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Supply Chain Relationship Quality and Corporate Technological Innovations: A Multimethod Study

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Abstract: In practice, technological innovation has increasingly become an important means for enterprises to cope with global competition and obtain sustainable development. An increasing number of companies are relying on supply chain resources in the technology development process. Based on the framework of knowledge resource orchestration and the survey data of Tier 1 and Tier 2 suppliers in China’s automotive industry, this study comprehensively analyzed the influencing factors of technological innovations in supply chain enterprises. The analysis of the research by the Bootstrapping method found that supply chain relationship quality (SCRQ) positively impacts corporate technological innovations, in which knowledge sharing and knowledge integration play a dual mediating role. The investigation of the fuzzy set qualitative comparative analysis (fsQCA) revealed that individual elements do not constitute a necessary condition for high-tech innovations in supply chain firms. Mutual commitment among supply chain members plays a more pervasive role in generating high-tech innovations. The two results corroborate each other and further illustrate the vital role of the intersection of SCRQ and knowledge management for corporate technological innovations.

Keywords: supply chain relationship quality; knowledge sharing; knowledge integration; technological innovations; configuration effect

1. Introduction

The importance of technological innovation for the sustainability of organizations has now been recognized, both in the increasingly changing digital economy and in the core research of organizational innovation theory. In the area of theory, based on the innovation theory proposed by Schumpeter, technological innovation has been repeatedly studied and explored by scholars [1–3]. In the field of practice, there is no shortage of cases of companies creating sustainable competitive advantage through technological innovation, such as Huawei (China), Haier (China), and Apple (USA). In general, the use of technological innovation to empower sustainable organizational development has become a consensus among scholars and managers.

However, with the rapid development of technology and the economy, the life cycle of technological products has become progressively shorter. In the face of technology blockade and value chain capture by developed countries, Chinese enterprises recognize the importance of the need to change their technological innovation model and gradually shift from relying only on internal resources for innovations to cross-organizational cooperation in technological innovation behaviors [4]. Moreover, in the context of the speedy development of outsourcing, globalization, and information technology, the interdependence of knowledge and technology between upstream and downstream supply network enterprises is greatly enhanced. Enterprises increasingly rely on supply chain resources in the process of technological development [5]. Therefore, firms should actively cultivate the relationship network and quality with supply chain members to strengthen collaboration, accelerate technological innovations, and optimize resource allocation.
Although studies on supply chain relationship quality (SCRQ) and technological innovation are increasingly in-depth and rich, there are still two deficiencies: first, resource acquisition is not equal to resource utilization according to the resource orchestration theory. Effective management of resources is required to realize their potential value [6,7]. From the perspective of knowledge management and orchestration, the supply chain is a learning system [8,9]. Enterprises are organizations of knowledge sharing and knowledge integration. So, the technological innovation process involves acquiring, utilizing, updating, and integrating supply chain knowledge by enterprises [10]. Moreover, most external knowledge gained by supply chain members usually presents characteristics of clutter and disorder, strong concealment, and high value [11]. Therefore, companies need to manage and orchestrate it effectively to play an active role in technological innovation. However, previous research has mainly examined the relationship between SCRQ and technological innovations from the perspective of resource acquisition. Few studies have investigated this relationship from the view of knowledge resource orchestration. Furthermore, with the supply-side policy reform implemented by the Chinese government, enterprises are gradually paying more attention to the supply side. Supplier management has become more prominent in enterprise technological innovations. Since technological innovations are more concerned with customer needs and satisfaction, previous studies have mainly focused on technological innovation from the perspective of cooperation between enterprises and downstream customers. However, few studies have investigated the upstream suppliers.

To bridge these gaps, this paper attempted to explore the influence of SCRQ on enterprise technological innovations based on the framework of knowledge resource orchestration. It analyzed the mediating mechanism of the two sub-dimensions of knowledge management, these being knowledge sharing and knowledge integration, in the above relationships. Moreover, this study set the research context to the Chinese automotive industry and focused on the relationship quality between suppliers and vehicle manufacturing companies regarding technological innovations. In addition, based on empirical analysis, this research introduced QCA research to integrate the relevant elements of supply chains and enterprises in terms of knowledge orchestration. The purpose of this investigation was to examine the impact of the holistic interaction between supply chains and enterprises on technological innovations from a configuration viewpoint, using the fuzzy set qualitative comparative analysis method (fsQCA) and to uncover the complex antecedents of corporate technological innovations.

The theoretical contributions of this paper are reflected in the following three aspects: first, this study introduces the resource orchestration theory into supply chain management research, primarily focusing on the orchestration and management effects of knowledge resources in supply chain networks, which enriches the research context of resource orchestration theory. Second, the present research theoretically describes and empirically verifies the dual mediators between knowledge sharing and knowledge integration in SCRQ and technological innovations from the perspective of knowledge resource orchestration, which adds a new theoretical view to explain the relationship between SCRQ and technological innovations. Third, to the best of our knowledge, this is the first study to examine the complex role of supply chain systems and firm interactions on technological innovations based on the fsQCA approach. This thesis provides new insights into the antecedent research of technological innovations in supply chain firms from a holistic configuration perspective.

2. Literature Review and Research Hypothesis

2.1. The Analysis Framework: Resource Orchestration Theory

The theory of resource orchestration is based on the resource-based view (RBV), and is a supplement and extension of the RBV. RBV pointed out that valuable, scarce, inimitable, and irreplaceable resources are the basis for enterprises to obtain competitive advantages [12]. However, Barney, an essential founder of RBV, also admitted that simply having resources does not guarantee a competitive advantage or create value. Enterprises
should effectively manage resources [13]. Lippman and Rumelt (2003) stated that resources could only generate value if adequately evaluated, manipulated, and deployed [14]. To fully explain how enterprises transform resources into value, Sirmon et al. (2011) put forward the view of resource orchestration [7]. They described the dynamic process of resource orchestration, i.e., acquisition, mobilization, renewal, integration, and reconstruction. This framework was process-oriented and highlighted the importance of managers, making it clear that resource utilization was as vital as resource ownership [15]. In this paper, under the framework of resource orchestration theory, we analyze the influence mechanism of SCRQ on technological innovations from the perspective of knowledge resource acquisition and reconstruction. A corresponding theoretical model has been constructed accordingly.

