate and catch up with the latest technological trends in order to seek economic benefits, thereby improving the overall profitability of the enterprise and reducing agency problems. In addition, executive governance guides management to continuously carry out innovative activities by providing generous salary rewards, which in turn have a significant effect on promoting corporate innovation activities. At this point, an increase in corporate innovation performance can help management obtain more compensation and rewards, thereby forming a virtuous cycle conducive to corporate innovation.

In terms of shareholder governance, it can constrain management's avoidance of long-term innovation investment behavior for personal gain. By exercising supervisory power, management should avoid pursuing short-term benefits and invest more funds in innovation activities, thereby pursuing potential returns on innovation. However, if shareholders lack an understanding of technological innovation development, they may encounter communication conflicts with management when innovation expectations are not met, leading to their excessive intervention in innovation activities. Even major shareholders use exit threats to force management to excessively or underwhelmingly invest in innovation, affecting the overall development of the enterprise. Therefore, shareholder governance also requires controlling the behavior of major shareholders. Through the mutual constraints among shareholders, they jointly judge the rationality of management's innovative activities, reducing their excessive intervention in innovation, and thus alleviating the phenomenon of agency tension.

### 5.2. Board-Driven Configuration

In the configuration (P1\*P2\*P3\*~P5), in addition to shareholder and executive factors, board governance and the lack of government legitimacy are also core conditions. The specific analysis is as follows:

When enterprises lack legitimacy and cannot receive government support, they can only use their own resources to maintain a competitive advantage. To pursue economic efficiency and seize a share of the market, it is necessary to establish an innovation orientation through scientific decision making, and then break through task boundaries. Therefore, board governance is crucial. Generally speaking, the board of directors, as the core leadership responsible for strategic decision making, can determine the direction of enterprise innovation and development. High-order echelon theory is also applicable to explain this phenomenon, where the composition of internal board members is mapped to decision-making strategies, becoming a key factor affecting innovation decision making.

Companies with a large board size and a large number of members usually have diverse characteristics and can effectively break through existing technological fields. Due to the diversity of their members, board members with different functional backgrounds have rich experience, which enables them to have insight into strategic models and identify innovation opportunities. Especially when it comes to new fields, through group thinking they can ensure that all decision-making viewpoints are fully demonstrated, minimizing relevant decision-making risks, which helps achieve results from innovative activities. Enterprises with lower innovation capabilities have smaller board sizes and members are usually concentrated in one functional area, making it difficult to effectively identify innovation. In addition, the size of the board of directors will remain at a certain level. A cross-functional team with high-level authority may be beneficial, but having too many board members will make it difficult to operate. The degree of consensus among the company's members will decrease, which will correspondingly affect their decision-making efficiency.

### 5.3. Legitimacy-Driven Configuration

In the configuration (~P1\*P2\*P3\*P4\*P5), in addition to shareholder and executive factors, government legitimacy plays a core role, while market legitimacy serves an auxiliary role. According to institutional theory, the specific analysis is as follows:

In the context of China, the innovation and development of enterprises face pressure from the government and the market, making the innovation process of enterprises full of complexity. Institutional theory emphasizes that enterprises should integrate into the institutional environment. The legitimacy of the system is a key factor affecting enterprises, which brings expectations and pressure to enterprises and can stimulate their innovation and improve their innovation performance. Of the types of legitimacy, government legitimacy stems from government policy leadership, while market legitimacy originates from the expectations of market stakeholders, both of which form standard guidelines to constrain corporate behavior.

The legitimacy of the government comes from the policies of government departments. Enterprises should comply with government policies, adjust their business activities according to policies, and obtain legal identities by responding to government calls, thereby obtaining their policy resources and gaining competitive advantages. On the one hand, government legitimacy can bring innovation subsidies and tax reductions to enterprises, thereby reducing their internal innovation costs and alleviating financing constraints, creating favorable conditions for enterprise innovation. On the other hand, the legitimacy of government recognition can reduce information asymmetry between enterprises and market investors, indirectly transmitting signals to the market that such enterprises are recognized by the government. This can help companies gain more investor attention and expand financing channels, which is beneficial for companies to better implement innovation. Simultaneously proving the legitimacy of government recognition allows

enterprises not only to directly obtain resources from government departments, but also, indirectly, allows them to obtain market resources.

The legitimacy of the market comes from the external soft environment, usually referring to the fact that enterprises are constrained by industry standards and the external environment, and do not have mandatory requirements. With the improvement of knowledge in the manufacturing industry, the value system of high-tech manufacturing is beginning to change, gradually forming a development trend of overall industry collaboration and co-construction. To cater to stakeholders and avoid mutual exclusion, companies usually consider the opinions and expectations of market stakeholders when making innovation decisions. They ensure recognition of their legitimate identity by choosing to comply with norms and constrain themselves, thereby achieving innovative interaction with stakeholders in the region and promoting their innovative development.

