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Citation

Liu, Gordon; Chen, Yantai and Ko, Wai Wai (2025). Justice and Contracts as Double-Edged Swords: Collaborative Product Innovation in Hub-and-Spoke Supply Chain Networks. *Journal of Supply Chain Management* (Early access).

URL

<https://oro.open.ac.uk/102451/>

DOI

<https://doi.org/10.1111/jscm.12340>

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ORIGINAL ARTICLE OPEN ACCESS

Justice and Contracts as Double-Edged Swords: Collaborative Product Innovation in Hub-and-Spoke Supply Chain Networks

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Received: 7 December 2023 | **Revised:** 23 January 2025 | **Accepted:** 27 January 2025

Funding: This work was supported by National Natural Science Foundation of China, 72032008.

Keywords: formal contracts | inter-organizational justice | new product development | supply chain relationship | transaction cost economics

ABSTRACT

This study explores how inter-organizational justice, and formal contracts influence new product development (NPD) collaboration in supply chain networks. Challenging traditional transaction cost economics (TCE), the research focuses on collaborative NPD in hub-and-spoke supply chain structures. Data from 183 Chinese suppliers and 22 executive interviews reveal unexpected patterns in NPD collaboration. Procedural justice exhibits an inverted U-shaped relationship with NPD collaboration, linking higher fairness to improved collaboration up to a point, beyond which further increases may associate with diminishing returns. In contrast, distributive justice shows a U-shaped relationship with NPD collaboration, where higher equity initially relates to reduced collaboration but later correlates with renewed engagement. Notably, formal contracts amplify the negative interactions between these justice dimensions. This contradicts the conventional view of their complementary roles. These findings contribute to theoretical advancements by illustrating how inter-organizational justice mechanisms function differently in complex network structures compared to simple dyadic relationships. Careful calibration of inter-organizational justice dimensions and formal contracts proves essential for fostering productive NPD collaboration. These governance insights offer directions for enhancing supply chain relationship management.

1 | Introduction

Supply chain partners increasingly collaborate on new product development (NPD) to sustain competitive advantages (Peng, Heim, and Mallick 2014). While traditional supply chain collaboration focuses on process improvements in logistics and inventory, collaborative NPD enhances market responsiveness by creating new revenue streams. Industries experiencing rapid technological changes particularly benefit from this cross-supply chain product innovation (Liu and Rong 2015). Researchers

have shown that firms adjust their supply chain structures in order to achieve specific objectives, such as innovation, while maintaining control and flexibility in the face of environmental uncertainty (Namdar, Modi, and Blackhurst 2025). The consumer electronics and automotive sectors exemplify this trend, as electric vehicle development demands intensive collaboration between manufacturers and suppliers (Ding, Ye, and Wu 2019). The growing complexity of products and the need for specialized expertise beyond organizational boundaries underscore NPD's critical role in supply chain collaboration (Davis 2016).

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Inter-organizational justice,¹ conceptualized as fair practices within inter-organizational dynamics, serves as a critical foundation for collaborative relationships (Narasimhan, Narayanan, and Srinivasan 2013). Transaction cost economics (TCE) demonstrates how inter-organizational justice reduces opportunistic behavior in supply chain collaborations (Huo, Wang, and Tian 2016). Contemporary market opportunities have transformed business collaboration patterns from dyadic partnerships to sophisticated interfirm networks, particularly the hub-and-spoke model (Liu and Rong 2015). The consumer electronics and automotive manufacturing sectors exemplify this evolution, where hub-firms coordinate relationships and allocate resources effectively (Liu, Aroean, and Ko 2022).

This paradigmatic shift poses profound challenges to established theoretical frameworks—particularly TCE—because TCE traditionally focuses on dyadic relationships (Poppo and Zhou 2014). The inherent complexity of hub-and-spoke supply chain networks challenges several core TCE assumptions in significant ways. The multilateral nature of these networks creates intricate relationships between multiple suppliers (spoke-firms) and a central hub-firm (Chae, Choi, and Hoetker 2024). This complexity exceeds TCE's typical analytical scope (Fang et al. 2016; Liu, Aroean, and Ko 2022). A substantial information asymmetry exists, with hub-firms possessing superior network intelligence compared to individual suppliers. This asymmetry challenges TCE's presumption of balanced information access for decision-making (Dhanaraj and Parkhe 2006; Mascarenhas, Kesavan, and Bernacchi 2008). Additionally, the varied scale and scope of transactions within these networks influence the perception and management of transaction costs (Chae, Choi, and Hoetker 2024), particularly regarding network-level efficiencies. The dynamic character of these networks, marked by the potential entry and exit of suppliers, further challenges TCE's assumptions about relationship stability (Cropanzano, Prehar, and Chen 2002). Hub-firms frequently implement standardized procedures unilaterally in hub-and-spoke supply chain networks. This practice contradicts TCE's traditional assumption of bilateral procedure negotiation (Williamson and De Meyer 2012).

Within these hub-and-spoke supply chain networks, the dynamics of procedural and distributive justice² assume particular significance. These two dimensions of justice merit specific examination due to their alignment with inter-organizational dynamics within supply chain networks (Griffith, Harvey, and Lusch 2006; Poppo and Zhou 2014). Procedural justice, which emphasizes perceived fairness in decision-making processes (Narasimhan, Narayanan, and Srinivasan 2013), is closely related to arrangement efficiency and monitoring cost reduction. Distributive justice, concerning fair outcome allocation based on inputs (Fang et al. 2016), aligns with TCE principles by safeguarding against opportunism and ensuring equitable benefit distribution.

This study proposes distinct curvilinear effects of procedural and distributive justice on NPD collaboration within hub-and-spoke supply chain networks. These nonlinear patterns emerge from the opposing forces of benefits and costs³ (Haans, Pieters, and He 2015). Traditional TCE frameworks

require extension to explain inter-organizational justice dynamics in these networks. The implementation of standardized procedures by hub-firms adds complexity to procedural justice dynamics (Liu, Aroean, and Ko 2022). Hub-firms' centralized approaches generate varying supplier perceptions of procedural fairness. This variation produces an inverted U-shaped relationship between procedural justice and NPD collaboration. This relationship arises as decreasing monitoring costs are offset by escalating adaptation costs. Information asymmetry significantly affects distributive justice dynamics, particularly regarding monetary and non-monetary rewards (Luo 2007). This asymmetry creates a U-shaped relationship between distributive justice and collaboration outcomes. The U-shape reflects the interaction between increasing information-gathering costs and decreasing safeguarding costs as fairness perceptions improve.

Furthermore, in hub-and-spoke networks, procedural and distributive justice function as substitutes, where high distributive justice overshadows procedural justice in shaping supplier participation. Suppliers prefer costs associated with distributive justice due to their direct connection with tangible outcomes (Che, Jiang, and Pei 2024; Poppo and Zhou 2014). The dominant position of hub-firms increases suppliers' transaction costs in navigating imposed decision-making processes. High distributive justice mitigates these risks and aligns with outcome-based performance metrics, leading suppliers to prioritize fair outcomes over procedural engagement. Formal contracts moderate this substitution effect between justice types in hub-and-spoke supply chain networks by fostering stable partnerships and balancing power dynamics through explicit outcome specifications and risk allocation clauses (Li, Poppo, and Zhou 2010). By reducing uncertainty and emphasizing measurable outcomes, formal contracts diminish suppliers' need for procedural involvement, thus reinforcing the primacy of distributive justice in supplier decision-making.

The analysis combines dyadic, time-lagged survey data from a hub-firm and 183 Chinese suppliers with insights from 22 executive interviews, revealing three key theoretical implications. First, the study extends the applicability of TCE (Poppo and Zhou 2014; Williamson 2008) to hub-and-spoke supply chain networks. This extension demonstrates how procedural and distributive justice influence NPD collaboration through different transaction cost effects. Procedural justice shows an inverted U-shaped effect on NPD collaboration, while distributive justice exhibits a U-shaped effect. This framework enhances the understanding of justice perceptions, transaction costs, and NPD collaboration within these networks. Second, the findings reveal a substitution pattern between procedural and distributive justice in supply chain relationships, challenging the established complementarity perspective (Brown, Cobb, and Lusch 2006; Luo 2007). This pattern provides a new analytical framework for examining how firms balance transaction costs within hub-and-spoke supply chain relationships. Third, formal contracts strengthen the substitution effect, enhancing TCE's contract conceptualization. While formal contracts reduce certain transaction costs (Poppo and Zenger 2002), they also alter the balance between justice types, offering new insights into contract management within hub-and-spoke supply chain networks.

2 | Theory and Hypothesis

2.1 | Literature Background

Researchers have increasingly focused on inter-organizational justice in supply chain relationships, categorizing it into three key streams. The first stream conceptually explains how fairness influences the behavior of parties in supply chain relationships (e.g., Boyd et al. 2007). Building on this foundation, researchers have developed scales to measure the different types of inter-organizational justice (e.g., Kashyap, Manolis, and Brashear 2008) and conducted qualitative studies to explore how these types influence supply chain firms' behavior (e.g., Karaosman, Marshall, and Villena 2023). This research has established a foundation for understanding inter-organizational justice's critical role in shaping firms' behavior within supply chain relationships.

The second research stream examines inter-organizational justice as a moderating factor in how specific supply chain factors influence firm behavior and performance. This body of literature investigates the moderating effects of individual types of justice and compares the distinct impacts of various forms of inter-organizational justice. For example, Wei, Yin, and Chen (2021) demonstrated that distributive justice weakened the effect of internal-external integration on performance while strengthening the impact of external integration. Procedural justice enhanced the performance effects of internal-external integration but showed no significant influence on external integration. Additional studies have compared the moderating effects of procedural and interactional justice (Liu, Aroean, and Ko 2019) and procedural versus distributive justice (Kaynak et al. 2015).