2.2. The Analysis of the Relationship between SCRQ and Technological Innovations

The concept of relationship quality was first applied to the study of interpersonal relationships and was gradually introduced into supply chain management. Crosby et al. (1990) proposed a theoretical framework of SCRQ, which refers to the degree of dependence of supply chain organization members on future behavioral choices based on past transactional cooperation [16]. Fynes et al. (2005) suggested that SCRQ is a high-order construct of inter-organizational relationship management that includes dimensions such as commitment, trust, communication, cooperation, and satisfaction [17]. Raskovic et al. (2013) argued that inter-organizational trust and commitment could influence organizational member satisfaction [18]. Therefore, satisfaction should be viewed as an output, rather than a dimension, of SCRQ. Moreover, both Medlin et al. (2005) and Lai et al. (2009) identified trust and commitment as two core constructs of SCRQ [19,20]. Thus, this paper concludes that SCRQ reflects the degree of mutual trust and mutual commitment among supply chain members. Where trust refers to the confidence and belief of both supply chain parties in each other’s reliability and honesty, commitment indicates that the supply chain members desire to maintain the relationship and ensure that it endures.

Innovations are expensive. Enterprises are acutely aware in their technological innovation activities that the resources available within the organization alone cannot cope with the differentiated and individualized demands of competitive markets. Therefore, companies need to engage in cross-border network resource orchestration behaviors to achieve sustainable growth [10,21]. According to the definition of SCRQ, this paper proposes that SCRQ based on trust and commitment helps enterprises achieve technological innovations. To be specific, good relationship quality among supply chain members implies a high degree of trust and commitment to each other, forming a close relationship of “all gain or all lose”. As a result, a unified dialogue platform can be built among supply chain members to reduce the occurrence of suspicion, mutual blame, and negative burnout through timely and effective communication. This approach can also guarantee the flow of innovative ideas and technical knowledge transfer and stimulate companies to sprout new technological thoughts and new product intentions [22]. Moreover, good relationship quality among members of supply chain organizations enhances the closeness of cooperation and eliminates uncertain and speculative collaboration behaviors. Good relationship quality also provides an external environment for cooperative use and reconfiguration of innovation knowledge, reducing the cost of technological innovations. In addition, a high level of relationship quality helps facilitate the joint solution of complex technical problems among supply chain nodes. It promotes the overall upgrading and renewal of enterprise technology [23]. In summary, relying on the excellent quality of relationships among members of supply chain organizations, enterprises can mine, acquire, utilize and reconstruct valuable technological innovation knowledge and ideas from the supply chain relationship network, and realize the practical arrangement of knowledge resources. All these guarantee the smooth implementation of the final technological innovations. Based on this, the following hypothesis is proposed in this paper:

Hypothesis 1 (H1). The SCRQ has a positive impact on enterprise technological innovations.
2.3. The Analysis of the Mediating Role of Knowledge Management

Although the SCRQ could promote technological innovations, good relationship quality is only an intangible asset of the enterprise, providing a supportive context for the firm to construct and utilize knowledge resources. However, this context does not directly contribute to the enterprise’s output; its effect on innovation needs to be realized through certain behaviors or activities [22,24]. This paper argues that testing direct relationships is insufficient to show how SCRQ contributes to firm technological innovations. Instead, it is essential to clarify what actions firms should take to translate SCRQ into technological innovations. Knowledge is a crucial foundation for enterprise technological innovations. According to the research, supply chains are not only “material supply chains” but also “knowledge supply chains” and “knowledge supply and demand networks” among organization members, which are dynamic and complex systems of inter-enterprise knowledge management [25]. To innovate technologies, enterprises need to continuously acquire, update, integrate, and reconstruct knowledge resources from supply chains to manage them effectively [26]. Thus, the knowledge management process may be a mediating path through which SCRQ affects technological innovations. Knowledge sharing and knowledge integration, as two critical components of knowledge management [27], focus on the dissemination, acquisition, reconstruction and utilization of knowledge resources, which can help companies strengthen the orchestration of supply chain knowledge resources. Moreover, according to resource orchestration theory, resource acquisition is not the same as resource utilization, and resource utilization is as essential as resource acquisition [7]. Knowledge sharing and knowledge integration play significant roles in supply chains and cannot replace each other. In summary, this paper explores the mediating roles of knowledge sharing and knowledge integration between SCRQ and technological innovations, respectively.

a. The mediating role of knowledge sharing

Knowledge sharing is a process in which independent individuals exchange knowledge and jointly create new knowledge [28]. From the perspective of supply chains, knowledge sharing involves communication and cooperation between members with different technical expertise in the supply chain so as to acquire knowledge. Through knowledge sharing, supply chain members can receive new knowledge, digest and utilize it, and eventually update and reconstruct new abilities to add value to the original knowledge. Therefore, knowledge sharing enables the orchestration of knowledge resources and dynamically amplifies static knowledge. The supply chain is described as a learning system among enterprises [9]. A good SCRQ can mobilize the members’ enthusiasm for knowledge sharing, knowledge processing, and knowledge creation. It creates conditions for enterprises to realize knowledge sharing and, thus, orchestrate knowledge resources, promoting technological innovations. Based on the above analysis, this paper argues that knowledge sharing is a vital component of the technological innovation process, mediating SCRQ and technological innovations.

