Technological Capability Strength/Asymmetry and Supply Chain Process Innovation: The Contingent Roles of Institutional Environments in China

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Abstract

Despite the importance of process innovation in fostering supply chain competitiveness, existing studies primarily emphasize product innovation and overlook institutional environments. This study builds on the dyadic capability-based view and institutional theory to investigate how buyer's and supplier's technological capabilities jointly affect supply chain process innovation in China. We differentiate between two distinct dimensions, technological capability strength and technological capability asymmetry, and propose that technological capability strength negatively influences supply chain process innovation whereas technological capability asymmetry promotes such innovation. We also examine how formal (i.e., government intervention) and informal (i.e., guanxi importance) institutional factors moderate the effects of technological capability strength and asymmetry on supply chain process innovation. Empirical analyses based on 157 buyer–supplier dyads in China offer strong support for our hypotheses, which provide important implications for the supply chain innovation collaboration literature and managerial practice.

Keywords: Supply chain process innovation, technological capability strength, technological capability asymmetry, government intervention, guanxi importance, buyer–supplier exchanges

INTRODUCTION

As the cornerstone of global manufacturing, China has been striving for high-quality development by promoting supply chain competitiveness through innovation (Deloitte, 2014; Zhou, Lazonick, & Sun, 2016). *Supply chain process innovation*, defined as the degree to which supply chain partners jointly adopt novel technologies, procedures, and practices, is critical for facilitating partner cooperation, improving operational efficiency, and maximizing joint performance (Liu, Prajogo, & Oke, 2016; Sodero, Rabinovich, & Sinha, 2013; Wong & Ngai, 2019). Despite the importance of supply chain process innovation, however, prior research has focused primarily on product innovation (Chae, Yan, & Yang, 2020; Wang, Li, & Chang, 2016a; Yan & Dooley, 2013). Supply chain process innovation differs, though, from product innovation along key dimensions, including strategic foci, value-creation approaches, and imitability/protection issues (Haneda & Ito, 2018; Hullova, Trott, & Simms, 2016). Hence, insights gleaned from analyzing product innovation may not be directly applicable to understanding process innovation (Damanpour, 2010; Un & Asakawa, 2015). As a result, supply chain process innovation is a seriously under-explored topic (e.g., Cao & Zhang, 2011; Slot, Wuyts, & Geyskens, 2020).

Moreover, supply chain innovation collaboration is shaped by the surrounding institutional environments (Wang et al., 2016a; Wang & Zhang, 2021). Emerging markets such as China are featured with rapid institutional changes in economic, political, and socio-cultural aspects, which significantly shape the efficacy of business strategies (Barasa et al., 2017; Peng, 2003; Zhou et al., 2016). Prior studies have however focused mainly on the moderating roles of market-based resources and task environments (Ju et al., 2013; Su et al., 2013; Yu et al., 2014; Zhou & Wu, 2010), overlooking the role of institutional environments. Given the ubiquitous impact of institutional environments on coordination and exchanges between partners (Bai, Sheng, & Li, 2016; Zhou et al., 2016), we must examine the moderating roles of institutional forces to fully understand supply chain process innovation.

To address these research gaps, we examine how partner technological capabilities affect supply chain process innovation, with the moderating effects of salient institutional factors in China. According to the capability-based view (CBV), *technological capability* (TC hereafter), defined as skills and knowledge that are involved in deploying various types of technological resources, is critical for innovation development (Kang, Baek, & Lee, 2017; Moeen & Mitchell, 2020; Zhou & Wu, 2010). For individual firms, strong TC reflects experience and competence in undertaking innovation tasks (Mindruta, Moeen, & Agarwal, 2016; Song, Di Benedetto, & Nason, 2007). In our context of buyer–supplier exchange, process innovation is a relational and inter-organizational effort (Ojha, Shockley, & Acharya, 2016), which requires collective action and mutual adjustment between partners (Kim, Kumar, & Kumar, 2012; Naveh & Marcus, 2005; Wuttke, Rosenzweig, & Heese, 2019). Hence, both buyer's and supplier's TC play significant roles in affecting their joint motivation and ability to engage in supply chain process innovation. Thus, this study takes a dyadic view to examine explicitly how buyer's and supplier's TC jointly affect supply chain process innovation in China.

Inspired by the dependence research on interfirm exchanges (Casciaro & Piskorski, 2005; Gulati & Sytch, 2007; Lee, Mun, & Park, 2015), we develop a dyadic CBV by distinguishing between *TC strength* (i.e. the sum of a buyer's TC and a supplier's TC) and *TC asymmetry* (i.e. the absolute difference between a buyer's TC and a supplier's TC). We propose that TC strength may negatively affect supply chain process innovation because partners with strong TC lack a joint motivation to change their practices. We argue further that TC asymmetry facilitates supply chain process innovation because the relative capability gap stimulates mutual adjustment and enables the partner with stronger TC to take charge and coordinate the process. Moreover, drawing on institutional theory, we examine the moderating roles of formal (i.e., government intervention) and informal (i.e., guanxi importance) institutional factors in China. We posit that government intervention reduces the impacts of TC strength and TC asymmetry while guanxi importance amplifies the effects of TC strength and TC asymmetry on supply chain process innovation. Figure 1 depicts our conceptual model.

*** Insert Figure 1 here ***

The results obtained from a matched sample of 157 buyer–supplier dyads in Chinese manufacturing industries provide strong support for our hypotheses. Accordingly, our study makes three major contributions to the supply chain innovation literature. First, while the prior supply chain collaboration literature focuses primarily on product innovation, we shift the attention to examining supply chain process innovation, which helps construct a complete picture of innovation in the supply chain. Second, by showing a negative effect of TC strength and a positive impact of TC asymmetry on supply chain process innovation, our study challenges the conventional CBV by revealing the dark side of high TC in the supply chain context. In so doing, we extend the CBV to the dyadic level. Third, we show how the effects of TC strength and asymmetry depend on institutional environments in China, offering a more nuanced understanding of the TC–supply chain process innovation relationship. This study thus answers Zhou et al.'s (2016) call for more research that contributes to explicating the influence of institutional environments in emerging markets.

CONCEPTUAL DEVELOPMENT

Supply chain product and process innovation

There are two major types of innovation taking place in the supply chain: product innovation and process innovation (Wagner & Bode, 2014): the former changes *what* the partners offer to the outside world (Haneda & Ito, 2018; Mitrega et al., 2017) whereas the latter reflects changes in *how* partners create and deliver their offerings (Crossan & Apaydin, 2010; Damanpour, 2010). For instance, in the automobile sector, the development of electric vehicles is *supply chain product innovation*, as traditional automakers (e.g., Ford) and battery suppliers (e.g., BYD) work closely together to offer innovative products to external customers.[1] Meanwhile, *supply chain process innovation* occurs when automakers and their suppliers jointly adopt advanced technologies/tools/practices (e.g., three-dimensional CAD/CAM) for collaborative design, engineering, and manufacturing, which improves operational efficiency greatly.