The third research stream explores the antecedents and impacts of inter-organizational justice. Regarding these antecedents, Lund, Scheer, and Kozlenkova (2013) revealed that national cultural traits like uncertainty avoidance and long-term orientation enhance fairness perceptions, while power distance reduces procedural fairness. Researchers have examined the influence of inter-organizational justice on two primary outcomes. Performance-related outcomes include financial performance (e.g., Griffith, Harvey, and Lusch 2006), market performance (e.g., Qiu 2018), growth (e.g., Zaefarian et al. 2016), and innovation (e.g., Kim, Lee, and Lee 2017; Zhou, Govindan, and Xie 2020). Relationship outcomes include opportunistic behavior (e.g., Huo, Wang, and Tian 2016) and supply chain cooperation (e.g., Wei, Yin, and Chen 2021). Several studies have also examined the combined effects of different types of inter-organizational justice on various outcomes (e.g., Brown, Cobb, and Lusch 2006; Narasimhan, Narayanan, and Srinivasan 2013). Other studies have investigated inter-organizational justice as a mediator, exploring its antecedents and consequences concurrently (e.g., Malagueño, Gölgeci, and Fearne 2019; Mir et al. 2022).

This research extends the third stream of inter-organizational justice literature by addressing limitations and advancing TCE's application to complex supply chain network structures. The predominant focus on dyadic relationships has restricted the understanding of justice mechanisms in hub-and-spoke

supply chain networks (Liu, Aroean, and Ko 2019; Williamson and De Meyer 2012). Existing frameworks often overlook the nonlinear relationships between justice dimensions and collaboration outcomes, interactions between justice types, and the role of formal contracts. Applying TCE to these networks represents a significant theoretical advancement, as modern business networks surpass the scope of traditional dyadic relationships (Poppo and Zhou 2014; Williamson 2008). This study examines the nonlinear effects of justice dimensions, their interactions, and the moderating role of formal contracts, offering novel insights into justice dynamics in contemporary supply chain relationships. It also lays the foundation for a conceptual framework on supply chain-based NPD collaboration.

2.2 | TCE Perspective of Supply Chain-Based NPD Collaboration

Collaboration on NPD projects among firms within the supply chain has become increasingly crucial for capturing complex market opportunities. This shift toward collaborative innovation reflects the increasing need for diverse expertise and resources to develop more sophisticated products (Liu and Rong 2015). By leveraging the resources and knowledge of supply chain partners, firms can achieve superior results compared to operating in isolation (Cao and Zhang 2010; Wei, Yin, and Chen 2021). This collaborative approach enables firms within supply chains to pool their strengths, overcome individual limitations, and create synergies that drive innovation.

TCE provides a foundational framework for analyzing supply chain collaboration in NPD projects. This framework illuminates organizational collaboration drivers and management methods. TCE aims to reduce transaction costs that emerge from opportunistic behavior among parties (Williamson 2008). Innovation uncertainty in NPD projects creates substantial transaction costs. Supply chain partnerships help firms decrease these costs in joint NPD activities. More specifically, supply chain partnerships achieve cost reduction through three primary mechanisms: integrated systems that lower coordination expenses, trust-based relationships that minimize monitoring needs through aligned goals, and shared access to resources and expertise that decreases acquisition costs (Cao and Zhang 2010; Peng, Heim, and Mallick 2014).

According to TCE, inter-organizational justice mechanisms reduce transaction costs in supply chain partnerships through distinct pathways. Procedural justice establishes fair decision-making processes between collaborating organizations. These clear procedures decrease both monitoring costs and adaptation expenses, encouraging ongoing partnership development (Che, Jiang, and Pei 2024; Luo 2008). Distributive justice ensures fair outcome sharing among supply chain partners. This equitable distribution minimizes the need for extensive information-gathering and safeguarding measures (Che, Jiang, and Pei 2024; Poppo and Zhou 2014). Research confirms that these types of justice work together to strengthen collaborative behavior (Brown, Cobb, and Lusch 2006; Luo 2007). While these studies do not always use TCE terminology directly, their findings support core TCE principles. Both justice

forms reduce uncertainty, opportunistic behavior, and resource conflicts, thereby lowering transaction costs in supply chain partnerships.

However, TCE's explanatory power regarding procedural and distributive justice in dyadic supply chain relationships faces limitations when applied to complex hub-and-spoke supply chain networks. In these networks, hub-firms maintain significant influence through centralized control and resource concentration (Liu, Aroean, and Ko 2022; Williamson and De Meyer 2012). This influence shapes how procedural and distributive justice functions, affecting suppliers' perceptions of justice's role in mitigating transaction costs and encouraging participation in joint NPD projects with supply chain network members. This study extends TCE to enhance its explanatory capacity regarding justice types in facilitating NPD collaborative behavior. The extension requires evaluating how hub-firms' centralized control affects procedural justice's capacity to reduce specific transaction costs while potentially increasing others. In addition, the study examines how hub-firms' resource concentration influences distributive justice's role in transaction cost mitigation and potential exacerbation.

Furthermore, these dynamics within hub-and-spoke supply chain networks highlight the need to consider formal contracts as a moderating factor. TCE scholars emphasize the role of formal contracts in mitigating transaction costs and promoting supply chain partners' collaborative behavior (Cao and Lumineau 2015; Poppo and Zenger 2002). Previous studies also suggest that formal contracts facilitate the development of procedural and distributive justice (Poppo and Zhou 2014; Song et al. 2018). However, research lacks an examination of how formal contracts moderate these justice dimensions' influence on supply chain -based NPD collaboration. Formal contracts hold particular significance in hub-and-spoke supply chain networks where hub-firms possess stronger bargaining power (Williamson and De Meyer 2012). Integrating TCE principles with justice concepts and the role of formal contracts provides a robust framework for understanding supply chain collaboration in NPD projects. Figure 1 presents this study's conceptual framework, with the related arguments discussed in the following sections.

2.3 | The Influence of Procedural and Distributive Justice on NPD Collaboration

Recent research has demonstrated the complex relationship between procedural justice perceptions and NPD collaboration in hub-and-spoke supply chain networks, challenging traditional

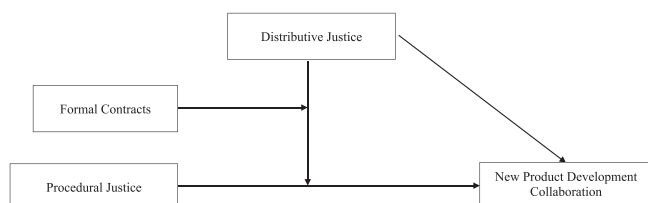


FIGURE 1 | Conceptual framework. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

understanding. TCE suggests that suppliers base supply chain collaboration decisions for joint NPD projects on transaction costs related to managing partners' self-interest and opportunistic behavior (Cao and Zhang 2010). Procedural justice serves as a crucial factor, reflecting suppliers' fairness perceptions in supply chain decision-making processes and influencing transaction cost calculations regarding partners' potential opportunistic behavior (Che, Jiang, and Pei 2024; Poppo and Zhou 2014). In dyadic supply chain relationships, direct partner interactions shape procedural justice perceptions (Griffith, Harvey, and Lusch 2006; Narasimhan, Narayanan, and Srinivasan 2013). When suppliers perceive decision-making processes as fair, adaptation becomes simpler, and monitoring requirements decrease in joint NPD projects, suggesting perceived procedural justice's positive association with supplier NPD collaboration engagement.

In hub-and-spoke supply chain networks, hub-firms' centralized control significantly shapes the nature and implementation of procedural justice (Liu, Aroean, and Ko 2019). This centralization leads to standardized procedures across the supply chain network (Fang et al. 2016). Standardized decision-making processes strengthen suppliers' procedural justice perceptions by fostering beliefs about fair network-wide treatment. As perceived procedural justice increases, suppliers' monitoring costs initially decrease, thus encouraging NPD collaboration with network members. Clear and fair decision-making processes reduce uncertainty and vigilance requirements, enhancing collaboration appeal (Williamson and De Meyer 2012). However, beyond a threshold, high procedural justice levels increase adaptation costs. Hub-firms' detailed procedural requirements may demand significant supplier investments in internal process alignment (Liu, Aroean, and Ko 2022), potentially offsetting reduced monitoring costs.

The relationship between perceived procedural justice and adaptation costs follows a nonlinear pattern. Low-to-medium procedural justice perceptions maintain manageable adaptation costs. However, beyond a threshold, adaptation costs escalate rapidly as suppliers exhaust simple adjustments and require substantial changes to meet stringent requirements (Serdarasan 2013). This creates an inverted U-shaped relationship between perceived procedural justice and NPD collaboration. Initially, reduced monitoring cost benefits dominate, but excessive procedural justice leads to escalating adaptation costs that outweigh benefits, potentially deterring supplier collaboration in hub-and-spoke supply chain network NPD projects. This pattern emerges from the interplay of two countervailing forces, as suggested by Haans, Pieters, and He (2015). Rising procedural justice perceptions steadily reduce monitoring costs, encouraging NPD collaboration. However, adaptation costs increase slowly at first before escalating rapidly beyond an optimal threshold, ultimately exceeding the benefits of monitoring cost reduction. Thus,

Hypothesis 1. *The effect of procedural justice on NPD collaboration has an inverted U-shape in a hub-and-spoke supply chain network.*

In dyadic supply chain relationships, perceptions of distributive justice also arise from direct partner interactions (Griffith,

Harvey, and Lusch 2006; Narasimhan, Narayanan, and Srinivasan 2013). Perceived fair outcomes reduce safeguarding needs and transaction costs, making NPD collaboration more attractive. However, in hub-and-spoke supply chain networks, hub-firms orchestrate supplier collaboration in NPD projects (Dhanaraj and Parkhe 2006), using concentrated resources to deploy sophisticated network monitoring systems (Fang et al. 2016). This creates information asymmetry between hub-firms and suppliers, limiting suppliers' visibility into others' contributions (Mascarenhas, Kesavan, and Bernacchi 2008). Rising distributive justice perceptions increase suppliers' input-reward balance awareness, intensifying competitiveness. Limited visibility into others' contributions complicates "fair" distribution determination, particularly regarding monetary and non-monetary rewards (Luo 2007). This compels initial supplier investment in information gathering, increasing transaction costs.