First, SCRQ helps to achieve knowledge sharing among companies. Knowledge sharing at the supply chain level implies the free flow of knowledge among supply chain members. However, it is also accompanied by the emergence of risks, such as monopoly knowledge leakage, knowledge plagiarism, and speculation. Hence, a high level of relationship quality, with mutual trust and relevant commitment, becomes a sufficient condition for knowledge sharing among supply chain members [29]. Good faith among supply chain members can eliminate suspicion, doubt, and disconnection, avoid the risk of speculative behaviors and knowledge leakage, and help members share and exchange valuable technologies and knowledge without hiding. Moreover, a high relationship commitment reflects a strong desire to maintain long-term relationships among supply chain members. It builds a belief that both parties share common goals and that knowledge sharing is necessary to achieve long-term benefits. In conclusion, SCRQ has a positive impact on knowledge sharing.
Second, knowledge sharing significantly promotes enterprise technological innovations. The successful operation of technological innovation activities must be based on corresponding knowledge stock. Efficient acquisition, utilization, updating, and reconstruction of knowledge accompany the whole process of technological innovations of enterprises [10]. According to the definition of knowledge sharing, knowledge sharing is an essential act of creating and orchestrating knowledge resources, which can effectively promote the implementation of technological innovations in enterprises. Specifically, enterprises can transfer knowledge within the organization, increasing the organizational knowledge stock and encouraging corporate members to update and create new knowledge. All these activities break through the constraints of knowledge resources and, thus, improve the speed and quality of technological innovations. Moreover, knowledge sharing can facilitate learning among supply chain members [30], which helps in the reconstruction and application of new knowledge, laying the knowledge and capability foundation for technological innovations. In conclusion, knowledge sharing accelerates enterprises' acquisition of knowledge resources, updates, and rebuilds knowledge resources and significantly influences technological innovations.

Third, knowledge sharing is a channel through which SCRQ affects technological innovations. According to the theory of resource orchestration, the management and utilization of resources are crucial [7]. Companies need to effectively manage and orchestrate supply chain knowledge in terms of the complex relationship between supply chain management and knowledge management. If an enterprise does not take appropriate actions, it is not easy to transfer the advantages of SCRQ to technological innovations [24]. Enterprises can realize the reprocessing, recreation, and rearrangement of knowledge, successfully acquire fundamental knowledge, technology, and other core resources, and ultimately enhance technological innovations by knowledge sharing. Therefore, based on the resource orchestration analysis framework, knowledge sharing plays a mediating role in the relationship between SCRQ and technological innovations. Based on this, the following hypothesis is proposed in this paper:

**Hypothesis 2 (H2).** Knowledge sharing plays a mediating role between the SCRQ and enterprise technological innovations.

b. The mediating role of knowledge integration

Knowledge integration refers to the organic integration and fusion of acquired new knowledge and pre-existing technologies, ideas, and knowledge by enterprises [31], thus orchestrating a new core knowledge system. Since the supply chain involves different industries and enterprises, the scope of supply chain-related knowledge is broader. Enterprises need to effectively sort out and integrate knowledge. Therefore, knowledge integration is always crucial in supply chain management and is the basis of enterprise technological innovations [32]. Although it has been pointed out in previous content that SCRQ can explain the differences in technological innovation of enterprises to a certain extent, according to the resource orchestration theory, the demand for knowledge resources of technological innovations is also part of the process of dynamic change. To maintain the competitiveness of product markets and meet changing knowledge demands, enterprises need to continuously integrate new knowledge in the supply chain. Therefore, this paper argues that knowledge integration is an essential part of the technological innovation process of enterprises and plays a mediating role between SCRQ and technological innovation relationships.

First, SCRQ has a positive impact on knowledge integration. According to the definition of knowledge integration, knowledge integration is a dynamic cycle of acquiring, deconstructing, integrating, and reconstructing local knowledge of different forms and contents shared by supply chain members [33]. It can be seen that crossing organizational boundaries and finding knowledge sources in the supply chain is a prerequisite for knowledge integration. Good SCRQ helps companies acquire external essential knowledge
and technology, thus, effectively facilitating the integration and reconstruction of supply chain knowledge with local knowledge [34]. Moreover, in the context of mutual trust and commitment, the willingness of supply chain members to share the information “behind” the knowledge is enhanced, which is conducive to exploring and expanding the depth of the knowledge reserve of enterprises and laying a solid foundation for the process of knowledge system reconstruction. In conclusion, SCRQ can promote the knowledge integration of enterprises.

Second, knowledge integration will effectively promote enterprise technological innovations. At the supply chain level, the technological innovations of an enterprise involve a single company and relate to the innovation of various links and industries in the supply chain [5]. Furthermore, supply chain members possess the technical knowledge required for upper-level design related to corporate technological innovations. Therefore, enterprises need to integrate the relevant knowledge in supply chains in a timely and effective manner to lay the foundation for technological innovations. Knowledge integration is a behavioral process by which enterprises actively acquire, integrate and reconfigure internal and external knowledge of the organization. This process brings a broader range of knowledge resources to the enterprise. It helps to organize advanced information and technology into the organizational knowledge system, thereby reducing the time and risk of technological development. In addition, according to the resource orchestration theory, the effective integration and orchestration of knowledge resources can promptly meet the knowledge resource demands of enterprise innovation activities and help businesses identify and discover potentially valuable opportunities, which plays an essential role in promoting corporate technological innovations. All in all, knowledge integration helps to enhance the knowledge resources and capability base of enterprise technological innovation.

Finally, SCRQ exerts a positive influence on firm technological innovations through knowledge integration. The role of SCRQ on corporate technological innovations is mainly reflected in knowledge acquisition. In fact, scattered and disordered knowledge hardly works. Only knowledge integrated into a comprehensive knowledge system can become the basis of the core competitiveness of enterprises [35]. Through knowledge integration, enterprises can effectively orchestrate external and local knowledge across organizational boundaries to build an organic and dynamic knowledge system, which can create value that individual enterprises cannot obtain on their own. Based on knowledge, technological accumulation and integration are facilitated, and corporate technological innovations become more rule-based. This paper assumes, in line with the above analysis, that knowledge integration plays a critical mediating role in SCRQ, driving enterprise technological innovations. In this regard, the following hypothesis is proposed in this paper:

Hypothesis 3 (H3). Knowledge integration has a mediating role between the SCRQ and corporate technological innovations.