Supply chain product and process innovation differ in their strategic foci, value-creation approaches, and imitability/protection issues (Pavitt, 1984; Wagner & Bode, 2014; Wong & Ngai, 2019). Product innovation aims at meeting external market needs and its success depends on external customers' acceptance. Such innovation can be easily observed in the external environment and is generally more readily apparent to customers (Un & Asakawa, 2015). By improving product quality/functionality and increasing product differentiation, product innovation enables supply chain partners to charge a premium price over competitors' products (Badir, Frank, & Bogers, 2020; Damanpour, 2010). As product innovation is observable, competitors can imitate it through reverse engineering (Un & Asakawa, 2015).

[1] https://www.futurecar.com/3954/Chinese-Battery-Maker-BYD-to-Supply-EV-Batteries-to-Ford-Motor-Company

In contrast, supply chain process innovation has an internal focus and is primarily efficiency-driven (Ballot et al., 2015; Damanpour & Aravind 2006; Terjesen & Patel, 2017). By streamlining physical product flows, information flows, and/or financial flows, it facilitates communication and cooperation between supply chain partners, reduces bottlenecks, and facilitates product development and commercialization (Damanpour & Gopalakrishnan, 2001; Lee et al., 2018). As supply chain process innovation is intangible and invisible externally, its success is evaluated primarily by the involved partners themselves while it is difficult to imitate by competitors (Pisano & Shih, 2012; Stadler, 2011; Un & Asakawa, 2015). Table 1 summarizes the differences between supply chain product and process innovation.

-----Insert Table 1 about here-----

Supply chain process innovation often involves a large aggregate of tools, machines, people, and social systems, so the implementation of supply chain process innovation requires close interaction, cooperation, and commitment from exchange parties (Wuttke et al., 2019). Such mutuality has yet to be explicitly considered, however, raising two key issues. First, whereas supply chain process innovation requires active participation of supply chain partners, it is difficult to motivate them jointly. For individual firms, the motivation to adopt a particular innovation depends on the criticality of the problem and the potential for the solution to be useful (Autry et al., 2010; Liu et al., 2016). Because partners often have varying or even conflicting priorities and evaluations, they may fail to reach a consensus that stimulates *joint motivation* to engage in supply chain process innovation. Second, supply chain process innovation requires significant interaction, integration, and collaboration across firms' boundaries to realize its full potential (Kurkkio, Frishammar, & Lichtenthaler, 2011; Pisano, 1997). The complexity of decomposing inter-dependent tasks and unexpected adaptation issues generate *coordination difficulty* between partners.

A dyadic capability-based view of supply chain process innovation

According to the CBV, heterogeneous, sticky, and difficult-to-trade capabilities are the most valuable drivers of competitive advantage (Teece, 2007). Embedded in a firm's managerial and organizational routines, capabilities play a pivotal role in enabling a firm to exploit, integrate, and reconfigure internal resources and functional experience to generate superior value (Teece, 2007; Wilden & Gudergan, 2015). Prior research highlights the critical role of TC in innovation (Zhou & Wu, 2010). Advanced TC enables firms to utilize existing distinctive and superior technology and equipment proficiently (Leiblein & Madsen, 2009; Song et al., 2007).

The CBV implies, however, that a strong capability can turn into a core rigidity that encourages firms to resist change (Leonard-Barton, 1992). With advanced TC, firms may become increasingly complacent and less motivated to search for new knowledge beyond an existing technological trajectory (Zhou & Wu, 2010). Also, as capabilities reside in organizational processes and routines (Teece, 2007), a firm with strong TC often has a well-entrenched technological base, instilling a propensity to resist change that might require developing a new or incompatible technological base (Leonard-Barton, 1992). In this respect, however, prior studies address capability–rigidity issues in individual firms but pay limited attention to such concerns in the context of buyer–supplier collaboration.

In innovation collaboration research, prior studies emphasize the important role of complementarity of resources and capabilities in developing product innovation (Mindruta et al., 2016). For example, Makri, Hitt, and Lane (2010) find that complementary technological knowledge stimulates the development of novel and quality inventions during the partner post-merger period. Wang et al. (2016a) show that, while buyers and suppliers serve as critical sources of complementary (distinct) ideas and practices, they need compatible knowledge bases to understand each other for better new product development performance. These studies highlight that different *types* of resources and capabilities held by collaborating partners bring non-overlapping value to innovation activities (Cheung, Myers, & Mentzer, 2010).

However, partners not only differ in the *types* of capabilities, but also vary in the *levels* of a particular type of capability (e.g., TC) (Harrison & Klein, 2007). Unfortunately, we know little about the implications of different *levels* between buyer TC and supplier TC on supply chain process innovation.

Borrowing from the dependence research (Casciaro & Piskorski, 2005; Gulati & Sytch, 2007; Lee et al., 2015), we develop a dyadic approach that yields two distinct TC dimensions: TC strength and TC asymmetry. TC strength captures the sum of partner capabilities in the dyad. While high TC strength signals the dyad's prominence and superiority in the existing technological domain, it also implies the presence of well-established technological bases and well-established routines in both partners (Ahuja, Polidoro, & Mitchell, 2009). TC asymmetry reflects the absolute difference in TC between partners. When TC asymmetry is high, one partner is substantially more experienced and efficient than the other in performing technological tasks. When working together, the low-capability partner often needs support from the other partner to make adjustments and achieve synchronization in the dyad (Zollo, Reuer, & Singh, 2002). Given a particular level of TC strength, the levels of TC asymmetry in buyer–supplier dyads could vary (and vice versa). Thus, the two dimensions together provide a dyadic portrayal of the capability structure in buyer–supplier exchanges.

Moderating roles of institutional environments in China

The CBV also indicates that, as capabilities enable a firm to exploit external opportunities and fend off external threats, their efficacy is bounded by external environment (Sirmon, Hitt, & Ireland, 2007; Teece, 2007). According to institutional theory, supply chain collaboration is embedded in its macro institutional environments, such that partners need to behave in a manner that is desirable and proper according to socially constructed systems of norms, values, and beliefs (Bai et al., 2016; Rogers, Leuschner, & Choi, 2007). Institutions can be formal or informal: Formal institutions include political and regulatory rules, which create regulatory pressures on organizations for compliance (North, 1990; Oliver, 1991; Peng, 2003). Informal institutions are constituted by the values and norms embodied in culture, customs, or traditions, generating normative pressure on organizations to undertake socially acceptable practices (Dacin, Oliver, & Roy, 2007; Oliver, 1991; Rogers et al., 2007).

