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Research on Antecedent Conditions of TQM and Technological Innovation Process Coupling from Configuration Perspective

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Abstract: According to the basic theory of total quality management, the connotation and process of technological innovation, this paper explores the antecedents that affect the coupling of total quality management and technological innovation process. The results show that market data identification, demand scale, knowledge gatekeeper ability and organization dynamic ability are the core factors that affect the coupling of quality management and technological innovation process. Among them, demand scale is the most critical antecedent variable, followed by market data identification.

1. Introduction

As China's economy changes from “speed first” to “quality first”, companies re-examine their attitude towards innovation, and quality management research enters the research paradigm of quality innovation[1-2], more and more companies seek technology upgrade, market diversification, consumer preference acquisition, etc. achieve the purpose of quality innovation-to meet consumer demand. Continued changes in consumer demand have prompted companies to increase their demand for technological innovation. However, in the actual operation of enterprises, there are still problems such as the disconnection of technological innovation and market demand, unequal supply and demand, and product defects. Therefore, under the requirements of high quality and diversified demand, how to dynamically coordinate the technological innovation brought about by consumer demand and the product quality required by long-term enterprise development can not only fully satisfy consumers' personalized and diversified demands, but also guarantee The quality of products, how to achieve the level of technological innovation guaranteed by quality management, and the spiral rise of technological innovation to improve product quality are urgent problems that need to be solved in the long-term development of enterprises.

The factors that affect quality management and the factors that affect technological innovation are nested, integrated, mutually promoted, and mutually inhibited. With a single factor analysis, the role of quality management and technological innovation unilaterally emphasizes the factors themselves to the results. The impact of the search for the best solution, but ignore the complex effects between the factors, and the analysis from the perspective of configuration not only fully consider the combined effects between condition variables, but also accepted the equivalence and concurrency of the combination of factors[3]. The earliest application of the configuration perspective in the field of management is in the field of strategic management [4], and it indicates that binary or multivariate linear analysis cannot fully explain the relationship between strategy and structure. Meyer also recognizes that the interdependence among the variables explaining social phenomena requires a more systematic and holistic thinking solution [5]. Although Misangyi et al. [6] propose a new configuration perspective that can more fully analyze the variables and the complexity of the results than the traditional configuration perspective, there is no substantive difference between the two, and the article does not carry out on the two. The distinction is still based on the theory of configuration theory.

In the research of applying the configuration perspective to the management field and enterprise innovation performance, most of them are biased to how various conditions combine to improve the enterprise innovation performance and how to affect enterprise management. However, it is theoretically to study the coupling of total quality management and technological innovation from the configuration perspective It is relatively weak. In the study of the coupling between total quality management and technological innovation, the coupling degree and coupling coordination degree between the two are mainly evaluated by establishing the function and coupling degree model[7], and the factors that affect the coupling effect between the two What are these, and whether these factors can have a sustained impact on the coupling effect between the two, has not yet formed a perfect theoretical system.

Therefore, the article adopts the configuration perspective to take total quality management, technological innovation connotation and process as the theoretical basis, and takes the process coupling of total quality management and technological innovation as the research object, starting from the process coupling theory of total quality management and technological innovation, and fully consider the interaction between various causal conditions, study the causal conditions that promote the coupling effect, explore the key factors that affect the coupling between total quality management and technological innovation, and provide a theoretical reference for promoting the coupling of total quality management and technological innovation.

2. Theoretical Analysis

In the classic Deming Cycle of total quality management: “one process, four stages”, total quality management includes four basic stages: planning, execution, inspection, and processing. According to the PDCA cycle process, total quality management activities are based on the implementation of specific plans of the quality management plan, and the quality management activities are checked, fed back and corrected, and the quality management activity plans are revised according to the processing results to achieve a spiral of quality management.

In the process of enterprise production practice, technological innovation, as a direct method of product development, is an important means to realize product profitability and give play to product value. In the process of technological innovation, in accordance with the technological innovation process, from the formulation of innovation plans, product production and R&D to the carrier of technology application-product sales, it is a step-by-step process. However, in the process of innovative technology application, the problems and the solutions discussed not only modify the

technological innovation process in time, but also provide reference value for the next application of the same type of technology. Therefore, the technological innovation process is a circular process of implementation, improvement, then reimplementation, and the end of each cycle-summary of the technological innovation process can also promote the completion of a new technological innovation cycle.