3. Research Method
3.1. Methodological Framework

This study validates the research model and hypotheses based on the Bootstrapping analysis developed by Hayes (2013) [36]. Bootstrapping is more suitable for exploratory prediction studies than other mediation test procedures, can handle non-normal sample data more effectively, and helps ensure consistency of study findings. Fuzzy set qualitative comparative analysis (fsQCA), as a complementary research method, can supplement the Bootstrapping model test net effects with the analysis of multiple variable interactions and their complex mechanisms of action on corporate technological innovation.

Qualitative comparative analysis uses Boolean operation to determine set membership affiliation with a necessity-sufficiency test [37]. In this study, if we observe that all organizations included in the set of high technological innovation firms have high SCRQ, it can be inferred that firms with high SCRQ are a subset of firms with high technological innovation. Thus, high SCRQ is a sufficient condition for high technological innovation. However, this does not mean that the necessity holds, i.e., high technological innovation does not
necessarily require high SCRQ. For example, firms with high technological innovation may also include high knowledge sharing or high knowledge integration, and not create high SCRQ. Thus, high SCRQ is a sufficient but unnecessary condition for high technological innovation. Boolean operation also breaks the single linear combination between variables and allows analysis of the logical combination of antecedents for certain outcomes [38], such as having high SCRQ, high knowledge sharing, and high knowledge integration as causal formulations for firms to achieve high technological innovation.

In summary, the combination of two research methods, Bootstrapping and fsQCA, can ensure a high match between the research model and the empirical data, and improve the credibility and reliability of the research findings. Moreover, the triangulation validation constructed by the two research methods can make the research conclusions more robust.

3.2. Samples and Data Collection

A questionnaire survey was conducted for a domestic vehicle manufacturer and its local upstream Tier 1 and Tier 2 suppliers in China. The reasons for selecting the automotive industry for this study were as follows: first, the automotive industry is a reflection of a country’s comprehensive strength, represents the country’s industrial level, plays a vital role in the development of the national economy, and is one of the pillar industries of China, so the selection of the automotive industry is typical. Second, the automotive supply chain is one of the most complicated industry supply chains among many sectors, involving many suppliers at different levels. Creating a solid supply chain is crucial for member companies. Therefore, supply chain research based on the automotive industry is quite representative. To avoid social approval bias from questionnaires, we used bilateral research to collect data on technological innovations from suppliers and manufacturers. For each supplier, the interviewees were executives familiar with the company’s strategic direction and operations management. For manufacturers, 12 purchasing leaders filled out the questionnaire. During this process, due to the confidentiality of procurement information, the automaker only allowed us access to three directors, resulting in the return of only a small number of questionnaires completed by the manufacturer.

The research period was from July to December 2019, and 295 questionnaires were distributed to suppliers mainly through emails and face-to-face interviews. Among them, 230 questionnaires were distributed to Tier 2 suppliers, 174 valid questionnaires were collected, 65 questionnaires were distributed to Tier 1 suppliers, 30 valid questionnaires were collected, and the overall effective return rate was 69.15%. In addition, 45 questionnaires were distributed to manufacturers asking them to evaluate the technological innovation performance of their suppliers, and all 45 questionnaires were collected with a valid return rate of 100%.

In this paper, we matched 45 suppliers that received feedback from vehicle manufacturers with the suppliers that obtained valid data. We found that there were 38 groups of questionnaires in which manufacturers and suppliers filled in technological innovation evaluation data simultaneously. After that, we performed cross-tests on the 38 groups of data. The results showed a high correlation between the two groups and no significant difference ($p > 0.10$). Therefore, the following empirical part of this paper analyzes the mechanism of the impact of SCRQ on technological innovations using the data from 204 questionnaires provided by Tier 1 and Tier 2 suppliers as a sample. The sample distribution is presented in Table 1.

3.3. Measurements

We rated all items with a seven-point Likert-type scale, where 1 = strongly disagree, and 7 = strongly agree.

Supply chain relationship quality (SCRQ). Consistent with prior research [20], SCRQ was measured with a twelve-item scale developed by Johnson et al. (2004) [39]. Among them, six items measure the trust dimension, and six items measure the commitment dimension.
Table 1. Descriptive statistics of sample firms.

| Sample Characteristics                          | Frequency | %     |
|------------------------------------------------|-----------|-------|
| Supplier tier                                  |           |       |
| Tier 1 supplier                                | 30        | 14.71 |
| Tier 2 supplier                                | 174       | 85.29 |
| Industry                                       |           |       |
| Textiles and leather                           | 37        | 18.14 |
| Plastics and rubber                            | 24        | 11.76 |
| Ferrous metal smelting and rolling processing   | 9         | 4.41  |
| Transportation equipment manufacturing          | 30        | 14.71 |
| Wholesales (machinery, equipment, and parts)    | 20        | 9.80  |
| Auto parts and accessories manufacturing        | 84        | 41.18 |
| Number of full-time employees                  |           |       |
| 100 and below                                  | 23        | 11.27 |
| 100–300 employees                              | 41        | 20.10 |
| 300–500 employees                              | 7         | 3.43  |
| 500–800 employees                              | 43        | 21.08 |
| 800–1000 employees                             | 22        | 10.78 |
| 1000 and above                                 | 68        | 33.33 |
| Firm age                                       |           |       |
| <5 years                                       | 81        | 39.71 |
| 5–10 years                                     | 96        | 47.06 |
| 15–20 years                                    | 13        | 6.37  |
| >20 years                                      | 14        | 6.86  |

Knowledge sharing (KS). Five items were adopted from Spender and Marr (2006) to measure knowledge sharing [40].

Knowledge integration (KI). We adopted a five-item symbolization scale from Yli-Renko et al. (2001) to measure knowledge integration [41].

Technological innovations (TI). We measured technological innovations using a six-item scale developed by Prajogo and Ahme (2006) [42].