Accordingly, both formal and informal institutions could influence coordination and exchange between supply chain partners (Bai et al., 2016; Wang et al., 2016b), in turn affecting their joint motivation and mutual adjustment in strategic actions. Therefore, we consider the moderating roles of government intervention and guanxi importance, which represent, respectively, important formal and informal institutional factors in China (Cai, Jun, & Yang, 2010; Child, Chung, & Davies, 2003; Wang et al., 2016a). *Government intervention* reflects the extent of government interference with business operations (Luo, 2005; Wang et al., 2016a; Wang, 2018). Given China's underdeveloped legal systems, government officials participate actively in economic and social affairs, making government intervention a primary concern (Child et al., 2003; Sheng, Zhou & Li, 2011; Wang et al., 2016b). Such intervention increases uncertainty in business operations and constrains supply chain partners' ability to make effective decisions (Delios & Henisz, 2003).

Guanxi importance, a critical informal institutional factor in China, reflects the extent to which inter-personal relationships are used to coordinate business activities (Cai et al., 2010; Child et al., 2003; Park & Luo, 2001). China has a long history of using inter-personal relationships to establish expectations and facilitate the exchange of favors between involved parties (Lu & McInerney, 2016; Wang et al., 2016a). As guanxi emphasizes social relations and mutual norms (Gu, Hung, & Tse, 2008), guanxi importance motivates supply chain partners to commit to joint benefits (Cai et al., 2010; Park & Luo, 2001).

HYPOTHESES

With high TC strength, exchange partners have well-established technological bases and routines, ensuring that tasks can be accomplished efficiently (Ahuja et al., 2009; Vandaie & Zaheer, 2014). We predict however that high TC strength may reduce supply chain process innovation in an exchange dyad. First, TC strength likely induces complacency and undermines exchange partners' joint motivation to embark on supply chain process innovation. With high TC strength, exchange partners have already developed advanced technological routines, which make them prefer to maintain the status quo (Autry et al., 2010; Liu et al., 2016). Also, well-developed technological routines fuel strong internal resistance to change, because supply chain process innovation requires exchange partners to change their existing organizational structures and redesign business processes (Leiblein & Madsen, 2009). In contrast, if TC strength is low, both partners realize that there is greater room for improving efficiency and hence are highly motivated to engage in supply chain process innovation. Meanwhile, because such partners have not developed less well-established cooperation routines, they are more open to and flexible for engaging in supply chain process innovation.

Second, with high TC, partners may encounter challenges in reaching mutually agreeable decisions, increasing the coordination difficulty associated with supply chain process innovation. Successful supply chain process innovation hinges on joint decision-making and mutual adaptation to achieve inter-firm alignment and integration (Ojha et al., 2016; Wang et al., 2016a). With high TC strength, the respective identities and egos of buyer and supplier firms may be intertwined with their expertise (Groysberg, Polzer, & Elfenbein, 2011). As favorable self-evaluations increase the difficulty of identifying with one another, partners' task-related debates and conflict may escalate into relationship conflict in which egos are at stake (Gardner, Gino, & Staatset, 2012). As a result, partners with high TC strength may be less willing to accommodate each other's needs and requirements, increasing the coordination difficulty associated with supply chain process innovation. Overall, these arguments suggest:

H1a. TC strength relates negatively to supply chain process innovation.

In contrast, we posit that TC asymmetry may foster the development of supply chain process innovation. When working together, partners need to agree on common working structures, schedules, budgets, and deliverables; they must also work on inter-dependent subtasks (Takeishi, 2002). With high TC asymmetry, though, the partner with stronger TC is more effective at identifying technological opportunities and is more efficient at completing relevant tasks (Lavie, Haunschild, & Khanna, 2012). Meanwhile, it takes time for the partner with weaker TC to recognize a problem and to agree on the need for action, which creates major bottlenecks that slow the joint problem-solving process (Zollo et al., 2002). Such capability mismatch motivates partners to engage in supply chain process innovation that creates effective partner-specific routines for improving efficiency (Kotabe, Martin, & Domoto, 2003; Zollo et al., 2002).

Moreover, when TC asymmetry is high, the partner with stronger TC often takes the lead in coordinating the exchange, smoothing the implementation of supply chain process innovation. Because the partner with higher TC has a superior capacity to lead and direct the joint innovation process, the partner with lower TC will likely follow its lead (Gardner et al., 2012; Johnsen, Lacoste, & Meehan, 2020). As a result, the relationship benefits from a state of order, which facilitates the efficiency of supply chain process innovation. In contrast, when two partners are comparable in their respective capabilities (i.e. there is low capability asymmetry), they may compete for influence, thereby leading to coordination difficulty (Bertrand & Lumineau, 2016; Johnsen et al., 2020). Hence:

H1b. TC asymmetry relates positively to supply chain process innovation.

Moderating effects of government intervention

Government intervention may manifest in unpredictable industrial policy launches, frequent changes in regulatory rules, and inconsistent policy implementation (Cai et al., 2010). As government intervention constitutes a major external source of uncertainty in China and threatens corporate survival, supply chain partners must respond by adjusting their strategic behaviors (Luo, 2005).

We propose that government intervention weakens the negative effect of TC strength on supply chain process innovation. First, frequent government intervention results in an unstable and unpredictable business environment (Wang et al., 2016a). Sudden changes in government policies may disrupt supply chain partners' normal operations and force them to make prompt changes (Wang et al., 2016b). In this situation, partners with strong TC likely recognize the challenges and the need to respond. Thus, government intervention may address the inertia and inaction caused by TC strength, reducing its negative impact on supply chain process innovation.

Second, government intervention compels supply chain partners to act quickly to cope with policy changes (Wang et al., 2016a). To respond effectively in such contingencies, supply chain participants are compelled to adapt quickly in unforeseen situations, requiring them to take joint actions (Wang et al., 2020). In this circumstance, partners with high TC are more likely to forgo self-interested mindsets and focus on collaboration. Therefore, government intervention likely reduces the coordination difficulty associated with TC strength regarding supply chain process innovation. Hence:

H2a. The negative effect of TC strength on supply chain process innovation is weaker when government intervention in China is high.

We argue that government intervention reduces the positive effect of TC asymmetry on supply chain process innovation. First, frequent and sudden government intervention injects uncertainty into business policies and increases the pressure to adapt business operations (Kaufmann, Kraay, & Mastruzzi, 2008; Wang et al., 2016b). When government intervention is high, both buyers and suppliers face survival challenge, which motivates the partners to adapt and assign top priority to responding rapidly to external threats. As a result, government intervention pushes partners to detect problems that might arise in their collaboration and invest collective efforts into improving their relationship. In this case, the facilitating role of TC asymmetry in supply chain process innovation diminishes.