The current research on the coupling of technological innovation has shown that technological innovation can have a coupling effect with the ecological environment [8], financial innovation[9], economic growth[10], and institutional innovation[11], but it is affecting quality management and technological innovation. There are few studies on integration. Most of them believe that quality management and innovation can be organically combined through qualitative analysis. Palm K et al. [12] find that quality management and innovation can be developed in parallel, and the two promote each other. Based on the PDCA process theory, Zhang Zhiqiang [7] conducts an empirical study on the process coupling of quality management and technological innovation. The results show that there is a good coupling between total quality management and technological innovation. It can be seen from this that technological innovation can be well coupled with other systems, and there is a coupling effect between quality management and enterprise innovation that promotes mutual competitive advantage. However, the research on the coupling effect of technological innovation and total quality management is mostly based on the relationship between the independent variable and the dependent variable based on the linear relationship. The linear relationship between the two or more variables is studied, but the interaction between the antecedent variables is ignored (figure 1). Therefore, starting from the configuration theory, this paper uses fuzzy-set qualitative comparative analysis (fsQCA) to explore the antecedent variables of the coupling effect of total quality management and technological innovation (figure 2).

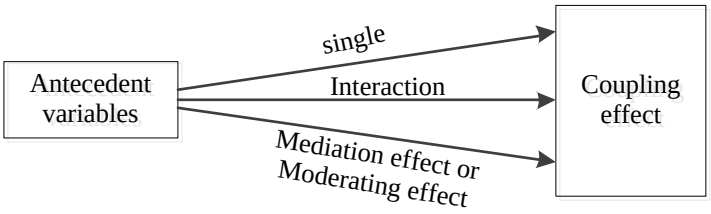

Figure 1: Research on coupling effect under linear relationship.

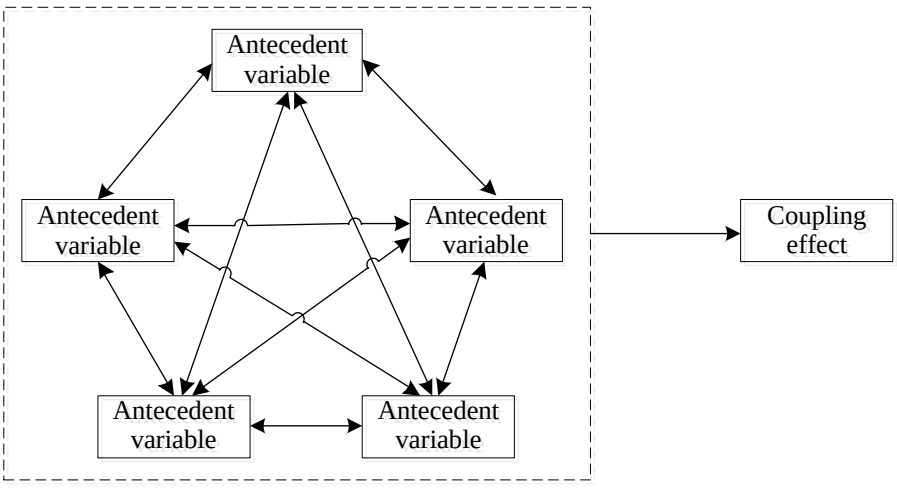

Figure 2: Research on the coupling effect from the configuration perspective.

3. Selection of antecedent variables coupling TQM and technological innovation process

The ultimate goal of quality management and technological innovation is to meet the needs of consumers. Technological innovation is a direct means to improve the inherent attributes of products to stimulate consumption and meet diversified multi-level needs. Quality management systems and process control are the inherent attributes of products to meet the needs of consumers. Protection. Therefore, in the coupling process of quality management and technological innovation, market data identification, demand scale, organizational innovation environment, knowledge gatekeeper capabilities and organizational dynamic capabilities are the antecedent variables that affect the coupling effect.

(1) Market data identification. Quality management and technological innovation need to identify and meet consumer needs, formulate technological innovation plans, and implement quality control to achieve higher benefits. Therefore, the ability to accurately identify market information and consumer demand is a prerequisite for implementing technological innovation, carrying out quality management, and controlling quality costs to reduce losses. The more data in the market data that reflects consumer demand, such as consumer income differences and consumer preferences, the stronger the interpretation of consumers, the more able to develop new products and services to meet consumer demand. Therefore, the ability to identify market data is a prerequisite for coupling quality management and technological innovation.