However, the sophisticated monitoring systems implemented by hub-firms enhance suppliers' trust by providing transparency and reliability in tracking performance metrics across the network (Dhanaraj and Parkhe 2006). Such trust cultivates distributive justice perceptions. Suppliers link accurate monitoring with fair reward distribution, creating a paradoxical effect. The growing confidence in fair outcome distributions diminishes the perceived need for safeguarding measures. At a specific threshold, positive network effects become evident (Davis 2016). The growing trust in the system makes it advantageous for all suppliers to rely on hub-firms' reward distribution decisions. This reliance leads to decreased safeguarding efforts and associated costs, which encourages collaborative NPD projects. Furthermore, as suppliers reduce safeguarding efforts, they can redirect resources to other activities, such as innovation. The combination of reduced transaction costs and increased innovation potential significantly enhances the benefits associated with higher levels of distributive justice, encouraging suppliers to participate in joint NPD projects within hub-and-spoke supply chain networks. This pattern aligns with Haans, Pieters, and He (2015) framework of countervailing forces, producing a U-shaped relationship between distributive justice and NPD collaboration. Initial increases in distributive justice raise information costs due to the complexity of fair distribution. Beyond a certain threshold, the benefits of increased trust, reduced safeguarding costs, and innovation potential outweigh these initial challenges, driving a resurgence in NPD collaboration. Thus,

Hypothesis 2. *The effect of distributive justice on NPD collaboration has a U-shape in a hub-and-spoke supply chain network.*

Research has demonstrated that procedural and distributive justice perceptions create complementary effects in fostering collaborative behavior within dyadic inter-organizational relationships (Brown, Cobb, and Lusch 2006; Luo 2007). These types of inter-organizational justice reduce uncertainty, perceived opportunism risks, and resource allocation conflicts, thereby lowering transaction costs. However, they can function as substitutes within hub-and-spoke supply chain networks. High distributive justice levels diminish procedural justice's impact on supplier participation in collaborative NPD projects. Both justice types impose transaction costs on suppliers, yet suppliers favor

costs associated with distributive justice over procedural justice due to hub-and-spoke supply chain dynamics.

More specifically, hub-firms' superior decision-making authority in hub-and-spoke supply chain networks (Liu, Aroean, and Ko 2022; Williamson and De Meyer 2012) shapes supplier perceptions and behavior significantly. This authority causes suppliers to evaluate transaction costs differently across justice types, particularly in joint NPD projects. Transaction costs linked to procedural justice, such as comprehending complex decision-making processes (Che, Jiang, and Pei 2024), yield less predictable returns due to suppliers' limited network power. This unpredictability affects smaller, resource-constrained suppliers most significantly. The costs of managing procedural justice in supply chain collaboration are particularly high in hub-firm-administered joint NPD projects, where suppliers must navigate complex and uncertain decision-making processes. This dynamic makes it particularly challenging for smaller suppliers to participate effectively in the decision-making process. Conversely, transaction costs related to distributive justice, such as negotiating fair prices, are more directly tied to tangible outcomes (Poppo and Zhou 2014). Suppliers can more easily justify these costs because they directly impact their bottom line. When suppliers perceive rewards as fairly allocated, they feel more secure in their relationship with the hub-firm, which validates the costs of maintaining distributive justice.

This preference for distributive justice aligns with typical supplier performance evaluations, which emphasize outcomes such as cost, quality, and delivery time (Malagueño, Gölgeci, and Fearné 2019; Matopoulos et al. 2007). This alignment drives suppliers to prioritize distributive justice-related transaction costs. High distributive justice levels lead suppliers to de-emphasize aspects of procedural justice. Fair outcome distribution benefits outweigh the perceived value of engaging with hub-firm decision-making processes (Poppo and Zhou 2014). Consequently, high distributive justice weakens procedural justice's impact on NPD collaboration willingness. Suppliers prioritize fair outcomes over understanding decision-making processes, favoring distributive over procedural justice. This substitution departs from traditional dyadic relationships, where these justice types complement each other. Thus,

Hypothesis 3. *Distributive justice reduces the effects of procedural justice on NPD collaboration in a hub-and-spoke supply chain network.*

2.4 | Moderating Role of Formal Contracts

TCE establishes formal contracts as fundamental to inter-organizational relationships. These legally binding agreements outline exchange terms and conditions, mitigating uncertainty and opportunistic behavior (Poppo and Zenger 2002; Williamson 2008). By defining the rights and obligations of parties, formal contracts help establish stable partnerships, set expectations, and curb potential opportunism (Cao and Zhang 2010). This formalization proves crucial in non-equity-based supply chain relationships (Brown, Cobb, and Lusch 2006; Poppo and Zhou 2014). In hub-and-spoke supply chain networks, formal contracts balance power dynamics by providing

suppliers with legally binding assurances, reducing vulnerability to exploitation by hub-firms (Liu, Aroean, and Ko 2022).

Drawing on TCE, formal contracts within hub-and-spoke supply chain networks strengthen distributive justice by substituting procedural justice's role in NPD collaboration through three mechanisms. First, explicit outcome specifications in formal contracts provide benchmarks for equitable resource allocation (Li, Poppo, and Zhou 2010). Second, risk allocation clauses distribute gains and losses between parties, reinforcing distributive justice (Cao and Lumineau 2015; Poppo and Zhou 2014). Third, enforcement mechanisms and dispute resolution provisions ensure recourse if outcomes fail, enhancing the reliability of distributive justice. By reducing uncertainty with clear specifications and risk allocation (Poppo and Zenger 2002), formal contracts lower the need for supplier involvement in procedural decision-making and focus attention on measurable outcomes, prioritizing distributive over procedural justice. Additionally, formal contracts also enhance resource allocation efficiency (Williamson and De Meyer 2012). Clear contractual terms allow suppliers to focus resources on meeting specified outcomes rather than engaging in time-intensive procedural processes. This efficiency gain is particularly significant in NPD collaboration, where streamlined processes can accelerate collaborative cycles. Thus,

Hypothesis 4. *Formal contracts further enhance the moderating effect of distributive justice in reducing the effects of procedural justice on NPD collaboration in a hub-and-spoke supply chain network.*

3 | Research Method

3.1 | Empirical Setting

This study examined collaborative NPD within a Chinese manufacturing hub-and-spoke supply chain network, employing dyadic, time-lagged survey data from a hub-firm and 183 suppliers, complemented by 22 executive interviews. This mixed-methods approach (Creswell and Creswell 2017) integrates quantitative surveys with qualitative interviews to examine hub-firm-administered supply chain collaboration for joint innovation projects, where supplier selection rests on expertise for joint product development (Ding, Ye, and Wu 2019). China, known as the “world’s factory,” generates 28.7% of global manufacturing output (Richter 2021). As Chinese manufacturers transition from producing for foreign brands to designing their own products, many large firms coordinate with multiple suppliers in collaborative NPD (Ding, Ye, and Wu 2019). This transformation in Chinese manufacturing practices creates an ideal setting for studying supplier engagement in NPD collaboration within hub-and-spoke supply chain networks.

3.2 | Quantitative Survey

The research context employs a hub-and-spoke supply chain network that aligns with the study objectives and enhances the generalizability of the findings. This network encompasses a large outdoor product design and manufacturing company (hub-firm) with 800 active suppliers and annual sales exceeding

\$500 million, providing an ideal setting for examining inter-organizational justice, formal contracts, and NPD collaboration dynamics. The supply chain management literature supports the use of single network analysis for deriving generalizable conclusions about network structures (e.g., Duffy et al. 2013; Luo et al. 2011). This approach enables a focused analysis of power relationships and provides deeper insights into collaboration behavior within hub-and-spoke supply chain structures (Liu, Aroean, and Ko 2022). By concentrating on a single network, the study achieves tighter control over external factors, producing more reliable insights into NPD partnerships within hub-and-spoke supply chain structures and revealing nuanced patterns that multi-network studies might overlook.

The study employed five-point Likert scales across two dyadic surveys (see Appendix 1). The “hub-firm survey” measured NPD collaboration using scales developed by Peng, Heim, and Mallick (2014) to assess supplier involvement in joint NPD projects. The “supplier survey” captured inter-organizational justice using items from Narasimhan, Narayanan, and Srinivasan (2013) and Griffith, Harvey, and Lusch (2006), examining fairness in governance decisions and reward distribution. Formal contracts were assessed by adapting items from Li, Poppo, and Zhou (2010) to evaluate supply chain relationship arrangements. To control for the influence of supplier resources on NPD collaboration (Büyükköçkan and Arsenyan 2012), the study included firm size (number of employees) and firm age (years since establishment) (Li, Poppo, and Zhou 2010). It also accounted for relationship length (years of relationship with the hub-firm) because extended partnerships may lead to over-dependence (Narasimhan et al. 2009). Log transformations of firm size, age, and relationship length were applied to ensure robustness. Additionally, the analysis controlled for market turbulence and competitive intensity—factors that create uncertainty and hinder joint NPD efforts (Büyükköçkan and Arsenyan 2012)—using measures adapted from Liu, Aroean, and Ko (2022). The study also incorporated product development human capital, which influences collaborative NPD ability (Büyükköçkan and Arsenyan 2012), with a modified metric based on Zhang and Wu (2017). All these control variables were included in the “supplier survey.”

The survey development involved English-to-Mandarin translation, with hub-firm managers ensuring accurate sector-specific terminology. Pilot testing by hub-firm and supplier representatives verified translation clarity. The hub-firm distributed surveys to 220 NPD-active suppliers, achieving 183 responses (83.1% response rate). The methodology implements a dyadic, time-lagged design with a three-month interval between supplier and hub-firm surveys. This approach reduces common method bias through separate perspectives and enables causal inference examination (Hair et al. 2010; Williams, Hartman, and Cavazotte 2010). One author administered and matched the survey responses to maintain confidentiality. Early and late respondent comparisons revealed no significant differences in firm characteristics, indicating minimal nonresponse bias risk.