Second, when government intervention presents a salient external challenge, it directs partners' attention to closely monitoring the changes in regulations and policies to ensure their survival (Mccann & Bahl, 2017). In the presence of extensive government intervention, supply chain partners may rely to a greater extent on connections with government officials to obtain favorable results and depend less heavily on market-oriented resources (e.g., strong TC). The compulsory compliance stipulated by TC asymmetry may become weaker, in turn weakening its influence on initiating supply chain process innovation. While TC asymmetry helps reduce partner bargaining and smooth coordination, such advantages are less valuable when both partners are working together actively to address external challenges from the government:

H2b. **The positive effect of TC asymmetry on supply chain process innovation is weaker when government intervention in China is high.**

Moderating effects of guanxi importance

As an informal institutional factor in China, guanxi importance reflects the role of interpersonal connections in business operations (Child et al., 2003; Luk et al., 2008). The importance of guanxi not only motivates firms to invest in interpersonal relationships, but also significantly influences interfirm behaviors, such as the cooperation, trust, and knowledge exchange on which they depend to maintain their relationships (Cai et al., 2010; Lu & McInerney, 2016).

We propose that guanxi importance may amplify the negative effects of TC strength on supply chain process innovation. Guanxi importance signifies that business success and survival depend critically on social connections (Shou et al., 2014). Firms in a guanxi-dominated market may obtain orders, inside information, and extra support from business partners and government entities (Fu, Diez, & Schiller, 2013; Su & Littlefield, 2001). As a result, such firms are more likely to commit time and resources to building guanxi networks (Sheng et al., 2011) rather than focusing on developing market-based advantages. In this situation, high TC strength likely generates greater resistance to initiating process innovation, as a dyad with high TC finds it unnecessary to update and renew the partners' organizational processes and routines.

Moreover, with increasing level of guanxi importance, supply chain partners are more likely to establish cohesion and identification through interpersonal connections and socialization (Cai et al., 2010). Thus, they cultivate greater strategic consensus and values, which severely limit the dyad's openness to external information and environmental scanning (Zhou et al., 2014). When guanxi importance leads to such collective blindness, TC strengthen leads to greater complacency that undermines the motivation for continuous learning and innovation. Thus, guanxi importance likely intensifies the demotivating impact of TC strength on supply chain process innovation:

H3a. The negative effect of TC strength on supply chain process innovation is stronger when guanxi importance in China is high.

We also suggest that guanxi importance may increase the positive effect of TC asymmetry on supply chain process innovation. In a guanxi-based society, managers are more likely to commit time and resources to attending social networking activities (Fu et al., 2013; Xin & Pearce, 1996), which nurtures affective attachment and a strong sense of social obligations in business partners (Cai et al., 2010). Collaborating partners thus have greater motivation to solve the problems emerged during interactions because of their attachment to the relationship and the value they see in long-term mutual benefits. Specifically, collaboration inefficiency, as resulting from TC mismatch, may instill a heightened sense of responsibility in partners with stronger TC, persuading them to undertake and coordinate supply chain process innovation.

At the same time, when guanxi is prevalent, firms rely on their connections with business partners to gain valuable information, market intelligence, advanced technology, and manufacturing knowledge (Luk et al., 2008). In this situation, TC asymmetry represents a valuable opportunity for the weaker party to solidify its relationship with the stronger partner and upgrade its knowledge base through process innovation in the supply chain. Evidence shows that by maintaining the relationships with international multinational enterprises, emerging market suppliers develop and upgrade process capabilities and competitive advantage (Corredoira

& McDermott, 2014). As a result, guanxi importance likely amplifies the effect of TC asymmetry on supply chain process innovation:

H3b. The positive effect of TC asymmetry on supply chain process innovation is stronger when guanxi importance in China is high.

METHODOLOGY

Data Collection

To test our hypotheses, we conducted a survey of Chinese buyer–supplier dyads in two rounds. Due to uneven economic development and institutional transition, institutional environments in China vary greatly across different regions, providing a suitable context for investigating how institutional factors influence the impact of partner TC strength/asymmetry on supply chain process innovation (Bai et al., 2016; Wang et al., 2016b). We originally developed an English version of the survey instrument based on prior literature. Independently, two bilingual researchers with substantial experience in the area translated the survey into Chinese and back-translated it into English to ensure the equivalence of the concepts. Any conflict was discussed until a mutually agreeable decision was reached. To ensure content and face validity as well as the relevance of the constructs in the Chinese context, we conducted a pilot study with 20 senior purchasing managers. They not only answered all the questions but also provided feedback regarding the wording, design, and appropriateness of our measures. Based on the feedback we received during this process, we further modified and finalized the questionnaire.

For the final survey, we randomly identified 800 manufacturing firms from a sample list provided by All China Marketing Research Co. Ltd. (ACMR).[2] With the help of ACMR, we trained interviewers to conduct the survey onsite. This procedure is useful for clarifying the issues under study, verifying the suitability of the respondents, and obtaining quality data in emerging markets (Li, Poppo, & Zhou, 2008). The interviewers first placed telephone calls to contact mangers and scheduled appointments with them. They then visited the managers, presented the survey, and collected the completed questionnaires in person. During the interview process, to enhance the accuracy of responses, we assured respondents of their anonymity. The interviewers asked the purchasing managers to identify one of their largest suppliers and then answer relevant questions related to that supplier. At the end of each interview, we asked the interviewed purchasing manager to refer us to a senior manager in their supplier firm. The interviewers then contacted the supplier managers and administered the survey following similar procedures. Our efforts generated complete information from 349 buyer–supplier dyads, for a response rate of 43.63 percent. Approximately three years later,[3] in a follow-up survey, our interviewers contacted the buyer firms again to obtain information regarding supply chain process innovation with that particular supplier. In total, we collected completed questionnaires

[2] ACMR collaborates extensively with the China National Bureau of Statistics (NBS) and has access to the complete list of the Annual Census of Industrial Enterprises (ACIE) conducted by the NBS, which covers all Chinese firms with annual sales of more than 5 million RMB.

[3] We followed prior studies to conduct the second survey three years later (e.g. Heide, Wathne, & Rokkan, 2007; Tekleab, Takeuchi, & Taylor, 2005). Process innovation between a buyer and a supplier needs a considerable amount of time to materialize. Furthermore, a three-year lag can reduce the threat of common method bias and create an appropriate tradeoff between establishing causal relationships and not missing the effects (Podsakoff et al., 2003).

from 157 matched buyer–supplier dyads on two occasions, yielding an overall response rate of 19.63 percent.