(2) Demand scale. Lv Rongjie [13] and others believe that market size can affect the supply and demand of technology transfer. According to the theory of supply and demand, the demand for products on the market will also affect the production of the enterprise. The enterprise will produce or improve products that meet the multi-level needs of consumers in terms of user experience, hardware/software requirements, design, etc. based on market feedback. Therefore, the scale of product demand not only brings about the formulation and implementation of technical innovation plans that are influenced by product technical information, but also brings about consumers' requirements for product quality. This demand is conducive to promoting the combination of technological innovation and quality management, thereby driving total quality management. The coupling effect of process and technological innovation process.

(3) Organizational innovation environment. According to absorptive capacity theory, companies have to identify and absorb the factors that are beneficial to achieve a certain goal of the organization. A good organizational innovation atmosphere will have an impact on the realization and application of technological innovation, thereby stimulating production R&D in the process of technological innovation Interaction with process control in the total quality management system promotes high quality to achieve technological innovation. While effectively guaranteeing the quality of the technological innovation process and promoting the commercialization of technological innovation, the content of comprehensive quality management will be improved and the level of quality management will be improved.

(4) Knowledge gatekeeper ability. The technical innovation capability and quality of an enterprise depends on the ability of individual employees to accurately discover heterogeneous knowledge, learn to absorb and re-encode for internal combination and transformation of the enterprise. Educated employees in the organization rely on their own understanding of knowledge to evaluate the pros and cons of new knowledge. As the promoter and hinder of new knowledge entering the enterprise, they are the “gatekeepers” for enterprises to absorb new knowledge for technological innovation and ensure the quality of technological innovation. The degree of knowledge absorption, transformation and diffusion of the knowledge of the enterprise employees through the marketing channels and scientific research channels of customers and competitors, that is, the ability of the enterprise to “gatekeeper”. The stronger the ability of knowledge gatekeepers,

the more accurately they can evaluate the knowledge information entering the enterprise, tap the available knowledge, promote the allocation and reorganization of enterprise knowledge, and provide possible channels for enterprise technological innovation.

(5) Organizational dynamic capabilities. Dynamic capability is the ability of an enterprise to integrate, construct, and reconfigure internal and external resources to adapt to changes in the environment. The stronger the enterprise's dynamic capability, the more it can improve the technological innovation plan in time according to the changes in the market environment during the process of technological innovation, so that the implementation of technological innovation continuously matches the market environment and consumer preferences. At the same time, enterprises with strong dynamic capabilities can improve the technological innovation process and improve the quality of innovative products in a timely manner according to the policy environment and the technology introduction of leading companies in the same industry. Enterprise dynamic capabilities can effectively promote the smooth implementation of technological innovation under the quality management system standards and achieve the quality requirements of innovative products.

4. Research Design

This section provides research methods and variable measurement.

4.1 Research Methods

According to the research purpose of this paper on the exploration of the antecedent variable of the coupling effect of total quality management and technological innovation process, combined with the article to study the antecedent variable conception with configuration thought, the fuzzy-set qualitative comparative analysis method is selected, and the fsQCA software is used to carry out the research. After Charles C. Ragin conducted a qualitative comparative analysis of fuzzy sets from the configuration perspective and developed the fsQCA software, it greatly promoted the development and application of configuration theory [14]. Relevant scholars in China have also begun to study management [15], enterprise management and enterprise performance [16-19], agriculture[20], environmental protection [21], judicial administration [22-24] and social reputation [25] from the perspective of configuration. After fully considering the interaction between different condition variables, they select the condition combinations that meet the needs through the set case coverage, mainly focusing on how the different condition variables are combined and how the different combination forms affect the result variables. The configuration perspective is compared to the classic contingency perspective. (1) The configuration perspective emphasizes that the condition variables cannot be split and treated in isolation in consideration of the impact on the result variables, and considers the interaction between the condition variables. (2) The effect on the result variable is not a simple linear relationship in the perspective of contingency, but non-linear and complex. (3) A combination of different conditions may produce the same result, and there is equivalence. (4) The measurement of each variable is converted from the concept of variable to the measurement using the idea of membership. (5) The analysis method converts the linear regression between the variables and the interaction terms between the two variables into set analysis.