Control variables. We controlled for the relevant firms and individual characteristics that could influence technological innovations. Firm age (Age) was measured as the number of years the firm had been operating. We also used the total number of employees to measure firm’s size (Size), and individual CEO characteristics were (dummy) coded. Specifically, we controlled three variables, namely, CEO’s entrepreneurial experience (CEOenex), CEO’s managerial experience (CEOmaex), and CEO’s industry experience (CEOinex) in this study. As regards CEO’s entrepreneurial experience, we asked whether CEOs had founded any previous ventures (1 = Yes; 0 = No). CEO’s managerial experience was measured by asking whether CEOs had worked as senior executives in other firms before joining their current firm (1 = Yes; 0 = No). CEO’s industry experience was calculated using the number of years the CEO had spent in the firm’s industry.

4. Data Analysis and Hypothesis Testing

4.1. Reliability and Validity

The reliability of these constructs was evaluated with Cronbach’s alphas and composite reliability. As shown in Table 2, Cronbach’s alphas ranged from 0.828 to 0.896, which were above the 0.70 threshold, as suggested by Nunnally (1978) [43]. We also found that the values of CRs, ranging from 0.883 to 0.948, were above the recommended level, indicating satisfactory reliability [44].

To assess the construct validity of the critical study variables, we conducted a confirmatory factor analysis (CFA). As shown in Table 3, the hypothesized four-factor model fit the data better when compared to other alternative models. All items substantially loaded were statistically significant on their latent factor, and all factor loadings were above 0.727, indicating satisfactory convergent validity.
Table 2. Summary of the reliability and validity analysis.

| Variables | Factor Loading | Cronbach’s Alpha | CR  | AVE  |
|-----------|----------------|------------------|-----|------|
| SCRQ      | 0.520–0.868    | 0.859            | 0.948 | 0.609 |
| KS        | 0.802–0.889    | 0.896            | 0.925 | 0.712 |
| KI        | 0.744–0.808    | 0.828            | 0.883 | 0.602 |
| TI        | 0.668–0.817    | 0.846            | 0.890 | 0.576 |

Table 3. Comparison of alternative factor structures.

| Variable   | \(\chi^2/df\) | CFI  | GFI  | NFI  | RMSEA |
|------------|---------------|------|------|------|-------|
| Five-factor Model | 2.403         | 0.869 | 0.778 | 0.797 | 0.083 |
| Four-factor Model  | 2.276         | 0.885 | 0.801 | 0.814 | 0.079 |
| Three-factor Model | 3.793         | 0.738 | 0.671 | 0.677 | 0.117 |
| Two-factor Model  | 6.268         | 0.502 | 0.418 | 0.463 | 0.161 |
| One-factor Model  | 6.815         | 0.449 | 0.423 | 0.414 | 0.169 |

Five-factor Model: four theoretical constructs with the latent common methods variance factor; Four-factor Model: hypothesized model; Three-factor Model: KS and KI integrated into one factor; Two-factor Model: SCRQ, KS, and KI integrated into one factor; One-factor Model: SCRQ, KS, KI, and TI integrated into one factor.

Next, following Fornell and Larcker’s (1981) approach [44], we further assessed the discriminant validity of these constructs. As shown in Table 2, all of the average variance extracted (AVE) were above 0.5, which provided evidence of discriminant validity.

4.2. Common Method Variance

In the questionnaire survey, all of the variables were collected from the same source and same person. So, our data may be subject to common method biases [45]. We employed a few more techniques to address the issue to examine if common method variance could bias our results. First, Harman’s single-factor test indicated that no single factor accounted for a majority of the variance (the first factor accounted for 33.566% of the 70.712% explained variance). Second, we constructed a five-factor model with four theoretical variables and a latent common factor to test this issue. The result indicated that the fit indices of the five-factor model (\(\chi^2/df = 2.403\), CFI = 0.869, GFI = 0.778, NFI = 0.797, RMSEA = 0.083) were significantly poorer than the four-factor model (\(\chi^2/df = 2.276\), CFI = 0.885, GFI = 0.801, NFI = 0.814 and RMSEA = 0.079) (Table 3). In other words, the model with the latent common factor did not substantially improve model fit. Therefore, common method bias did not seem to be a serious threat in our study.

4.3. Hypothesis Testing

Considering the nature of our model, we tested all the hypotheses in the current investigation with the bootstrapping procedure using SPSS24.0. We employed Hayes’ PROCESS Model 4, as it allows simultaneous estimation of dual mediation. We used 10,000 bootstrapped samples to estimate 95% bias-corrected confidence intervals for specific and total indirect effects. To assess whether multicollinearity was a significant problem, we also calculated all regression models’ variance inflation factors (VIFs). All the variance inflator values ranged from 1.009 to 1.830, indicating that the threat to validity from multicollinearity did not appear to be a concern in this research.

Table 4 presents the path analysis and mediation results. Hypothesis 1 predicted a positive relationship between the SCRQ and technological innovations. After controlling for a range of individual- and firm-level variables, SCRQ was correlated with technological innovations (\(\beta = 0.398, p < 0.01\)), whereby hypothesis H1 passed the test.

Consistent with expectations, SCRQ was positively correlated with both knowledge sharing (\(\beta = 0.322, p < 0.01\)) and knowledge integration (\(\beta = 0.248, p < 0.01\)). Knowledge sharing (\(\beta = 0.279, p < 0.01\)) and knowledge integration (\(\beta = 0.155, p < 0.01\)) were positively related to technological innovations. Moreover, the path between SCRQ and technological innovations was still significant, indicating that knowledge sharing and knowledge integration partially mediated this path.
Table 4. Path analysis and mediation results.