At the time of our first survey, the average age of the buyer firms in our sample was 14.48 years and the average firm carried 1,305 employees. Of the buyer firms, 78.34% reported annual sales revenue of over US$3 million. In addition, 14.65% were state-owned enterprises and 31.85% were foreign firms (foreign subsidiaries or international joint ventures). On the other side, the supplier firms in our sample had been in operation for 14.41 years on average and carried 558 employees, with 77.07% reporting annual sales revenue of more than US$3 million. Of the supplier firms, 8.28% were state-owned enterprises and 36.31% were foreign firms.

On average, respondents from the buyer firms had been working at their companies for 7.40 years and their average industry experience was 11.30 years. Respondents from the suppliers had worked on average for 9.69 years in their industries and for 6.45 years with their companies. These responses indicate that our respondents had accumulated extensive experience with their firms. To investigate the potential for non-response bias, we performed a series of t-tests to compare whether responding firms differed from nonresponding firms at Time 1 and whether the responding firms at Time 2 were representative of the sample firms at Time 1 in terms of age, size, ownership, and annual sales revenues. The results did not yield any significant differences at the 0.05 level, suggesting that our data were not subject to non-response bias.

Measures

We adapted our measures from prior literature. We list the measurement items and report results indicating their reliability and validity in Appendix I.

Supply chain process innovation. As there is no established measure of supply chain process innovation, we adapted the scales of process innovation from Chang, Bai, and Li (2015), Li et al. (2018), Piening and Salge (2015), and Tomlinson (2010) to highlight the collaboration feature between supply chain partners. We used three items to evaluate the extent to which a buyer and a supplier jointly adopt new production technologies, new processes, or new managerial and organizing approaches in their collaboration process.

TC strength and TC asymmetry. Based on prior studies (DeSarbo et al., 2005; Wilden & Gudergan, 2015), we developed a four-item scale for *buyer (supplier) TC* and asked suppliers (buyers) to assess the degree of the buyer's (supplier's) ability in accomplishing the task during cooperation with superior TC. Following previous research on mutual and asymmetric dependence between partners (e.g. Casciaro & Piskorski, 2005), we measured TC strength as the sum of buyer TC and supplier TC and TC asymmetry as the absolute difference between buyer TC and supplier TC.

Moderators. We asked buyers and suppliers to evaluate their institutional environments with adapted scales from previous studies. Specifically, we adapted a four-item scale from Child et al. (2003) and Wang et al. (2016a) to measure government intervention and evaluate the extent to which government officials change regulatory policies and adopt actions affecting business behaviors. For guanxi importance, we used a three-item scale to assess the extent to which firms depend on guanxi connections in business operations and how such connections determine success in the market (Cai et al., 2010; Child et al., 2003). As there may be differences in supply chain partners' interpretations of their external environments, we measured government intervention and guanxi importance for buyer–supplier dyads as the average of buyer's and supplier's perceptions of their institutional environments.

*Control variables***.** We included a series of controls to rule out alternative explanations. Because older or larger firms may have accumulated more knowledge and experience they can use when engaging in innovation, we controlled for *buyer (supplier) age* and *buyer (supplier) size* (Gao, Xie, & Zhou, 2015). *Buyer (supplier) age* was measured as the natural logarithm of the number of years a buyer (supplier) had been in operation. *Buyer (supplier) size* was calculated as the natural logarithm of the number of employees in buyer (supplier) firms. As distinct types of firms may differ in their motivations and capacities to engage in innovation, we included *buyer (supplier) state ownership*, coded as 1 for *state-owned* enterprises and 0 otherwise, and *buyer (supplier) foreign ownership*, coded as 1 for international joint ventures or foreign subsidiaries and 0 otherwise, with domestic private firms as the baseline. To control for a partner's strategic importance, we included *buyer concentration*, measured as the proportion of a buyer's annual demand for products obtained from the supplier, and *supplier concentration*, measured as the proportion of the supplier's annual sales of products sold to the buyer (Rokkan, Heide, & Wathne, 2003). *Prior exchange history* could influence coordination and exchanges between supply chain partners, so we measured the natural logarithm of the number of years a buyer–supplier dyad had been doing business with each other (Bai et al., 2016; Zhou et al., 2014). We also added prior process innovation between the buyer and supplier as a control. Finally, we included industry fixed effects to control for industry heterogeneity.

Reliability and Validity

We conducted confirmatory factor analyses (CFAs) to assess the reliability and validity of our focal constructs. In the CFA model, we set each item to load on its prior specified construct, allowing the items and constructs to correlate with each other. As shown in Appendix Ⅰ, the fit indexes of CFA results include: χ^2/df = 2.11, $p < 0.01$, confirmatory fit index (CFI) = 0.93, incremental fit index (IFI) = 0.93, root mean square error of approximation (RMSEA) = 0.08. All standardized factor loadings are highly significant at the 0.01 level, indicating satisfactory convergent validity. We further compared the current measurement model with alternative models in which some items were loaded onto other constructs and found that the current model exhibited the most significant fit indexes (Lance, Butts, & Michels, 2006). We also computed composite reliabilities and average variance extracted (AVE). The composite reliabilities of the constructs range from 0.85 to 0.98 and the coefficients between the items for each construct were more than twice as high as their standard errors. The AVEs of focal constructs range from 0.59 to 0.94, demonstrating that the variance explained by the construct is greater than the variance explained by the measurement error. These results indicate that the constructs exhibit satisfactory reliability and convergent validity (Hair et al., 2006).

We assessed discriminant validity for all the constructs. First, the value of the AVE for each construct is higher than the shared variance between that construct and any other construct, lending support to the existence of construct discriminant validity in the model (Koufteros, Cheng, & Lai, 2007). Second, we conducted chi-square difference tests for all possible pairs of constructs to compare the two-factor CFA model in which the correlation between a pair of constructs was set at 1 with the unconstrained CFA model (where the correlation was estimated freely). The chi-square values were significantly lower for all unconstrained models at the 0.01 level, providing additional evidence of the discriminant validity of the constructs. Table 2 presents the means, standard deviations, and correlations between all constructs.

---- Insert Table 2 about here ----

Common method bias

To diminish the threat of common method bias, we collected information on our independent variables and dependent variables from multiple sources at varying times (Podsakoff et al., 2003). In the first round of the survey, we collected information on buyer TC from supplier managers and supplier TC from buyer managers. In the follow-up survey, we obtained information on supply chain process innovation from buyer managers. Furthermore, we calculated TC strength and asymmetry based on buyer TC and supplier TC values and then examined their contingent effects. Common method variance is unlikely to influence the estimation because the respondents were unlikely to have complex relationships in mind or to have speculated on interactive relationships between the variables (Siemsen, Roth, & Oliveira, 2010). Such a multi-source and multi-method approach can effectively diminish the threat of common method variance (Podsakoff et al., 2003).