3.3 | Qualitative Interviews

Qualitative interviews supplemented survey findings on justice perceptions and NPD collaboration in hub-and-spoke supply

chain networks. The interviews explored transaction costs from procedural and distributive justice considerations, their effects on NPD collaboration decisions, and formal contracts' moderating role. Through purposive snowballing, the research engaged three supplier executives outside the surveyed network and expanded to 22 executives via professional networks. This approach enabled access to hard-to-reach populations while mitigating single-network bias (Miles and Huberman 1999). The broader scope facilitated theoretical saturation through diverse perspectives and enhanced external validity through cross-network triangulation (Creswell and Creswell 2017). Semi-structured interviews of 60–90 min used a protocol with four core questions and follow-ups (see Appendix 2), ensuring consistency in data collection and analysis. Prior to interviews, participants received briefings on firm background and key academic concepts. The interviews examined justice perceptions in hub-firm relationships and formal contracts' influence on supplier NPD engagement.

The analysis followed the six-phase framework of Braun and Clarke (2006). In Phase 1, data familiarization occurred through immersion in 22 executive interview transcripts and documentation of supply chain collaboration cost dynamics. Phase 2 implemented a two-stage coding approach where one author developed systematic coding templates across the dataset, while another validated these independently. The coding captured elements revealing how procedural and distributive justice shaped supplier and hub-firm relationships, including transaction costs. Detailed records documented suppliers' responses to perceived fairness and formal contracts in relationship management. For example, the code “trust-enhanced safeguarding reduction” applied to statements like “our reliance on trust has significantly reduced the need for extensive safeguarding measures, allowing us to allocate resources more efficiently” (Supply Chain Manager #4).

In Phase 3, both authors independently reviewed and agreed upon emerging themes from validated codes. This process revealed patterns in supplier–hub-firm relationship evolution under varying justice perceptions and formal contracts, focusing on transaction cost implications. Related codes grouped under broader themes, such as “trust-enhanced safeguarding reduction” and “efficiency-driven resource optimisation” consolidated under “accelerated reduction in safeguarding costs due to increasing trust.” Phase 4 encompassed a comprehensive theme review comparing themes against coded extracts and the dataset, confirming themes such as “streamlined governance costs through distributive justice prioritisation” and “reduced coordination costs through contractual specification.” Phase 5 refined theme definitions and selected illustrative examples, examining transaction cost emergence within these relationships until theoretical saturation was reached.

Phase 6 presented findings revealing how inter-organizational justice influences transaction cost configuration in hub-and-spoke supply chain networks. The identification of specific transaction costs through interviews supplements quantitative findings by revealing the mechanisms through which procedural and distributive justice determine cost allocation. The analysis identified patterns in suppliers' fairness perceptions shaping transaction cost investment and management.

The interviews illuminated nuanced aspects of the justice–transaction cost relationship, including how perceived fairness levels led suppliers to reconfigure transaction cost structures. Furthermore, the data clarified how justice-influenced transaction cost allocations shape NPD collaboration decisions within supply chains. This mixed-methods approach strengthens both the theoretical rigor and practical relevance of the findings (Creswell and Creswell 2017; Miles and Huberman 1999).

4 | Analysis and Results

4.1 | Validity and Reliability

The validity and reliability of the quantitative data were established through the following steps. First, a confirmatory factor analysis was performed. The model, consisting of four hypothesized factors, exhibited an adequate fit (chi-square $[X^2]=97.110$, degree of freedom $[df]=57$, p value <0.001 , comparative fit index $[CFI]=0.982$, normed fit index $[NFI]=0.958$, Tucker–Lewis index $[TLI]=0.975$, root-mean-square error of approximation $[RMSEA]=0.062$). A significant chi-square result could indicate misspecifications, but further examination revealed no major issues. Only 2 of the 91 standardized residuals exceeded 2.58, and only 1 modification index exceeded 10, indicating an adequate fit.

The second step involved assessing the average variance extracted (AVE), composite reliability (CR), and variance inflation factor (VIF). The AVE exceeded 0.5, and the square roots of AVE were greater than the inter-construct correlations, thus demonstrating validity (Table 1). The CR exceeded 0.7, indicating reliability (Table 1). Procedural and distributive justice were highly correlated ($r=0.573$), as expected (Narasimhan, Narayanan, and Srinivasan 2013; Poppo and Zhou 2014). They still achieved a VIF of 1.226, below 10, which indicates no evidence of multicollinearity (Hair et al. 2010). A third step assessed “common method variance” (CMV). Respondent confidentiality was ensured to reduce CMV. Harman's single-factor analysis showed no single factor explained most variance. The CFA marker technique, using “adaptability” (De Clercq, Thongpapanl, and Dimov 2014), showed non-significant results between the models (CFA Baseline, Method-C, Method-U, and Method-R), indicating an absence of CMV bias (Williams, Hartman, and Cavazotte 2010). Thus, there was no evidence of a significant CMV risk.

The qualitative data validation employed a rigorous, multi-step process. Two authors independently coded interview findings following the thematic analysis approach of Braun and Clarke (2006). The authors discussed coding discrepancies until they reached agreement. This collaborative coding enhanced internal consistency and reduced single-coder bias. The analysis calculated Cohen's κ to assess interrater reliability (MacPhail et al. 2016). The κ value of 0.8948 demonstrated almost perfect agreement between coders, indicating reliable coding decisions. Furthermore, the validation process included member-checking with five interviewees, representing 27% of the interview sample. External validation ensured that analytical interpretations accurately reflected participants' experiences. Consensus

TABLE 1 | Descriptive statistics.

	1	2	3	4	5	6	7	8	9	10
1. Firm size	—									
2. Firm age	0.394*	—								
3. Relationship length	0.185*	0.395*	—							
4. Competitive intensity	0.002	−0.061	0.133	—						
5. Market turbulence	0.062	−0.071	0.171*	0.551*	—					
6. Product development human capital	0.048	0.012	0.067	0.218*	0.380*	—				
7. Procedural justice	0.077	−0.048	0.169*	0.341*	0.424*	0.590*	0.870			
8. Distributive justice	0.037	−0.066	0.085	0.411*	0.510*	0.584*	0.573*	0.915		
9. Formal contracts	−0.010	−0.057	0.101	0.264*	0.522*	0.465*	0.398*	0.458*	0.956	
10. New product development collaboration	−0.050	0.031	−0.163*	−0.189*	−0.164*	0.136	−0.073	0.071	−0.040	0.849
Mean	1.942	1.132	0.829	4.250	4.108	4.555	3.713	4.299	4.638	4.548
Standard deviation	0.507	0.335	0.361	0.838	0.928	0.669	0.829	1.082	0.528	0.695
Composite reliability	—	—	—	—	—	—	0.846	0.939	0.969	0.910
Average variance extracted	—	—	—	—	—	—	0.651	0.837	0.914	0.721

Note: $N = 183$. Average variance extracted (AVE) square roots are shown in bold on the correlation matrix diagonal;

* $p < 0.05$.

discussions resolved disagreements. A robust foundation for data analysis reliability was established with independent coding, collaboration, external validation, and consensus-building. Thus, qualitative insights accurately reflect interviewees' perspectives.

4.2 | Analysis and Results

Prior to the regression analysis, the variables of procedural justice, distributive justice, and formal contracts were mean-centered to create quadratic and interaction terms (Hair et al. 2010). Table 2 presents the regression results across the four models. Model 1 includes the control variables, procedural justice, distributive justice, and their quadratic terms. Model 2 incorporates the control variables, procedural justice, distributive justice, and their interaction terms. Model 3 builds on Model 2 by adding formal contracts, their interaction terms with procedural justice and distributive justice, and a three-way interaction among procedural justice, distributive justice, and formal contracts. Model 4 represents the full model.

4.2.1 | Inverted U-Shaped Impact of Procedural Justice on NPD Collaboration

Hypothesis 1 proposes an inverted U-shaped effect of procedural justice on NPD collaboration in hub-and-spoke supply chain networks. Following Haans, Pieters, and He (2015) guidelines,

Model 1 demonstrates that procedural justice ($\beta = -0.728$, $p < 0.001$; 95% CI: $-1.541, -0.746$) and its quadratic term ($\beta = -0.585$, $p < 0.001$; 95% CI: $-1.088, -0.501$) negatively relate to NPD collaboration, with a substantial effect size (Cohen's $f^2 = 0.208$). This satisfies the first condition of significant coefficients with the expected signs. The analysis confirmed steep curve slopes at both data range ends, with significant slopes at the low-end point ($t = 3.493$, $p = 0.001$) and high-end point ($t = -4.010$, $p < 0.001$), satisfying the second condition. The turning point calculation yielded -0.622 , falling within the Fieller method's 95% interval of -1.130 to -0.114 , meeting the third condition. These results support Hypothesis 1, with Figure 2a illustrating this inverted U-shaped relationship.

The relationship between procedural justice and NPD collaboration emerges through monitoring efficiency and adaptation demands in hub-and-spoke supply chain networks. The qualitative analysis revealed three distinct themes, with supporting quotes in Table 3. The first theme demonstrates how standardized protocols minimize monitoring costs, as Firm #6's CEO explained:

“When we work on joint NPD projects, we follow the guidelines from HUB-FIRM,⁴ it leads our collaboration. We make decisions in an open way, which builds trust. Instead of wasting time and energy trying to track everyone's movements, it simplifies things significantly, allowing us to concentrate on what really matters.”

TABLE 2 | Results.