4.2 Variable measurement and data sources

The measurement of the coupling of total quality management and technological innovation process, through the different stages of total quality management and technological innovation process, based on the PDCA cycle process, drawing on the process coupling evaluation index system used

by Zhang Zhiqiang [7], integrates total quality management and technological innovation The evaluation of the process coupling is divided into four parts: planning, execution, inspection, and processing. The settings are shown in table 1. The measurement of the selected antecedent variable is based on the definition, and 2-3 questions are set for investigation respectively. The evaluation indicators and evaluation contents are shown in table 2.

Table 1: Process coupling measurement of total quality management and technological innovation.

Evaluation dimension	Evaluation index	Index content
Plan	Technology Innovation Plan	Perfect Technology Innovation Plan
	Process quality control	Production R&D according to quality management standards
Do	Improve quality management	Improve quality control during technology development
	Process compliance	Use quality tools to check technological innovation process
Check	Quality control system	Build quality control system
	Variation information feedback mechanism	Variation information feedback mechanism
	Corrective measures	Process variation information in a timely manner consistent with quality objectives
Action	Product Improvement	Improve product attributes based on feedback
	Technology Innovation Goals	Clear Technology Innovation Goals

Table 2: Measurement of antecedent variables on coupling of total quality management and technological innovation process.

Evaluation dimension	Evaluation index	Index content
Market data identification (m)	Technology innovation goals	Master the market data collection
		Can I accurately identify market information
		Can market data be identified in a timely manner
Demand scale (d)	Product demand	Market demand for innovative products
Organizational innovation environment (c)	Innovation atmosphere	Is there a good atmosphere for innovation
		Does the company have a tendency to create a good innovation atmosphere
Knowledge gatekeeper ability (a)	Employee knowledge absorption ability	Can employees assess the pros and cons of new knowledge
		Can employees practice and spread new knowledge
Organizational dynamic capabilities (o)	The size of dynamic capabilities	The ability of enterprises to adapt to environmental changes

According to the designed variable measurement scale, data collection was carried out on the concepts involved in the study of the antecedent variable coupling the total quality management and technological innovation process. The questionnaire is mainly aimed at the management personnel of the manufacturing enterprise. They have a certain understanding of the current status of the company's quality management, and are engaged in management work. They have rich management experience, and can fully control the company's movements and can control the company's trends. Evaluation of the quality management situation, knowing the direction of enterprise technological innovation and the status of technological innovation. Excluding rejected answers and invalid questionnaires, a total of 385 valid data were obtained.

The collected data is analyzed by fuzzy-set qualitative comparative analysis, according to the theory of membership, according to the size of the original data value of the structure is divided into four categories, according to the four-value assignment method: complete membership $\rightarrow 1$, comparative membership $\rightarrow 0.67$, relatively not affiliated $\rightarrow 0.33$, not affiliated at all $\rightarrow 0$, the original data is mapped between [0,1]. The descriptive statistical results of the variables are shown in table 3.

Table 3: Variable descriptive statistics.

	Raw data				QCA data			
Variables	Mean	Std. Deviation	Minimum	Maximum	Mean	Std. Deviation	Minimum	Maximum
PC	3.7244	0.77039	1.67	5.29	0.5126	0.37868	0	1
M	3.6221	1.02159	1	6	0.5418	0.38564	0	1
D	3.4294	1.07227	1	5	0.5531	0.37819	0	1
C	3.5403	1.14522	1	5	0.6564	0.42364	0	1
A	3.7	0.93137	1	5.5	0.5557	0.36305	0	1
O	3.7662	0.8794	1	5.5	0.5982	0.35391	0	1

5. Empirical Analysis and Results

Necessity test is performed based on the obtained QCA analysis data. When the result variable is a subset of the antecedent variable, it means that the existence of the antecedent variable is a necessary condition for the realization of the outcome variable, but the appearance of the antecedent variable does not necessarily lead to the occurrence of the outcome variable, that is, the antecedent variable is necessary for the outcome variable condition. According to the formula $consistency(Y_i \le X_i) = \sum(min(X_i, Y_i))\sum(Y_i)$ calculate the consistency score. The results are shown in table 4. In the result of the necessity test, the consistency value of the univariate is below the consistency threshold of 0.9, and all are greater than 0. 0<coverage<1, which means that the necessity test needs to be met, indicating that the test single variable is not a necessary condition for the formation of the dependent variable, that is, the combination of total quality management and technological innovation does not require a certain variable to participate (~ indicates that this condition does not exist).