Results

In Table 3, we present the results derived from the multiple regression models. We included the control variables in Model 1, added the independent variables and moderators to Model 2, and added interactions terms with each moderator to Models 3 and 4. Model 5 is the full model.

---- Insert Table 3 about here ----

As the results reported in Table 3 show, the impacts of TC strength and TC asymmetry are consistent across all models (Model 2–Model 5). The estimate of Model 2 (Table 3) shows that TC strength has a negative effect on supply chain process innovation ($\beta = -0.198$, $p < 0.01$), whereas TC asymmetry relates positively to supply chain process innovation ($\beta = 0.216$, $p < 0.01$), providing strong support for H1a and H1b.

Hypotheses 2 and 3 predict that government intervention and guanxi importance, respectively, moderate the hypothesized relationships. As we show in Table 3, the results derived from Models 3 and 4 are consistent with those derived from Model 5. With the full model (Model 5, Table 3), we find that government intervention positively moderates the effect of TC strength ($\beta = 0.226$, $p < 0.01$) and negatively moderates the effect of TC asymmetry ($\beta = -0.168$, $p < 0.05$) on supply chain process innovation, in support of H2a and H2b. Interaction between guanxi importance and TC strength is negative and significant ($\beta = -0.260$, $p < 0.01$), in support of H3a. Interaction between guanxi importance and TC asymmetry has a negative effect on supply chain process innovation ($\beta = 0.194$, $p < 0.05$), providing support for H3b.

To gain deeper insights into the moderating effects, we followed the procedure of Aiken and West (1991) and performed simple slope tests. Figure 2 presents evidence of the influences of TC strength and TC asymmetry on supply chain process innovation across low (one standard deviation below the mean) and high (one standard deviation above the mean) levels of government intervention and guanxi importance. Panel A of Figure 2 shows that the relationship between TC strength and supply chain process innovation shifts from negative ($\beta = -0.670$, $p < 0.01$) to nonsignificant ($\beta = -0.120$, $p > 0.10$) when government intervention moves from low to high levels. Panel B of Figure 2 indicates that, when government intervention is low, the relationship between TC asymmetry and supply chain process innovation is positive and significant ($\beta = 0.907$, $p < 0.01$); however, when government intervention is high, the effect becomes nonsignificant ($\beta = 0.089$, $p > 0.10$).

Furthermore, as Panel C of Figure 2 reveals, when guanxi importance is low, the effect of TC strength on supply chain process innovation is nonsignificant ($\beta = -0.080$, $p > 0.10$), whereas it has a negative effect on supply chain process innovation in the presence of high guanxi importance ($\beta = -0.710$, $p < 0.01$). In contrast, Panel D of Figure 2 shows that the effect of TC asymmetry is positive but non-significant when guanxi importance is low ($\beta = 0.124$, $p > 0.10$) but becomes significantly positive when guanxi importance is high ($\beta = 0.872$, $p < 0.01$).

---- Insert Figure 2 about here ----

Endogeneity and robustness tests

Endogeneity analysis. Both TC strength and TC asymmetry render statistical analysis susceptible to an endogeneity problem. We account for this issue with the two-step control function approach (Petrin & Train, 2010), which has been widely used in previous survey-based studies (e.g., Katsikeas et al., 2018; Wang et al., 2017). To address the endogeneity concern, we need to find the suitable instrumental variable satisfying the relevance and exclusion criteria. That is, theoretically and empirically, the instrumental variable should relate to the independent variables (the relevance requirement) and must not have a direct effect on the dependent variable (the exclusion requirement). Legal support may influence the development of the relevant capability by supply chain partners (Malik & Kotabe, 2009; Peng, 2003) and yet it is unlikely to directly influence strategic behaviors on the part of buyers and suppliers.[4]

Empirical analyses show that the instrumental variables in our study have significant effects on the corresponding endogenous variables, whereas their effects on the dependent variable (i.e., supply chain process innovation) are not significant (please see the results reported in Appendix Ⅱ, Table A-2), providing empirical validation of our instruments. An Anderson-Rubin test indicates that the error term in supply chain process innovation is not significantly associated with the instrumental variables (F = 2.263, p > 0.10), thus confirming that the exclusion restriction is satisfied. Specifically, the correlation between legal support strength and the error term is nonsignificant (r = -0.119, p > 0.10), and the correlation between legal support difference and the error term is also nonsignificant (r = 0.106, p > 0.10). Thus, legal support strength and legal support difference could serve as valid exclusion variables.

In the first stage of the control function approach, we regressed TC strength and TC asymmetry on the instrumental variables and relevant controls (please see the Appendix Ⅱ, Table A-2). We included the residual terms of the first-stage regression in the second stage as control variables. As such, TC strength and TC asymmetry as explanatory variables no longer correlate with the error terms in the regression, confirming consistency with the independence assumption regarding TC strength/TC asymmetry and the error term and thus mitigating the endogeneity

[4] We adapted the three-item scale from Bai et al. (2016) and Child et al. (2003) to measure buyer (supplier) perceived legal support. Following the measurement approach for TC strength and asymmetry, we measured legal support strength as buyer-perceived legal support plus supplier-perceived legal support, and legal support difference as the absolute difference between buyer-perceived legal support and supplier-perceived legal support.

concern (Petrin & Train, 2010). The results derived from the second-stage model are highly consistent with the previously reported results (please see the results reported in Appendix Ⅱ, Table A-3).[5]

Robustness test: In previous analyses, we used the original scores for buyer TC and supplier TC to calculate TC strength and asymmetry. To ensure that buyer and supplier TC have the same reference point, we used their *standardized scores* to compute TC strength and asymmetry and reran the analysis. The results remain consistent (Appendix Ⅲ, Table A-4).

DISCUSSION

Theoretical implications

This study contributes to the extant literature in several ways. First, by examining supply chain process innovation, we enrich supply chain innovation and collaboration research. While both product and process innovation enhance competitive positioning of supply chains, supply chain process innovation remains largely under-explored in prior literature (Chae et al., 2020; Wang et al., 2016a). Our study fills this gap by investigating how involved parties' TC and external institutional environments affect supply chain process innovation. Moreover, extant supply chain studies suggest partner collaboration as a strategic vehicle for achieving supply chain innovation and success (Cao & Zhang, 2011; Wang et al., 2016a). We highlight the inter-organizational and collaborative nature of supply chain process innovation (Wuttke et al., 2019), i.e., the internal motivating and coordinating difficulties between supply chain partners that challenge its initiation and implementation. Buyers' TC and suppliers' TC jointly affect their motivation and

[5] The result of a Durbin-Wu-Hausman test is not significant ($\beta_{\textit{TC strength -1st stage residual}} = 0.518$, $p > 0.05$; $\beta_{\text{TC asymmetry-1st stage residual}} = -0.362$, $p > 0.10$), suggesting that endogeneity is not a major issue. In this situation, a normal ordinary least squares (OLS) regression is more efficient (Papies, Ebbes, & Van Heerde, 2017, Zhong et al., 2019). We thus use OLS regression to test the hypotheses and treat endogeneity analysis as a robustness test.

ability to engage in supply chain process innovation. In so doing, our study advances our understanding of process innovation in the supply chain.