| Variables | KS Coefficient | 95%CI | KI Coefficient | 95%CI | TI Coefficient | 95%CI |
|-----------|----------------|-------|----------------|-------|----------------|-------|
| Size      | 0.005 (0.064)  | [−0.120, 0.130] | 0.074 (0.065)  | [−0.054, 0.202] | 0.042 (0.041)  | [−0.040, 0.124] |
| Age       | −0.056 (0.063) | [−0.180, 0.067] | −0.081 (0.064) | [−0.207, 0.045] | 0.012 (0.041)  | [−0.068, 0.092] |
| CEOenex   | 0.043 (0.067)  | [−0.089, 0.174] | 0.054 (0.068)  | [−0.081, 0.188] | 0.051 (0.043)  | [−0.034, 0.137] |
| CEOmaex   | −0.028 (0.062) | [−0.151, 0.095] | −0.051 (0.064) | [−0.177, 0.074] | −0.010 (0.041) | [−0.090, 0.070] |
| CEOinex   | 0.240 (0.070) *** | [0.102, 0.378] | 0.248 (0.072) *** | [0.107, 0.389] | 0.229 (0.047) *** | [0.136, 0.322] |
| SCRQ      | 0.322 (0.069) *** | [0.187, 0.457] | 0.248 (0.070) *** | [0.110, 0.386] | 0.279 (0.055) *** | [0.171, 0.386] |
| KS        | 0.279 (0.070) *** | [0.171, 0.386] | 0.248 (0.070) *** | [0.110, 0.386] | 0.398 (0.047) *** | [0.305, 0.491] |
| KI        | 0.155 (0.053) *** | [0.050, 0.260] | 0.279 (0.055) *** | [0.171, 0.386] | 0.398 (0.047) *** | [0.305, 0.491] |

Model Summary:

- R² = 0.240
- R² = 0.207
- R² = 0.683

Indirect effect of SCRQ on TI:

- Total: 0.128
- Effect: 0.240
- BootSE: 0.072
- LLCI: 0.198
- ULCI: 0.168

Note: *** Significant at 1%.

Further, mediation testing results showed that the mediating effects of SCRQ on technological innovations through knowledge sharing was 0.090, with a 95% bias-corrected bootstrap confidence interval of [0.039, 0.168], not containing zero. Hence, the mediating effect of knowledge sharing was significant, and hypothesis 2 was supported. Meanwhile, the indirect impact of the SCRQ on technological innovations via knowledge integration was 0.038, with a 95% bias-corrected bootstrap confidence interval of [0.007, 0.096], not containing zero, which provided support for the mediating effect of knowledge integration proposed in hypothesis 3.

Finally, complying with the dual mediation study [46], we compared the magnitude of the mediating effects of knowledge sharing and knowledge integration. We found that knowledge sharing accounted for 70.31% of the total impact, and knowledge integration made up 29.69% of the total effect. In other words, knowledge sharing was more vital than knowledge integration in the process of SCRQ affecting technological innovations.

4.4. Additional Test

Existing research suggests that exploring the relationship between mediating variables can help better explain innovation variability among firms. To further explore the relationship between knowledge sharing and knowledge integration, and the impact of such association on the relationship between SCRQ and technological innovations, we implemented an additional test to examine whether the model was subject to any sequential mediation effect. That is, whether the mediation paths that we proposed were alternative or sequential. We employed the Hayes’ PROCESS Model 6 (serial mediation) to estimate regression coefficients and used 10,000 bootstrapped samples to estimate 95% bias-corrected confidence intervals to examine the indirect paths. More specifically, SCRQ was indirectly and positively associated with technological innovation sequentially mediated, first through knowledge sharing and then through knowledge integration. As shown in Table 5, the specific indirect effect of SCRQ on technological innovation via knowledge sharing and knowledge integration was significant (indirect effect through knowledge sharing and knowledge integration = 0.011, p < 0.10, 95% bias-corrected bootstrap CI = [−0.007, 0.053]). Thus, there seemed to be a sequential mediation chain to fully integrate the links between SCRQ, knowledge sharing, knowledge integration, and technological innovations. Based on the results in Table 6, although we confirm they do have sequential indirect effect, the effect of those dual mediating mechanisms was still signifi-
cantly more substantial than the sequential indirect effect, which empirically confirmed the accuracy of our theoretical framework.

### Table 5. Sequential mediation results.

| Indirect Effect of SCRQ on TI | Effect | Boot SE | 95% LLCI | 95% ULCI |
|------------------------------|--------|---------|----------|----------|
| M1 = Through KS alone        | 0.090 *** | 0.032   | 0.040    | 0.167    |
| M2 = Through KI alone        | 0.027 **  | 0.015   | 0.009    | 0.059    |
| M3 = Through KS and KI       | 0.011 *  | 0.012   | −0.007   | 0.053    |

Note: * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

### Table 6. Variable calibration and descriptive statistics.

| Variable | Secondary Indicators | Calibration Anchors | Descriptive Statistics |
|----------|----------------------|---------------------|------------------------|
|          |                      | Fully in | Crossover Point | Fully out | Mean | Standard Deviation | Maximum | Minimum |
| TI       |                      | 7.00     | 5.83           | 4.00      | 5.66 | 0.952              | 7.00    | 1.33    |
| SCRQ     | TSCRQ                | 5.96     | 4.17           | 2.83      | 4.21 | 0.922              | 7.00    | 1.00    |
|          | CSCRQ                | 6.17     | 4.33           | 2.00      | 4.18 | 1.255              | 7.00    | 1.00    |
| KS       |                      | 7.00     | 5.80           | 4.20      | 5.74 | 0.879              | 7.00    | 2.00    |
| KI       |                      | 7.00     | 5.60           | 4.00      | 5.53 | 0.919              | 7.00    | 3.00    |
| CEOinex  |                      | 4.00     | 3.00           | 2.00      | 3.22 | 0.840              | 5.00    | 2.00    |

5. Empirical Analysis and Discussion Based on QCA

5.1. Selection and Calibration of Variables

Enterprises embedded in the supply chain system exhibit technological innovations which are influenced by an overall combination of elements, such as SCRQ and internal enterprise knowledge management. Investigating the influence of each component on technological innovations individually, or mining the relationship between variables from the traditional intermediary perspective, to some extent limits the strength of the supply chain system as a whole to explain enterprise technological innovation [37,47]. Ragin’s pioneering combination of set theory and qualitative comparative analysis (QCA) broke through the traditional division between qualitative and quantitative analyses using fuzzy set qualitative comparative analysis (fsQCA). This approach redefines the research paradigm with a holistic understanding and combinatorial thinking [38]. Therefore, this paper introduced qualitative comparative analysis and used a configuration perspective to explain how the interacting parts of the supply chain and the enterprise as a whole produced high-tech innovation.