	Model 1				Model 2				Model 3				Model 4			
	Coeff	t	p	CI (95%)	Coeff	t	p	CI (95%)	Coeff	t	p	CI (95%)	Coeff	t	p	CI (95%)
Controls																
Firm size	-0.069	-0.967	0.335	[-0.341; 0.117]	-0.024	-0.337	0.737	[-0.274; 0.194]	-0.040	-0.556	0.579	[-0.298; 0.167]	-0.072	-1.029	0.305	[-0.345; 0.109]
Firm age	0.123	1.615	0.108	[-0.068; 0.677]	0.113	1.438	0.152	[-0.104; 0.664]	0.098	1.261	0.209	[-0.137; 0.622]	0.110	1.467	0.144	[-0.094; 0.636]
Relationship length	-0.150	-2.076	0.039	[-0.672; -0.017]	-0.131 [†]	-1.764	0.079	[-0.640; 0.036]	-0.154*	-2.086	0.038	[-0.689; -0.019]	-0.160*	-2.223	0.028	[-0.696; -0.041]
Competitive intensity	-0.099	-1.255	0.211	[-0.253; 0.056]	-0.106	-1.297	0.196	[-0.264; 0.055]	-0.079	-0.960	0.338	[-0.239; 0.083]	-0.069	-0.852	0.395	[-0.225; 0.090]
Market turbulence	-0.170	-2.007	0.046	[-0.302; -0.003]	-0.137	-1.565	0.119	[-0.276; 0.032]	-0.124	-1.335	0.184	[-0.275; 0.053]	-0.146	-1.624	0.106	[-0.288; 0.028]
Product development human capital	0.129	1.451	0.148	[-0.058; 0.377]	0.192*	2.147	0.033	[0.019; 0.456]	0.184*	2.010	0.046	[0.004; 0.452]	0.121	1.349	0.179	[-0.070; 0.370]
Main effects																
Procedural justice	-0.728***	-5.679	<0.001	[-1.541; -0.746]	-0.586***	-4.791	<0.001	[-1.300; -0.541]	-0.700***	-5.387	<0.001	[-1.501; -0.696]	-0.876***	-6.583	<0.001	[-1.788; -0.963]
Procedural justice ^a	-0.585***	-5.346	<0.001	[-1.088; -0.501]									-0.419*	-2.111	0.036	[-1.103; -0.037]
Distributive justice	0.641***	4.563	<0.001	[0.413; 1.043]	0.257**	2.753	0.007	[0.083; 0.502]	0.366***	3.484	<0.001	[0.180; 0.651]	0.723***	4.988	<0.001	[0.496; 1.146]
Distributive justice ²	0.481***	4.433	<0.001	[0.197; 0.513]									0.403***	3.664	<0.001	[0.138; 0.459]
Formal contracts					0.083***	0.925	0.356	[-0.072; 0.198]					0.040	0.462	0.645	[-0.0.101; 0.162]
Interactions																
Procedural justice × distributive justice					-0.511***	-5.059	<0.001	[-1.084; -0.476]	-0.824***	-4.738	<0.001	[-1.782; -0.734]	-0.588**	-3.292	0.001	[-1.436; -0.359]
Procedural justice × formal contracts									-0.278*	-2.155	0.033	[-0.724; -0.032]	-0.200	-1.505	0.134	[-0.627; 0.085]

(Continues)

TABLE 2 | (Continued)

	Model 1			Model 2			Model 3			Model 4		
	Coeff	t	p	CI (95%)	Coeff	t	p	CI (95%)	Coeff	t	p	CI (95%)
Distributive justice × formal contracts					0.172 [†]	1.906	0.058	[-0.005; 0.299]	0.180*	2.051	0.042	[0.006; 0.303]
Procedural justice × distributive justice × formal contracts					-0.514**	-2.850	0.005	[-0.865; -0.157]	-0.484*	-2.577	0.011	[-0.850; -0.113]
Model summary												
F-value		7.464***				6.465***				5.292***		6.081***
p value		<0.001				<0.001				<0.001		<0.001
R-square		0.303				0.252				0.289		0.353
Adjusted R-square		0.262				0.213				0.235		0.295

Note: N= 183. Dependent variable = new product development collaboration. t = t value; p = p value; confidence intervals (CI) report as [lower bound; upper bound].

*Cohen's f^2 is an effect size measure used in the context of multiple regression to assess the impact of an independent variable on the dependent variable. It is particularly useful for evaluating the practical significance of predictors beyond statistical significance.

***p < 0.001;

**p < 0.010;

*p < 0.050;

†p > 0.100.

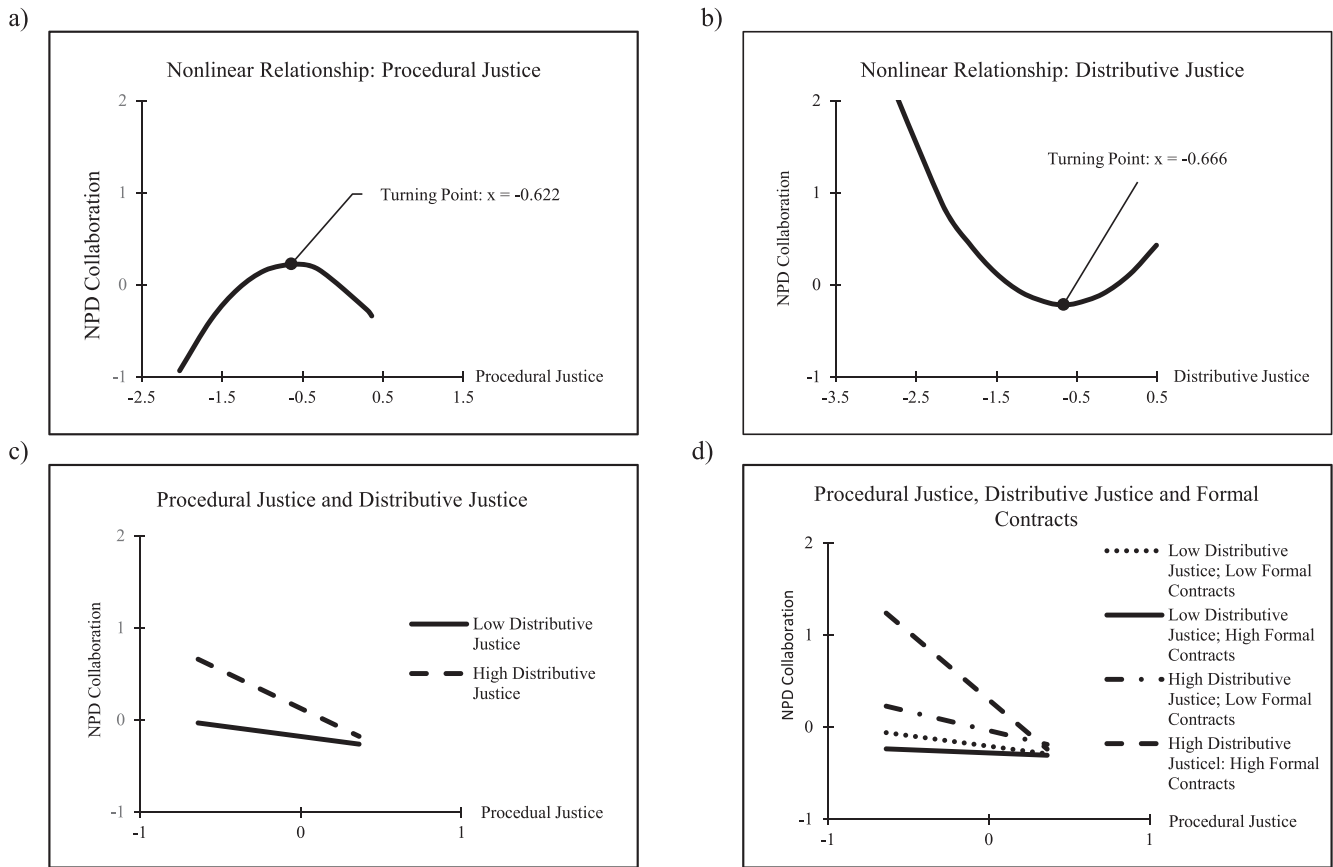


FIGURE 2 | Graphical representation. (a and b) On the x axis, units are based on mean-centered data ranges: Procedural justice ranged from -2.03 to 0.36 ; distributive justice ranged from -3.51 to 0.49 . (c and d) To maintain consistency, the moderating effect was calculated using the 16th and 84th percentiles of the data points rather than the usual ± 1 standard deviation (Hayes 2022). [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/jscm.12340)]

This observation aligns with TCE principles, where initial procedural justice reduces transaction costs by minimizing monitoring efforts (Che, Jiang, and Pei 2024). Hub-firms' standardized procedures facilitate NPD collaboration leadership (Williamson and De Meyer 2012), enhancing operational efficiency.

However, as procedural justice requirements become more stringent, a tipping point emerges. The second theme reveals that while initial standardization facilitates collaboration by reducing monitoring efforts, incremental rises in adaptation costs remain manageable through structured procedures. Firm #11's CEO described this balance:

“It was quite manageable to adapt to HUB-FIRM's requirements [the standardised procedure] when they were less rigorous. Consistency across projects was present, but not overwhelming. In the joint [NPD] project, we were able to adjust our processes incrementally without significant effort, while gradually aligning with our partners' expectations.”

As procedural justice requirements intensify further, the third theme emerges, where complex procedures trigger escalating

adaptation costs. A supply chain manager from Firm #17 described this challenge:

“We sometimes find it difficult to accommodate the procedures from HUB-FIRM when participating in complex joint [NPD] projects. Each additional procedural requirement appears to increase our costs exponentially. The rapid increase in compliance costs is straining our operations and bottom line, even though I agree that having a complex procedure covering all steps in our collaboration feels fair and appreciate the drive for consistency and quality. I do not feel comfortable about becoming involved in such a project because of this.”

This progression illustrates how excessive procedural requirements create operational and financial challenges (Serdarasan 2013). While hub-firms' centralized control initially promotes efficiency through standardization, it eventually leads to adaptation challenges as suppliers attempt to meet complex requirements. These dynamics explain the inverted U-shaped relationship between procedural justice and NPD collaboration, where initial monitoring cost benefits become outweighed by rising adaptation costs.