Second, our study develops a dyadic CBV by conceptualizing collaboration partners' capability as TC strength and TC asymmetry and empirically confirming their differential impacts on supply chain process innovation. The traditional view considers TC strength to be a critical driver of competitive advantage (Teece, 2007). Further developments have challenged the assumption that "more is better" by showing diminishing returns or even the dark side of capabilities (Wales, Parida, & Patel, 2013; Zhou & Wu, 2010). Adding to this research stream, our paper reveals that TC strength can become a liability in the context of buyer–supplier process innovation, where both partners' willingness to initiate change and subsequent inter-partner coordination are vital. In this situation, TC strength instills rigidity in a dyad and creates collaboration difficulty, thereby inhibiting supply chain process innovation.

The conventional view also treats partner asymmetry as harmful for cooperation; such asymmetry therefore needs to be managed or minimized (Lee et al., 2015; Vandaie & Zaheer, 2014; Yang, Zheng, & Zaheer, 2015). Our results reveal, however, that TC asymmetry can actually foster supply chain process innovation. This result echoes the finding of Bertrand and Lumineau (2016) that power asymmetry enables the emergence of a leader to better coordinate a relationship. It is also consistent with Sodero and colleagues' (2013) finding that competition asymmetry and power asymmetry are conducive to the assimilation of open-standard information systems. Taken together, these findings suggest that we must reconsider the role of asymmetry in exchanges between supply chain partners.

Third, this study enriches the CBV literature by revealing the contingent roles of macro-level institutional factors. In China, institutional environments are featured with large subnational variations (Sheng et al., 2011; Wang et al., 2016b). Prior studies thus call for research to investigate the role of institutional environments in shaping exchanges between supply chain partners in emerging markets (e.g., Bai et al., 2016; Wang et al., 2016b; Zhou et al., 2016). In particular, previous studies suggest that because government intervention leads to unstable business environments and decreases partner commitment for the collaboration, it undermines the effect of mutual learning (Wang et al., 2016a). Extending this line of enquiry, our findings indicate that, when they encounter government intervention, buyer-supplier partners need to recognize related challenges and adapt their practices, thus counteracting the liability associated with TC strength and diminishing the facilitative role of TC asymmetry on supply chain process innovation. Furthermore, prior literature indicates that guanxi importance can constrain opportunism and nurture trust between supply chain partners (e.g., Cai et al., 2010; Yang et al., 2020). Building on prior literature, our study shows that, as guanxi importance strengthens attachment and social obligations between partners, it amplifies the roles of TC strength and asymmetry on supply chain process innovation. Overall, our findings reveal differential moderating effects of government intervention and guanxi importance, providing evidence on the distinction between formal and informal institutions in supply chain innovation management (Wang et al., 2016a; Zhou et al., 2016).

Practical implications

Our findings carry important implications for managers in China. First, because process innovation plays an important role in improving supply chain competitiveness, managers need to understand how to initiate and facilitate supply chain process innovation. Collaboration partners should be aware of the downside of TC strength as an inhibitor of process innovation, as it could demotivate a dyad from adopting new technologies and create coordination difficulty. Yet, exchange partners should fully utilize the positive impact of TC asymmetry on supply chain process innovation. For instance, Pfizer, a leading research-based biopharmaceutical company with superior capability, effectively coordinate with a number of its suppliers and upgrade the supply chain by linking it through a single common cloud-computing based system for sharing data and enhancing inventory visibility (Raj & Sharma, 2014).

Second, supply chain partners should pay special attention to salient institutional factors, which vary significantly across regions in China. In particular, when they experience extensive or intrusive government intervention, supply chain partners should know that TC strength becomes less of a liability while TC asymmetry also becomes less useful for promoting supply chain process innovation. In such circumstances, partners could resort to other more effective means of motivating and coordinating partner exchanges for process innovation. When partners do not experience significant government intervention, they need to worry more about the negative impact of TC strength on supply chain process innovation. For example, in Shanghai, where government intervention is less obtrusive than in other inland cities, the collaboration between Tesla (a global leader in the electric vehicle [EV] industry) and CATL (Contemporary Amperex Technology Co., Limited, the largest battery cell manufacturer in China) was challenging.[6] It became difficult for the partners to reach consensus and make more changes on the battery package technologies for the supply chain while they achieved effective collaboration when CATL's TC was weak several years earlier.

Third, when guanxi is important, TC strength may erect even higher barriers against supply chain process innovation. In this situation, collaborating partners with advanced capabilities should not become complacent with what they have already achieved but should be alert against being trapped in existing processes. To facilitate process innovation, partners may need to

[6] https://libattery.ofweek.com/2022-07/ART-36001-8420-30569826.html

address the inertia and inaction caused by TC strength by keeping their minds open to external information and avoiding relational over-embeddedness. Meanwhile, partners need to fully utilize TC asymmetry to stimulate supply chain process innovation. For instance, in Wuhan, where guanxi importance is relatively high, NIO (a young EV company in China) collaborates effectively with CATL to optimize the battery layout within the EV and make the battery look like a bar of chocolate, which are critical for the "Battery as a Service (BaaS)" in the supply chain.[7]

Limitations and Suggestions for Future Research

Our study is subject to several limitations that suggest promising avenues for future research. First, although we highlight the distinctiveness between supply chain process innovation and product innovation, we empirically examine only the former. Further research is encouraged to simultaneously examine supply chain product and process innovation so as to fully identify their differences.

Second, we use perceptual measures to evaluate partners' TC and supply chain process innovation. It would be worthwhile using objective data (e.g., firm-level patent data, the actual adoption of new technologies and processes) to corroborate our findings. Moreover, our study focuses on how partners' TC affects supply chain process innovation, yet supply chain process innovation may in turn affect buyer and supplier capability development (Sodero et al., 2013). Future research could adopt a longitudinal research design to explore the co-evolution of partner capability and collaborative innovation.