The aforementioned theoretical studies and empirical analyses supported the effects of SCRQ, knowledge sharing, and knowledge integration on technological innovations and the positive relationship between CEO industry experience and technological innovations. In comparison, other control variables (e.g., age, size, etc.) were not significantly related to technological innovations. Based on this, the four variables of SCRQ, knowledge sharing, knowledge integration, and CEO industry experience, were selected as the conditional variables in this study. It is important to note that supply chain relationship quality contains two dimensions of trust (TSCRQ) and commitment (CSCRQ). This section opened them up for subsequent analysis using the two secondary indicators of trust and commitment, i.e., QCA analysis using five conditional variables.

In summary, trust, commitment, knowledge sharing, knowledge integration, and CEO’s industry experience are five important factors influencing corporate technological innovation. However, the relationships between each factor and technological innovation are not simply linear. There may be various types of complex non-linear correlations, and the symbiosis and competition among these factors may also have non-linear effects on technological innovation. Therefore, it is still an open question as to how the above five elements of the enterprise can synergistically drive technological innovation. This
paper integrated five key antecedent conditions, based on a configuration perspective, and dug deeper into the synergistic mechanism of trust, commitment, knowledge sharing, knowledge integration, and CEO’s industry experience driving technological innovation and the interaction between the five factors. Figure 1 lists the analysis model.

Figure 1. Analytical model: configuration effects of technological innovations in supply chain enterprises.

Calibration is the process of assigning cases to membership scores. This paper used the direct method to calibrate the variables as fuzzy sets [47,48]. The specific steps are as follows: the three calibration points (fully in, crossover point, fully out) for the five conditional variables and one outcome variable were set as the upper quartile, median, and lower quartile of the descriptive statistics of the case sample, respectively. The calibration of non-high-tech innovations was achieved by taking the non-set of high-tech innovations. The calibration anchor points and descriptive statistics for each variable are detailed in Table 6.

5.2. Necessary Condition Analysis

In this paper, fsQCA 3.0 software was used to perform the necessary condition test. As shown in Table 7, the necessary consistency of individual antecedent conditions for high-tech or non-high-tech innovations in supply chain firms were below 0.9 and did not constitute a necessary condition for the results, indicating the weak explanatory power of individual elements for corporate technological innovations.

Table 7. Analysis of necessary conditions.

| Condition Variable | High-Tech Innovation in Supply Chain Enterprises | Non-High-Tech Innovation in Supply Chain Enterprises |
|--------------------|-----------------------------------------------|-----------------------------------------------|
| TSCRQ              | 0.815                                         | 0.529                                         |
| ~TSCRQ             | 0.558                                         | 0.839                                         |
| CSCRQ              | 0.837                                         | 0.535                                         |
| ~CSCRQ             | 0.553                                         | 0.849                                         |
| KS                 | 0.824                                         | 0.538                                         |
| ~KS                | 0.516                                         | 0.797                                         |
| KI                 | 0.787                                         | 0.554                                         |
| ~KI                | 0.556                                         | 0.784                                         |
| CEOinex            | 0.865                                         | 0.609                                         |
| ~CEOinex           | 0.447                                         | 0.698                                         |

5.3. Sufficiency Analysis of the Configuration

Concerning existing studies [49–51], the consistency threshold and PRI consistency threshold were set to 0.8 and 0.7, respectively, and the case frequency threshold was set to 3. Core conditions and periphery conditions were distinguished by comparing intermediate and parsimonious solutions. Table 8 lists the configuration results. As shown
by the consistency index, three configuration paths constituted sufficient conditions for high-tech innovations in supply chain enterprises; as shown by the coverage index, each configuration had substantial explanatory power for high-tech innovations in enterprises. Each configuration is elaborated on below.

Table 8. The configuration that generates high-technological innovation in supply chain firms.

| Conditional Variable | Solution |
|----------------------|----------|
|                      | 1        | 2        | 3        |
| TSCRQ                | .        | •        |          |
| CSCRQ                |          | .        | •        |
| KS                   | ⊗        |          |          |
| KI                   | ⊗        | .        |          |
| CEOinex              | •        | •        |          |
| Consistency          | 0.967    | 0.985    | 0.968    |
| Raw Coverage         | 0.643    | 0.553    | 0.562    |
| Unique Coverage      | 0.141    | 0.051    | 0.059    |
| Solution Consistency | 0.947    |          |          |
| Solution Coverage    | 0.753    |          |          |

Note: • indicates the presence of core conditions; ⊗ and ◯ refer to the existence and absence of peripheral conditions; blank spaces indicate that the condition may be either present or absent.

Model 1: The trust-driven path led by commitment and experience. In configuration 1, commitment and the CEO's industry experience are the core conditions, while trust, non-high knowledge sharing, and non-high knowledge integration are the periphery conditions. It shows that when knowledge sharing and knowledge integration are not good simultaneously, as long as there is mutual trust and commitment among supply chain members, and the CEO has enough industry experience, enterprises can promote high-tech innovations.

Model 2: The interaction-driven path led by relationship quality and knowledge management. In configuration 2, trust and knowledge sharing are the core conditions, while commitment and knowledge integration are the periphery conditions. This configuration indicates that, regardless of the CEO's industry experience, high-tech innovations can be achieved with good relationship quality among supply chain members and knowledge management practices, such as knowledge sharing and knowledge integration.

Model 3: The knowledge management-driven path led by commitment and experience. In configuration 3, commitment and CEO industry experience are the core conditions, while knowledge sharing and knowledge integration are the periphery conditions. It shows that regardless of trust among supply chain members, a high level of commitment to each other, a CEO with sufficient industry experience, and with corporate knowledge management behavior process in place high-tech innovations in supply chain firms can be generated.