Table 4: Necessity test results.

	Consistency	Coverage		Consistency	Coverage
m	0.803487	0.760188	~m	0.367082	0.410611
d	0.818891	0.758828	~d	0.361711	0.414904
c	0.887757	0.693190	~c	0.189166	0.282226
a	0.874582	0.806684	~a	0.347826	0.401286
o	0.701936	0.601450	~o	0.468633	0.597841

According to the obtained simplified solution (table 5), intermediate solution (table 6) and complex solution (table 7), the combined path that influences the coupling of total quality management and technological innovation process (table 8) is obtained.

Table 5: Parsimonious solution that affect process coupling.

frequency cutoff: 1.000000			
consistency cutoff: 0.812122			
	raw coverage	unique coverage	consistency
	----------	----------	----------
c*m*d	0.679842	0.021993	0.837506
c*d*a	0.678119	0.020168	0.889229
m*d*a	0.713794	0.030455	0.875614
m*d*o	0.574745	0.010135	0.841582
d*a*o	0.584879	0.020168	0.884851
solution coverage: 0.840580			
solution consistency: 0.801856			

Table 6: Intermediate solution that affect process coupling.

frequency cutoff: 1.000000			
consistency cutoff: 0.812122			
	raw coverage	unique coverage	consistency
	----------	----------	----------

o*a*d	0.584879	0.020168	0.884851
o*d*m	0.574745	0.010135	0.841582
a*d*m	0.713794	0.030455	0.875614
a*d*c	0.678119	0.020168	0.889229
d*m*c	0.679842	0.021993	0.837506
solution coverage: 0.840580			
solution consistency: 0.801856			

Table 7: Complex solution that affect process coupling.

frequency cutoff: 1.000000			
consistency cutoff: 0.812122			
	raw coverage	unique coverage	consistency
	----------	----------	----------
c*m*d	0.679842	0.021993	0.837506
c*d*a	0.678119	0.020168	0.889229
m*d*a	0.713794	0.030455	0.875614
m*d*o	0.574745	0.010135	0.841582
d*a*o	0.584879	0.020168	0.884851
solution coverage: 0.840580			
solution consistency: 0.801856			

Table 8: Configuration combination that affect process coupling.

variables	pc				
	Path 1	Path 2	Path 3	Path 4	Path 5
m	●		●	●	
d	●	●	●	●	●
c	●	●			
a		●	●		●
o				●	●
consistency	0.837506	0.889229	0.875614	0.841582	0.884851
raw coverage	0.679842	0.678119	0.713794	0.574745	0.584879
unique coverage	0.021993	0.020168	0.030455	0.010135	0.020168
overall solution coverage	0.840580				
overall solution consistency	0.801856				

6. Conclusion

From the analysis results of fsQCA, we can see that the combination of five possible antecedent variables, including market data identification, demand scale, organizational innovation environment, knowledge gatekeeper capability and organizational dynamic capability, which influences the overall quality management and technological innovation process based on theoretical assumptions In the effect analysis, each variable is the core factor for the coupling effect. According to the research results, the effect of the dependent variable before the coupling effect is shown in figure 3. The five configuration paths c*m*d, c*d*a, m*d*a, m*d*o, d*a*o show that the scale of demand is the core factor affecting the coupling effect, so in the process of affecting the coupling effect, the demand scale is the most critical factor.