## 6. Conclusions

### 6.1. The Main Conclusions

This article conducts research from the perspective of corporate governance and institutional legitimacy, using the fsQCA to analyze 1282 HTME companies listed in 2021. Our main conclusions are as follows:

A single factor cannot constitute the necessary condition for HTME innovation, but they are all universally applicable to shareholder governance in HTME innovation; that is, regardless of the configuration path, they are the core conditions. This indicates that HTMEs require collaborative governance between executives and shareholders to suppress management's innovation risk aversion and alleviate the principal-agent conflict between shareholders and management. On the one hand, it is necessary for shareholders to reasonably supervise management and constrain other shareholders, effectively ensuring the effective implementation of HTME innovation activities. On the other hand, it is necessary to bind the interests of management with the long-term interests of the enterprise and motivate them to continuously innovate and pursue long-term development.

In the absence of political advantages, HTMEs focus on the coordinated development of internal governance, making the board of directors, executives, and shareholder governance the core conditions for corporate innovation. In addition, there is a significant substitution effect between government legitimacy and board governance. When companies lack legitimacy, they rely more on the internal board governance within an HTME. This requires board members to use group thinking to ensure that decision-making risks are minimized. At the same time, it is necessary to avoid reducing decision-making efficiency due to a bloated size of the board.

With political advantages as the main focus and market advantages as a supplement, HTMEs promote innovative development by combining executive and shareholder governance, and their innovation requires a higher degree of government legitimacy than market legitimacy. Government legitimacy can not only directly compensate for the shortage of innovation resources in enterprises, but also indirectly help them to obtain more market resources through government endorsement. Market legitimacy can promote innovative interaction between enterprises and stakeholders in the region, thereby implementing innovative development.

### 6.2. Contributions of this Research

This article expands the existing research perspectives on HTME innovation. At present, in terms of HTME innovation behavior, most studies only approach the issue from the perspective of institutional theory (Huang et al., 2022) [66] or corporate governance (Huang et al., 2023) [7]. However, in real-life scenarios, the factors that affect HTME innovation interact with each other rather than exist in isolation, and it is difficult to fully explain the HTME innovation process solely from the perspective of institutional theory or corporate governance. Therefore, studying the synergistic effects of corporate governance and institutional legitimacy on HTME innovation can complement existing research in

the field and is beneficial. This also expands the application of institutional theory and principal–agent theory to the field of enterprise innovation.

This article expands on existing HTME innovation research methods. By utilizing the fsQCA method to explore the combined synergy of corporate governance and institutional legitimacy factors on enterprise innovation, we can compensate for the shortcomings of traditional quantitative methods when exploring the impact of multiple factors' combined synergy on HTME innovation. This complements the synergistic impact of external institutional factors and internal governance factors on HTMEs, which is conducive to promoting the effective implementation of HTME innovation.

### 6.3. Suggestions

An HTME needs to have a profound understanding of the importance of corporate governance on innovative development. HTMEs need to enhance their innovation drive by incentivizing management, aligning its interests with the development of the enterprise, and pursuing the maximization of the effects of innovation on high-tech enterprises. Secondly, shareholder governance is also particularly important, as enterprises require effective supervision by shareholders to correct management's short-sighted behavior and reduce their inefficient investment behavior through mutual constraints, thereby ensuring the necessary implementing of innovation strategies.

When there is a lack of regulatory pressure, HTMEs need to focus on board governance. They need to ensure the correct size of the board of directors so that it can effectively support the innovative development of high-tech enterprises through brainstorming, diversified decision-making plans, and improved decision-making quality. At the same time, it is necessary to avoid an excessive number of board members, which would lead to a decrease in decision-making efficiency.

HTMEs need to enhance their understanding of institutional legitimacy so that enterprises can obtain innovation resources from the outside world and better promote HTMEs' implementation of innovation. Specifically, on the one hand, it is necessary for management to have close interaction with the government, to be able to more effectively interpret and grasp relevant policies, gain a sense of government recognition, and receive government funding support. On the other hand, HTMEs need to interact positively with investors, connect effectively with various innovative elements, and form innovative synergy, to assist in the development of innovation.

### 6.4. The Future Directions

This article adopts the fsQCA method for its research. Although other corporate governance studies have adopted the fsQCA method (Huang et al.) [7], traditional research in the field of corporate governance mostly uses regression, while future research can use both traditional, empirical methods and fsQCA methods for cross-validation.

Secondly, our research object is limited to listed HTMEs. In the future, we could further subdivide and explore the configuration paths for different types of HTME innovations.

Third, the group of research variables can be expanded; in the future, more institutional pressure variables or corporate governance variables could be added to obtain more configuration paths.

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