TABLE 3 | Qualitative findings.

Context	Theme	Additional notes
<p>Inverted u-shaped impact of procedural justice on NPD collaboration</p>	<p>Reduced monitoring costs through standardized protocols.</p>	<ul style="list-style-type: none"> • “With HUB-FIRM’s clear processes, the new product development project proceeded smoothly. By assigning specific roles and timelines, it reduced confusion and the need for constant monitoring. This approach fostered trust and enabled us to concentrate on innovation and delivery.” (CEO, Firm #20). • “With HUB-FIRM’s established protocols, seamless coordination was assured in a recent new [joint NPD] project. With their controlled approach, redundancies, such as overlapping design reviews, were eliminated, giving us more resources for critical work.” (Supply Chain Manager, Firm #4).
<p>Incremental rises in adaptation costs stay manageable through structured procedures.</p>	<p>Incremental rises in adaptation costs stay manageable through structured procedures.</p>	<ul style="list-style-type: none"> • “We modified our internal procedures to meet the needs of HUB-FIRM while developing a new product. Standardising our reporting style, for example, made it possible to share data without interfering with our daily business. We were able to successfully balance the new processes with our continuing activity since the demands were substantial but reasonable.” (CEO, Firm #11). • “The standardisation of design review phases in a recent joint project reduced the need for stringent control and facilitated easier collaboration. Despite the increasing complexity of the procedural requirements [established by the hub-firm], consistency was still manageable. As a result, we could align our processes without disrupting day-to-day operations or overburdening our workforce.” (CEO, Firm #6)
<p>Complex procedures trigger escalating adaptation costs.</p>	<p>Complex procedures trigger escalating adaptation costs.</p>	<ul style="list-style-type: none"> • “We had to work through multiple rounds of product testing to meet HUB-FIRM’s increasingly demanding procedural requirements in one of our recent joint NPD projects. While this ensures high standards, it consumes a lot of resources.” (Operations Manager, Firm #9).
<p>U-shaped impact of distributive justice on NPD collaboration</p>	<p>Rising information costs in seeking fair value assessment.</p>	<ul style="list-style-type: none"> • “Our latest NPD collaboration has become increasingly difficult because of HUB-FIRM’s requirements. For example, meeting its documentation and audit standards took a lot of effort. While I appreciate its commitment to quality, compliance costs are rising.” (CEO, Firm #21). • “It has gotten harder because of the procedures that HUB-FIRM enforced in a recent NPD campaign. For example, to satisfy their procedural requirements, we had to make a significant investment in specialist equipment. Despite the noble goals of these actions, the cost is preventing us from making a meaningful contribution to the project.” (General Manager, Firm #18). • “When we learned another supplier negotiated better terms for similar innovations, we started investing heavily in market intelligence. As a tier-2 supplier, we accepted the reward structure at first. Due to competitor partnerships, we have had to pull two engineers from R&D, which slows down our [joint NPD] project.” (Operations Manager, Firm #17) • “Understanding other suppliers’ reward arrangements became crucial when we collaborated. Instead of hiring an additional design engineer, we have created a new position for this purpose. This has impacted our ability to meet the hub-firm’s targets for the new product development.” (CEO, Firm #22).
<p>Declining safeguarding costs enable resource reallocation.</p>	<p>Declining safeguarding costs enable resource reallocation.</p>	<ul style="list-style-type: none"> • “Previously, we had an individual assigned to monitor contracts, but now that we have consistent fair treatment from the hub-firm, we can allocate that staff member to developing innovative materials for future projects.” (CEO, Firm #12). • “As soon as we started providing HUB-FIRM with electronic control devices, we devoted several hours to recording every conversation. Since it has shown that it follows fair profit-sharing procedures, we have moved our compliance staff to concentrate on the collaborative project.” (CEO, Firm #6). • “We have changed our focus entirely from focusing on reward allocation to collaborative innovation after seeing consistent fair treatment in reward allocation. We just contributed a lot to HUB-FIRM’s new initiative without hesitation last month.” (CEO, Firm #14).

(Continues)

TABLE 3 | (Continued)

Context	Theme	Additional quotes
Accelerated reduction in safeguarding costs due to increasing trust.		<ul style="list-style-type: none"> • “We used to spend considerable time validating profit-sharing calculations. Now, with established fair profit sharing, we have reallocated more people positions from compliance to R&D. This shift enabled us to co-develop an innovatively invasive surgical tool with the hub-firm, something we could not have achieved while operating in a defensive mode.” (General Manager, Firm #2) • “Previously, we devoted a lot of our project management resources to protecting our interests. Due to the hub-firm’s consistent fair treatment, we were able to reinvest that into collaborative innovation. We contributed to their new project because we trust their reward system.” (CEO, Firm #15).
Substitution effect of procedural and distributive justice on NPD collaboration	Streamlined governance costs through distributive justice prioritization for outcome assurance.	<ul style="list-style-type: none"> • “We were not sure if we were going to be in value assessment meetings as a supplier. After seeing that we contributed to the hub-firm’s initiative accurately, we are comfortable with their internal evaluation process. It is more important to get fair results than to figure out how they got them.” (CEO, Firm #19). • “Despite the fact that we are not part of the hub-firm’s innovation rewards committee, we accept their consistent fair allocation of benefits for our material developments. Despite not understanding their detailed assessment methodology, we got a fair deal on our recent innovation project.” (CEO, Firm #10). • “We used to make sure we were involved in evaluations. We let HUB-FIRM handle the assessment process now, seeing that our revenue share reflects our contribution to the joint project. There is less need for procedural transparency now since benefits are distributed fairly.” (CEO, Firm #7)
Moderating role of formal contracts	Reduced coordination costs through contractual outcome specification.	<ul style="list-style-type: none"> • “We have a contract with HUB-FIRM that includes performance metrics and benchmarks for rewards. We knew exactly what technical achievements would earn what rewards when we developed the new technology, so we did not have to watch their decision-making when we developed the new technology.” (CEO, Firm #16) • “A contract with HUB-FIRM details outcome-based incentives. This clarity allowed us to focus on improving our manufacturing process instead of fighting over reward allocation. The coatings breakthrough happened because we did not have to worry about monitoring.” (Operations Manager, Firm #20)
Decreased governance costs through contractual risk allocation.		<ul style="list-style-type: none"> • “Since our contract specifies clear compensation for development failures, we could fully commit to the hub-firm’s project without worrying about potential losses. Even when initial prototypes failed, we knew exactly how costs would be allocated.” (General Manager, Firm #2). • “A detailed risk allocation mechanism is in our contract. Since the contract clearly outlined how any development setbacks would be shared, we were confident when we collaborated on developing new materials for the hub-firm-led NPD project.” (CEO, Firm #21).
Reduced verification costs through measurable contractual targets.		<ul style="list-style-type: none"> • “Having explicit risk-sharing clauses in our parts contract changed our innovation approach. Due to the clear definition of how R&D risks would be distributed in the contract, we felt comfortable with their technical direction, so we agreed to explore unproven manufacturing techniques for their NPD program.” (Supply Chain Manager, Firm #5). • “Having measurable targets eliminated ambiguity and allowed us to focus purely on technology. We got certified three weeks early because everyone knew exactly what success looked like.” (Operation Manager, Firm #9) • “The hub-firm contract specifies clear metrics for our new system. Having such defined targets transformed our development approach. Rather than attending coordination meetings, our engineers focused exclusively on achieving these parameters, leading to successful validation in the first round.” (CEO, Firm #14).

4.2.2 | U-Shaped Impact of Distributive Justice on NPD Collaboration

Hypothesis 2 proposes a U-shaped effect of distributive justice on NPD collaboration in hub-and-spoke supply chain networks. Following Haans, Pieters, and He (2015) guidelines, Model 1 shows that distributive justice ($\beta=0.641$, $p<0.001$; 95% CI: 0.413, 1.043) and its quadratic term ($\beta=0.481$, $p=0.001$; 95% CI: 0.197, 0.513) positively relate to NPD collaboration, with a notable effect size (Cohen's $f^2=0.133$), satisfying the first condition. The analysis confirmed steep curve slopes at both data range ends, with significant slopes at the low-end point ($t=-6.116$, $p<0.001$) and high-end point ($t=4.861$, $p<0.001$), meeting the second condition. The turning point calculation yielded -0.667 , falling within the Fieller method's (Fieller 1954) 95% interval of -1.186 to -0.148 , satisfying the third condition. These results support Hypothesis 2, with Figure 2b illustrating this U-shaped relationship.

The qualitative analysis reveals three themes explaining the U-shaped relationship between distributive justice and NPD collaboration. The first theme demonstrates rising information costs as suppliers seek fair value assessments. Firm #10's CEO noted:

“We do not expect to receive our fair share of the rewards when we work with HUB-FIRM on NPD but accept that is the way it is. However, we discover all the ways to get our fair share. It makes us wonder, ‘Hmm, can we get a bigger share?’ [...]. We invest more resources in securing it. Our focus on survival distracts us from creating innovative products by collecting evidence about what others have done to protect our interests.”

This illustrates suppliers' changing approach to distributive justice in NPD collaboration, shifting from accepting uneven rewards to active pursuit of fair shares, consequently increasing information-gathering investments at the expense of innovation focus (Melander and Tell 2019).

The second theme reveals that declining safeguarding costs enable resource reallocation. A logistics manager in Firm #2 articulated this evolution:

“At first, we had to constantly check and double-check everything, but now we've an increasing sense of trust in the fair division of our gains. As the world becomes fairer, our need to defend our position lessens. We become less concerned about safeguarding our interests as the world gets fairer. Instead of looking over our shoulder, we are focusing on what we can do.”