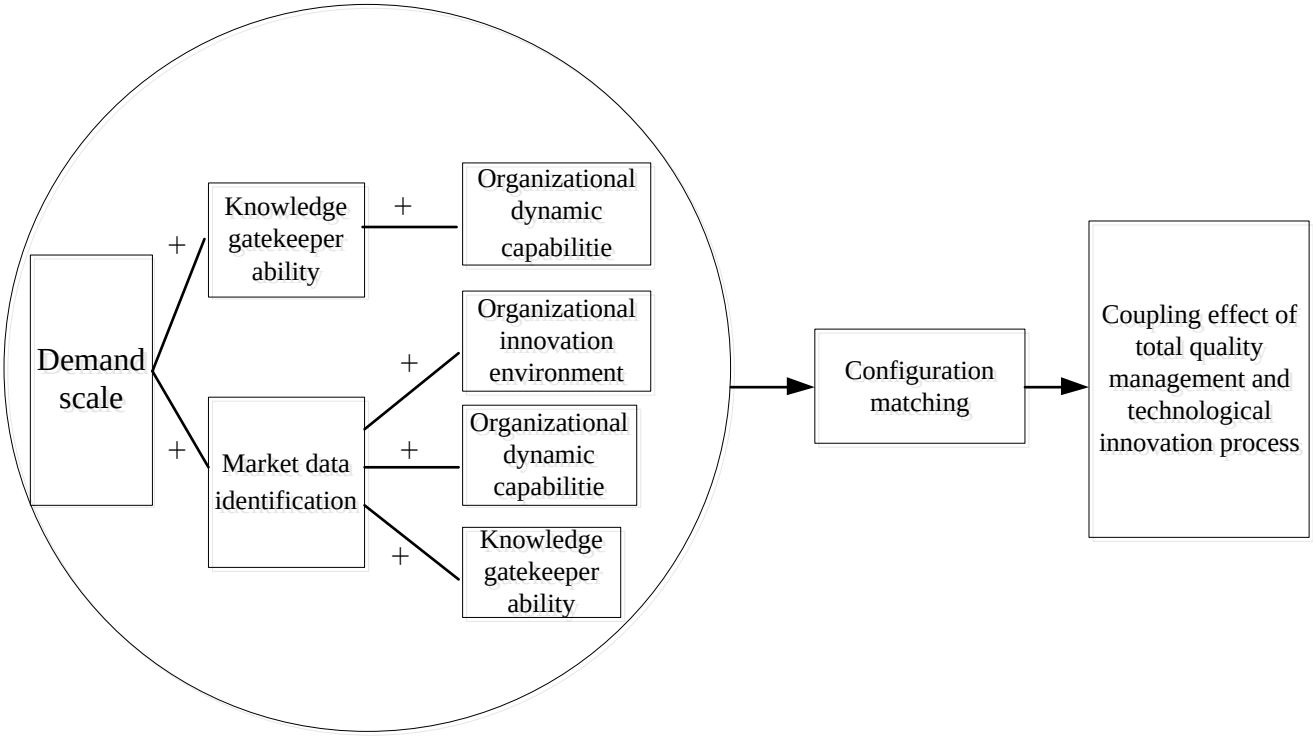

Figure 3. The effect of the antecedent variables on the coupling effect.

The second most influential factor is market data identification. According to the paths c*m*d, c*d*a, m*d*a, m*d*o, when the market has a certain demand scale, when an enterprise can identify market data, the knowledge gatekeeper ability, organization The innovation environment and organizational dynamic capabilities require only a certain factor to effectively promote the coupling effect of total quality management and technological innovation. It can be seen from the path d*a*o that when the market has a certain scale of demand, when the enterprise cannot effectively identify the market data, it depends on the knowledgeable employees in the enterprise to evaluate the pros and cons of the new knowledge, absorb and transform the new knowledge, and promote the creation of innovation awareness Rely on the organization's dynamic ability to respond to environmental changes, integrate relevant resources to ensure the implementation and quality of technological innovation, and then promote the coupling effect of total quality management and technological innovation.

Therefore, when promoting the coupling effect of the process of total quality management and technological innovation, attention needs to be paid to stimulate consumer demand and form a certain scale of market demand, which in turn effectively stimulates the development of enterprise technological innovation. Enterprises themselves also need to improve their ability to recognize market data to meet market demands in a timely manner. At the same time, the human resources department should pay attention to the employees' ability to accept and absorb new things and new knowledge when hiring, cultivate enterprise knowledge gatekeepers, and form a reserve knowledge storage force for enterprise technological innovation. When the enterprise fails to effectively identify market data. At the same time, under the action of the dynamic capabilities possessed by the enterprise, it can make up for the lack of market information recognition and ensure the coupling effect of total quality management and technological innovation.

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