6. Discussion and Conclusions

6.1. Conclusions

In the era of open innovation, enhancing trust and commitment with supply chain partners and the concept of “hold together for warmth” with upstream and downstream enterprises are important ways for companies to achieve sustainable development. In other words, SCRQ is particularly important for the sustained development of corporate technological innovation. Based on the knowledge resource orchestration framework and the introduction of two new variables, knowledge sharing, and knowledge integration, this study explored the factors and influence paths of SCRQ on corporate technological innovation using the Bootstrapping and fsQCA methods to analyze the combination of antecedent conditions that trigger high corporate technological innovation in the Chinese automotive industry. The following research findings are synthesized:

The Bootstrapping study indicated the importance of one key variable—SCRQ—in building the capacity for innovations and, in particular, for facilitating a firm’s technological innovation. Drawing on the organization’s knowledge resource orchestration perspective,
a framework that paves the way for a more nuanced understanding of the underlying process is developed. Specifically, this research demonstrates that knowledge sharing and knowledge integration jointly explain the indirect effects that are in play. In addition, by comparing the differential mediating effect of these two mechanisms, this study finds that knowledge sharing seems to be more significantly important than knowledge integration.

The fsQCA findings show that individual components do not constitute a necessary condition for high-tech innovations. Still, mutual commitment among supply chain members plays a more general role in generating high-tech innovations. Moreover, three system elements generate high-tech innovations in supply chain firms: the trust-driven path led by commitment and experience, the interaction-driven path led by relationship quality and knowledge management, and the knowledge management-driven path led by commitment and experience.

Next, the findings' implications to theory and managerial practice and the limitations and opportunities for future research are discussed.

### 6.2. Theoretical Implications

This research offers important contributions to several streams of research.

First, as results indicate that supply chain management may be an instrumental, enabling factor for inspiring a positive innovation outcome, the present study enlarges the scope of supply chain relationship management research by demonstrating the importance of SCRQ in driving critical firm performance metrics, such as technological innovation. Specifically, by examining what effect SCRQ may have on technology innovation, the results add at least one new insight. That is, the research demonstrates that the two dimensions of SCRQ, these being TSCRQ and CSCRQ, do not have an identical impact on technological innovation. Specific to the context, commitment plays a more general role than trust. Thus, the findings of this study open a new and holistic avenue for future work to recognize the differential effects of TSCRQ and CSCRQ [20].

Second, this study expands the literature on the organization’s knowledge resource orchestration perspective by addressing how knowledge management can be leveraged to enhance its innovation outcome. Specifically, this study provides theoretical arguments for empirical evidence that two knowledge orchestration processes, those of knowledge sharing and knowledge integration, serve as dual mediating mechanisms linking SCRQ and technological innovation. Thus, this research highlights the importance of the indirect process from SCRQ to technological innovation. While previous literature has helped catapult resource management to prominence as a means for understanding the process and outcomes of various organizations’ endeavors [10,15], the current paper attributes technological innovation to mechanisms related to a firm’s knowledge resource orchestration. In so doing, we respond to the call to expand the resource orchestration theory [7,52].

Third, as an exploratory study on the impact of SCRQ on corporate technological innovation, Bootstrapping only constructs fixed variable paths for simple statistical validation based on theory, and cannot analyze the complex mechanism of the interaction of multiple variables on firm technological innovation. Therefore, this study combined both Bootstrapping and fsQCA methods to further explore the complex causal relationship between SCRQ and technological innovation, based on the verification of the net effect of the variables.

### 6.3. Managerial Implications

The enlightenment of management practice in this paper lies in creating a highly committed supply chain system and cultivating good SCRQ. Mutually committed supply chain member relationships play a more prominent role in promoting corporate technological innovations, and good SCRQ facilitates corporate technological innovations. This article reveals that Chinese companies need to uphold willingness to cooperate in the long-term, to maintain a sense of loyalty and responsibility, and to build good relationship capital by establishing long-term alliance relationships in the supply chain collaborative
process. Strengthening the ability of knowledge management and giving full play to the
effectiveness of knowledge sharing and knowledge integration help enterprises translate
the quality of good supply chain relationships into technological innovations. By normal-
izing knowledge acquisition, utilization, updating, and reconstruction, enterprises can
better grasp the information and technology in the supply chain relationship network, thus
ensuring the smooth advancement of technological innovation. Furthermore, attaching
importance to the linkage and matching between supply chain, enterprises, and CEOs is
crucial. Optimizing a single element is not a prerequisite for high-tech innovations in a
supply chain enterprise. Technological innovations result from the interaction between
the supply chain members, enterprises, and CEOs. These results reveal that supply chain
enterprises should not be limited to developing a single element but should pay attention
to supply chain linkage, enterprises, and CEOs. These firms should create a “combination”
to optimize enterprise technological innovations.

6.4. Limitations and Directions for Future Research

This paper also has the following shortcomings, which deserve further research in
the future. First, we acknowledge the methodological limitations. For instance, the cross-
sectional nature of our data set did not afford insights into causal inferences. Longitudinal
data, were they to be available, would confer the ability to examine the dynamic nature
of the relationships we have discussed. Thus, in the future, time-series data could be
introduced for panel data analysis and time series QCA analysis. Furthermore, the influence
of the evolution of the relationship between supply chain members and internal changes
on the technological innovations of enterprises could be further explored to improve the
robustness of the conclusions.

Second, the sample was based on the automotive industry in China. Although au-
tomotive industry supply chain features are distinct, one could argue that SCRQ and
technological innovation issues are more relevant for relative industry and, thus, the per-
spective(s) offered herein may be contextually derived. It points to the need for future
empirical investigations to include multi-industry in samples. In addition, additional
studies that include data from other countries and cultures could help extend our findings.

Third, this paper obtained support for partial mediation of the relationship between
SCRQ and technological innovation, and there could be unanswered questions on the
process and possible other mediators in play. More fine-grained process-oriented studies
could examine such possibilities. At the same time, a key area for theoretical development
would be to study what may influence the existence or strength of the direct effects we
have examined. On this point, organizational factors, industry and environmental factors
or cultural settings can be brought to bear as potential moderators.

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