This reveals how improved distributive justice cultivates a more trusting environment. Declining safeguarding costs enables suppliers to redirect resources from defensive strategies to productive activities. As trust accumulates, safeguarding costs decrease more rapidly. Suppliers place greater reliance

on hub-firms' reward distribution decisions (Dhanaraj and Parkhe 2006). A supply chain planning manager in Firm #20 described this shift:

“Our way of working with our partners within the network's changed because many of them believe that HUB-FIRM behaves fairly when deciding who should receive what for their efforts. As a result, our resources for safeguarding have been reduced because we rely on the established system rather than constantly questioning it. This trust has allowed us to channel that energy into collaborative projects.”

This highlights how greater trust in the hub-firm's fairness translates into tangible resource reallocation. A client manager from Firm #1 captured this sentiment:

“You can focus on so many things that really matter when you feel like a weight's lifted off your shoulders, when you feel that you are getting what is fair. It was a collaborative effort between the hub-firm and supply chain firm to refine the technology.”

This reveals how fair distribution cultivates trust and enables suppliers to focus resources on productive activities. Collaborative innovation emerges when suppliers experience equitable treatment (Kim, Lee, and Lee 2017).

4.2.3 | Substitution Effect of Procedural and Distributive Justice on NPD Collaboration

Hypothesis 3 suggests that distributive justice moderates procedural justice's effect on NPD collaboration in hub-and-spoke supply chain networks. Model 2 demonstrates a significant negative interaction between procedural and distributive justice ($\beta=-0.511$, $p<0.001$; 95% CI: -1.084 , -0.476), with a substantial effect size (Cohen's $f^2=0.148$). These results support Hypothesis 3, with Figure 2c illustrating this two-way interaction.

The evidence demonstrates how distributive and procedural justice interact within hub-and-spoke supply chain networks. Streamlined governance costs emerge through prioritizing distributive justice for outcome assurance. A supply chain manager from Firm #8 explained the primacy of distributive justice during NPD collaboration:

“Honestly, if we are satisfied with the results [their share of the profits] and feel that the distribution's fair, we do not care so much about how they [the hub-firm] make the decisions. Their decision-making process can remain confidential.”

This underscores a key finding: Suppliers may prioritize fair outcomes (distributive justice) over involvement in decision-making processes (procedural justice) within these networks. From a TCE perspective, suppliers appear to accept the potential transaction

costs of being excluded from decision-making procedures in return for the perceived benefits of fair distributive outcomes. High distributive justice diminishes the perceived importance of procedural justice, suggesting a substitution effect between justice types. This contrasts with their complementary role in dyadic relationships (Brown, Cobb, and Lusch 2006; Luo 2007).

However, this does not entirely negate the value of procedural justice. As evidenced by the contrasting views of other industry professionals, some suppliers still value transparency in decision-making. For example, the CEO of Firm #15 stated:

“Whenever HUB-FIRM is honest about how it makes decisions about our [joint] NPD project, we feel this sense of trust. If we feel like it is not hiding anything from us, we are more relaxed about it getting a larger share of the profits. It puts in so much effort, so I guess it deserves it.”

In general, the preference for distributive justice derives from the power dynamics of hub-and-spoke supply chain networks, where suppliers possess limited decision-making authority (Liu, Aroean, and Ko 2022). Suppliers focus on gaining fair rewards rather than shaping complex decisions.

4.2.4 | Moderating Role of Formal Contracts

Hypothesis 4 proposes that formal contracts strengthen distributive justice's moderating effect on the procedural justice–NPD collaboration relationship in hub-and-spoke supply chain networks. Model 3 reveals a significant negative three-way interaction among procedural justice, distributive justice, and formal contracts ($\beta = -0.514$, $p = 0.005$; 95% CI: -0.865 , -0.157), with a substantial effect size (Cohen's $f^2 = 0.203$). These findings support Hypothesis 4, with Figure 2d illustrating this three-way interaction.

The analysis reveals how formal contracts in hub-spoke supply chain networks enhance the substitution of distributive justice for procedural justice in NPD collaboration. The first theme reveals how formal contracts in hub-spoke supply chain networks enhance distributive justice's substitution of procedural justice in NPD collaboration. Reduced coordination costs emerge through explicit outcome specifications (Li, Poppo, and Zhou 2010), lowering transaction costs (Williamson 2008). A supply chain manager in Firm #12 noted:

“In our joint product development projects, having a clear understanding of what we should deliver and what we will receive allows us to focus more on our goals rather than worrying about how decisions are made. The contract specifications have really simplified our coordination with other suppliers in the supply chain network.”

This highlights how concrete benchmarks for resource allocation align with distributive justice principles and reduce information

asymmetry, which is a key concern in TCE. Specifying outcomes in contracts minimizes the need for costly monitoring, thereby lowering transaction costs. The second theme demonstrates decreased governance costs through contractual risk allocation, addressing TCE's emphasis on risk and uncertainty (Poppo and Zenger 2002). An operations manager in Firm #7 highlighted this aspect:

“When we started the [joint] NPD project, we were initially concerned about potential risks. However, we are comfortable with HUB-FIRM taking the lead when it comes to project decisions because of the risk-sharing clauses in our contract. These contractual arrangements have significantly reduced our concerns about potential development failures.”

Furthermore, the third theme shows reduced verification costs through measurable contractual targets. The presence of formal contracts shifts the focus toward measurable outcomes (Cao and Lumineau 2015). A project manager in Firm #19 observed:

“Our business is ultimately driven by the outcomes stipulated in the contract, so we focus our energy on achieving those outcomes. As a result of the formal contract, we can focus on innovating and meeting our deliverables instead of trying to influence every decision. Our NPD process has become much more efficient.”

These interviewees' insights collectively reinforce how formal contracts strengthen distributive justice's role while reducing suppliers' perceived need for procedural involvement in hub-and-spoke supply chain networks engaged in NPD collaboration.

4.3 | Endogeneity

Prior research has identified formal contracts, relationship length, and environmental dynamism as key influencers of supply chain justice perceptions (Luo 2008; Song et al. 2018). To address potential endogeneity concerns, a two-stage residual inclusion model was employed, following Saboo, Kumar, and Anand (2017). In the first stage, justice variables were regressed on these influencing factors to obtain residuals. In the second stage, Models 1–4 were reanalyzed with these residuals included as controls. The results validated the initial findings and effectively addressed endogeneity concerns.

5 | Discussion and Conclusion

5.1 | Theoretical Implications

This study provides three important contributions to the literature. First, it extends the traditional TCE framework by addressing hub-and-spoke supply chain network dynamics. TCE theory suggests that transaction costs drive firms' collaborative decisions (Cao and Zhang 2010), while procedural and distributive

justice mitigate these costs and encourage collaboration (Huo, Wang, and Tian 2016; Poppo and Zhou 2014). Although scholars have primarily examined this theoretical argument within dyadic supply chain relationships (Che, Jiang, and Pei 2024), hub-and-spoke supply chain networks create a distinct environment where hub-firms exercise centralized control over concentrated resources, significantly influencing suppliers' justice perceptions (Liu, Aroean, and Ko 2022). The findings demonstrate nonlinear patterns in procedural and distributive justice regarding NPD collaboration. Fair procedures are associated with reduced monitoring efforts and lower transaction costs. However, excessive procedural requirements increase adaptation costs beyond an optimal point, potentially impeding NPD collaboration. Distributive justice exhibits a U-shaped effect: Suppliers face high safeguarding costs at low levels due to fairness concerns, while the benefits of reduced conflict outweigh increased information costs at high levels. These nonlinear relationships extend TCE (Che, Jiang, and Pei 2024; Williamson 2008) by illustrating how justice dimensions influence transaction costs within hub-and-spoke supply chain networks and foster effective NPD collaboration.

Second, the study challenges the existing literature on procedural and distributive justice's complementary roles in collaborative behavior (Brown, Cobb, and Lusch 2006; Luo 2007). Prior research suggests that both inter-organizational justice forms reduce overall transaction costs by minimizing uncertainty, opportunism risk, and resource allocation conflicts. However, within hub-and-spoke supply chain networks, procedural and distributive justice function as substitutes. The analysis reveals that suppliers prefer addressing transaction costs associated with distributive rather than procedural justice, reflecting their strategic calculations for managing overall transaction costs. This finding extends TCE (Che, Jiang, and Pei 2024; Williamson 2008) by demonstrating how different inter-organizational justice forms interact within transaction cost minimization. Firms must consider both absolute transaction cost levels and the interactions of justice forms within hub-and-spoke supply chain networks. This understanding provides a sophisticated application of TCE (Poppo and Zhou 2014; Williamson 2008) for explaining inter-organizational justice dimensions' influence on collaborative dynamics in supply chain relationships.

Third, the study reveals formal contracts' nuanced role beyond TCE's traditional view of reducing transaction costs and mitigating opportunism (Williamson 2008). Formal contracts moderate the interplay between dimensions of inter-organizational justice, clarifying how fairness perceptions influence collaboration. This finding extends beyond dyadic relationships to hub-and-spoke supply chain networks, where power asymmetries and resource dependencies create unique challenges (Liu, Aroean, and Ko 2022). Previous research has shown that contracts facilitate perceptions of procedural and distributive justice (Poppo and Zhou 2014; Song et al. 2018). This study expands on these insights by illustrating how contracts amplify the substitution effect of distributive justice on procedural justice in governing NPD collaboration. Contracts align supplier efforts with defined deliverables and results, encouraging outcome-focused collaboration. Beyond reducing transaction costs, contracts strategically manage justice perceptions and collaborative

behavior in supply chain networks. This perspective provides a holistic view of governance within complex structures, consistent with the TCE framework (Cao and Lumineau 2015; Poppo and Zenger 2002).

5.2 | Managerial Implications

This study offers key implications for managers in hub-and-spoke supply chain networks engaged in NPD collaboration. It provides guidance for both hub-firms and suppliers in optimizing collaboration and managing justice perceptions. First, the research identifies an inverted U-shaped relationship between procedural justice and NPD collaboration, where hub-firms' centralized control shapes procedural justice implementation. Low procedural justice involves minimal transparency, medium levels include partial explanations, and high levels ensure full transparency and consistency. While increased procedural justice initially enhances consistency and reduces monitoring costs, excessive levels create adaptation challenges. Hub-firms should implement clear, consistent procedures without bureaucratic burdens. A tiered system of procedural requirements, tailored to project complexity and regularly reviewed, can help maintain optimal procedural justice levels for improved NPD collaboration.

Second, this research identified a U-shaped relationship between distributive justice and NPD collaboration. Initial increases in distributive justice do not yield favorable outcomes until surpassing a critical threshold. Low distributive justice involves minimal profit-sharing or recognition of supplier contributions, while medium levels include partial profit-sharing and risk distribution, often perceived as insufficient. High distributive justice entails transparent, substantial profit-sharing aligned with contributions, fair risk distribution, and strong hub-firm support. Hub-firm managers should aim to exceed this threshold, as it reduces costly monitoring and enhances collaboration appeal. Transparent profit-sharing models tied to project outcomes and performance-based bonuses can help achieve this stage.

Third, the study's findings on the substitution effect between procedural and distributive justice provide critical insights into supplier relationship management. Hub-firm managers should recognize that suppliers may prioritize fair outcomes over involvement in decision-making processes. In situations where enhancing both forms of inter-organizational justice is challenging, focusing on improving distributive justice may yield better results for NPD collaboration. Nonetheless, maintaining a baseline level of procedural justice remains essential to ensure fairness practices.

Fourth, this study emphasizes formal contracts' strategic role in moderating justice perceptions and NPD collaboration within hub-and-spoke supply chain networks. Managers should utilize contracts to shape collaboration and reinforce substitution between procedural and distributive justice. Effective contracts should specify outcomes, allocate risks, and reduce uncertainty. Detailed performance metrics, balanced risk distribution, and flexible adjustment mechanisms enhance distributive justice while compensating for reduced procedural involvement. These

contractual elements create a framework promoting collaboration and innovation in NPD.

5.3 | Societal Implications

This study highlights the societal implications of hub-and-spoke supply chain networks during NPD collaboration. First, it emphasizes the need for these networks to balance procedural and distributive justice to develop responsible business models. Fair processes and efficient operations create equitable power dynamics, benefiting society through improved network cohesion and resource distribution (Cao and Lumineau 2015). Hub-firms that implement effective governance structures enhance both operational efficiency and societal value.

Second, the substitution effect between justice types demonstrates the importance of context-specific approaches to social equity. Supply chain firms can achieve efficient dispute resolution while maintaining fairness by adapting their strategies to specific situations. This adaptability enables networks to address urgent societal challenges through equitable outcomes rather than rigid procedures. Research shows that understanding situational dynamics helps create more effective justice mechanisms for societal benefit (Liu, Aroean, and Ko 2019; Zhou, Govindan, and Xie 2020).

Third, formal contracts address societal implications by reinforcing the substitution effect between procedural and distributive justice. Contracts manage fairness perceptions and promote collaboration, particularly in power-asymmetric networks (Williamson and De Meyer 2012). Embedding distributive justice into contractual terms, such as detailed performance metrics and balanced risk allocation, offsets procedural limitations and fosters equitable conditions for suppliers. This approach builds resilient supply chain relationships that contribute to societal welfare through responsible business practices.

5.4 | Research Limitations and Future Research Opportunities

First, this study examines a Chinese manufacturer's hub-and-spoke supply chain network. While aligning with existing studies (e.g., Duffy et al. 2013; Malagueño, Gölgeci, and Fearne 2019), the single industry and country focus limits generalizability. Future studies should explore multiple industries and countries to account for cultural, economic, and regulatory influences. Second, collection relied on hub-firm manager translations and selective sampling, potentially excluding firms with negative justice perceptions or those who withdrew. Future research should use independent translation verification and include all suppliers, including non-participants, for a more comprehensive perspective.

Third, the quantitative survey did not directly measure specific transaction costs. While qualitative insights from executive interviews reflect these costs, the lack of explicit measures limits testing their effects on justice-collaboration relationships. Future research should develop validated scales to measure transaction costs in hub-and-spoke networks, enhancing

understanding of their role in inter-organizational justice and collaboration. Fourth, the supplementary interviews had methodological limitations. The small sample size (22 interviews) and snowball sampling restricted generalizability and may have introduced bias. Future studies should use larger, more diverse samples with probability sampling to improve reliability and generalizability. Fifth, this study focused on how supply chain firms perceive hub-firm justice implementation. However, other firms' perceptions may also influence focal firms' views of inter-organizational justice (Fang et al. 2016; Liu, Aroean, and Ko 2022). Future research should include additional moderators or controls to capture network-wide influences.

Sixth, the survey design omitted factors affecting NPD collaboration willingness, including buyer-supplier dependency (e.g., Zaefarian et al. 2016), supply chain activity types (e.g., Matopoulos et al. 2007), knowledge sharing (e.g., Zhou, Govindan, and Xie 2020), and other variables. Future research should incorporate these variables to clarify collaboration dynamics in hub-and-spoke supply chain networks. Finally, future research should explore justice dimensions beyond procedural and distributive justice. For instance, studying interactional and informational justice (Duffy et al. 2013; Liu et al. 2012) could offer deeper insights into justice practices in supply chain relationships. Additionally, while this study focused on formal contracts, relational governance mechanisms are particularly important in emerging markets (e.g., Li, Poppo, and Zhou 2010; Luo et al. 2011). Future research should investigate the role of these mechanisms in shaping supply chain relationships.

5.5 | Concluding Remarks

This research advances understanding of inter-organizational justice and collaboration in hub-and-spoke supply chain networks during NPD. TCE extension reveals nonlinear relationships between procedural justice, distributive justice, and collaboration, showing substitutive characteristics. Formal contracts moderate these dynamics, contributing to theory and practice. As hub-and-spoke supply chain structures gain prominence through resource pooling and market opportunities, these findings prove timely. Future research should examine how technologies and market dynamics influence justice perceptions and collaborative behavior. This study enhances governance and innovation management knowledge in complex supply chain networks.

Endnotes

¹Just actions (rule adherence) generate fairness perceptions that influence justice interpretations (moral evaluations) in business practice. This study adopts an interchangeable approach to these terms, despite their distinctions in certain disciplines (e.g., Goldman and Cropanzano 2015). This integrated perspective aligns with established research on inter-organizational relationships and supply chain management (Mir et al. 2022; Narasimhan, Narayanan, and Srinivasan 2013).

²This study focuses on procedural and distributive justice within the dimensions of inter-organizational justice due to their close alignment with formal contracts in supply chain networks (Griffith, Harvey, and Lusch 2006). TCE theory supports this emphasis through their direct

connection to transaction costs and contractual governance (Poppo and Zhou 2014). In contrast, interactional and informational justice show limited relevance, as they pertain to individual-level interactions more closely aligned with social exchange theory (Cropanzano, Prehar, and Chen 2002; Liu et al. 2012; Luo 2007).

³We appreciate the editorial team's suggestion to apply the framework by Haans, Pieters, and He (2015). This approach has strengthened our ability to theorize and test the nonlinear relationships between justice dimensions and NPD collaboration in hub-and-spoke supply chain networks.

⁴This study uses the term "HUB-FIRM" as a fictitious name to refer to the specific company identified as a hub-firm in the interview quotations.

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Appendix 1

Measurements

Questionnaires completed by the hub-firm's suppliers	Loading
Procedural Justice	
The hub-firm has treated us fairly in our dealings.	0.643
The hub-firm explained fully the decision-making criteria to us.	0.886
The hub-firm applied consistent decision-making criteria in its dealings with us.	0.868
Distributive Justice	
The hub-firm made significant contributions to this engagement.	—
The hub-firm achieved substantial outcomes and rewards from this engagement.	0.904
We made substantial contributions to this engagement.	0.933
We attained significant outcomes and rewards from this engagement.	0.908
Formal Contracts	
We possess specific and comprehensive agreements with the hub-firm.	0.930
We maintain customized agreements that delineate the obligations of both parties.	0.962
We hold detailed contractual agreements specifically designed with the hub-firm.	0.975
Questionnaires completed by the hub-firm for each individual supplier	
New Product Development Collaboration	
This supplier has actively participated in the design initiatives of our supply chain networks based collaborative new product development projects.	0.647
This supplier cooperated with other suppliers within our supply chain networks to co-design these products.	0.933
Other suppliers within our supply chain networks frequently sought consultations from this supplier regarding the joint design of our products.	0.934
This supplier played a pivotal role in the design efforts of our collaborative new product development projects.	0.851

Note: —, items excluded with factor loadings below threshold ($\lambda = 0.362$; threshold: 0.400).

Appendix 2

Semi-Structured Interview Protocol.

Core Question 1: How would you describe the fairness of the hub-firm's decision-making processes in your collaborative NPD projects?

Follow-up queries:

- Probe for specific examples and experiences.
- Explore the participant's understanding of procedural justice in this context.

Core Question 2: How does the distribution of rewards and risks administered by the hub-firms in your joint NPD projects affect your firm's collaborative NPD efforts?

Follow-up queries:

- Encourage the participant to provide concrete instances of perceived equity or inequity.
- Investigate the factors contributing to these perceptions of distributive justice.

Core Question 3: How do formal contracts between your firm and the hub-firm influence your perceptions of fairness in decision-making processes and reward distribution?

Follow-up queries:

- Explore the role of contracts in shaping perceptions of both procedural and distributive justice.
- Inquire about specific clauses or aspects of contracts that impact these perceptions.

Core Question 4: Can you describe instances where your perceptions of fairness or unfairness in decision-making processes or reward distribution have influenced your firm's willingness to engage in joint NPD projects with the hub-firm?

Follow-up queries:

- Seek detailed examples of how justice perceptions have affected NPD collaboration.
- Probe for both positive and negative influences on collaboration willingness.

The number of follow-up questions will not be limited to two. If necessary, we will ask further clarifying questions based on the participants' responses and explore any emerging themes.