Third, our sample consists of buyer–supplier dyads operating in manufacturing industries in a single country (i.e., China). While China's institutional environment bears some similarities to those in other emerging markets, it also displays salient idiosyncrasies, which may limit the

[7] https://www.nio.com/news/nio-launches-battery-service

generalizability of our findings. Thus, it would be interesting to investigate the role of capability strength/asymmetry in other institutional contexts to better understand the roles of institutional environments in supply chain innovation.

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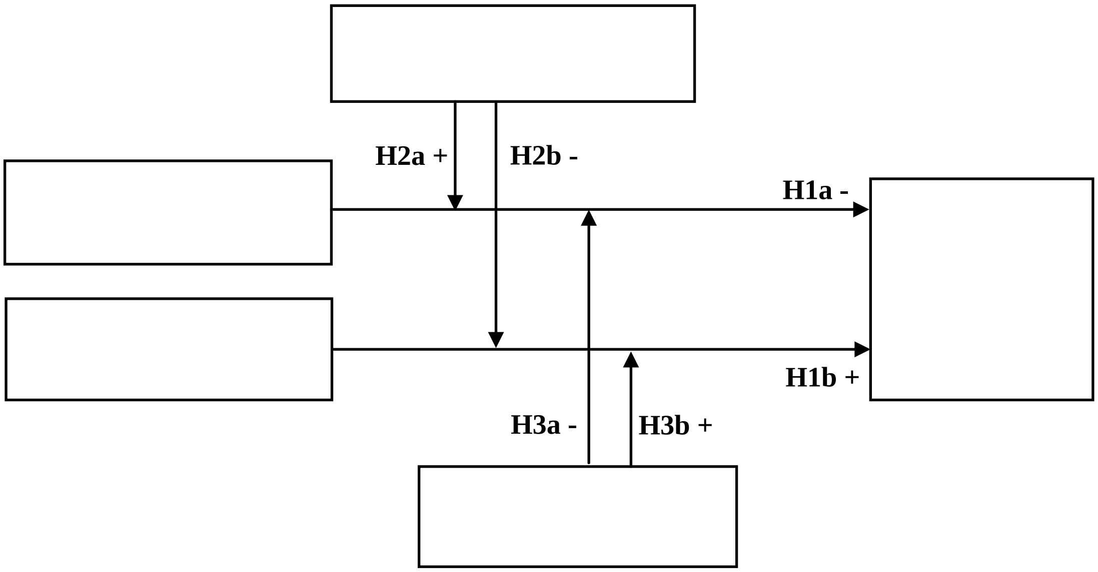


Notes:

[a] Responses from the buyer firm.
[b] Responses from the supplier firm.
[ab] Combining the responses from the buyer and the supplier firms.

Table 1 Comparison of supply chain product and process innovation

	Supply chain product innovation	Supply chain process innovation
Basic form	New products/product features	New technologies/production methods/management approaches/administrative systems
Essence	Changes in *what* the supply chain offers externally	Changes in *how* the supply chain creates and delivers related products.
Strategic foci	External focus; Market-driven	Internal focus; Efficiency-driven
Value creation and evaluation	Sustains a price premium over competitors' products; Success depends on external customers' acceptance	Streamline physical product flows, information flows, and/or financial flows; Evaluated by supply chain partners themselves
Imitability/ Protection	Easy to observe and imitate through reverse engineering	Intangible and invisible externally; Difficult to understand and imitate
Interplay	Supply chain product and process innovations are mutually supportive and complement each other. They can generate synergistic effects.	

Table 2 Basic descriptive statistics of the constructs

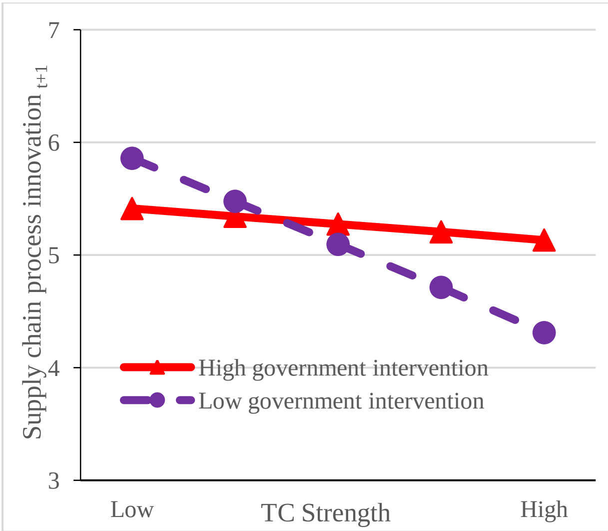
Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Supply chain process innovation $_{t+1}$																
2. TC strength	-0.14†															
3. TC asymmetry	0.17*	-0.03														
4. Government intervention	0.12	0.21**	-0.05													
5. Guanxi importance	-0.04	0.20*	-0.09	0.28**												
6. Prior exchange history	0.12	0.05	-0.07	0.16*	0.00											
7. Buyer age	0.15†	-0.01	0.06	0.05	-0.02	0.23**										
8. Supplier age	-0.02	0.03	0.00	-0.08	-0.17*	0.37**	0.16*									
9. Buyer size	0.04	0.10	0.05	0.25**	0.13	0.22*	0.25**	-0.04								
10. Supplier size	-0.08	0.15†	0.01	0.02	0.01	0.07	0.03	0.35**	0.21**							
11. Buyer state ownership	0.12	0.09	-0.13†	0.17*	0.17*	0.13	0.10	0.00	0.24**	0.23**						
12. Supplier state ownership	0.00	0.03	-0.10	0.14†	0.10	0.28**	0.08	0.33**	0.14†	0.34**	0.46**					
13. Buyer foreign ownership	0.10	0.02	0.09	0.06	-0.07	0.08	0.12	0.12	0.04	-0.01	-0.28**	-0.11				
14. Supplier foreign ownership	0.02	0.03	0.09	0.09	0.10	-0.16*	0.02	-0.05	0.10	0.04	-0.09	-0.23**	0.25**			
15. Buyer concentration	-0.11	-0.03	-0.12	-0.09	-0.10	0.17*	-0.00	0.17*	-0.11	0.05	-0.11	-0.06	0.11	-0.04		
16. Supplier concentration	0.18*	0.11	0.01	0.04	0.02	0.22**	0.02	-0.20*	0.16*	-0.20*	0.02	0.01	0.07	-0.21**	-0.01	
Mean	5.18	5.83	0.39	4.37	5.73	1.46	2.20	2.08	5.77	5.14	0.15	0.08	0.32	0.36	3.22	2.14
S.D.	0.85	0.57	0.43	1.03	0.80	0.55	0.54	0.68	1.47	1.32	0.35	0.28	0.47	0.48	1.06	1.17

Notes: †$p < 0.10$, *$p < 0.05$, **$p < 0.01$ (two-tailed tests).

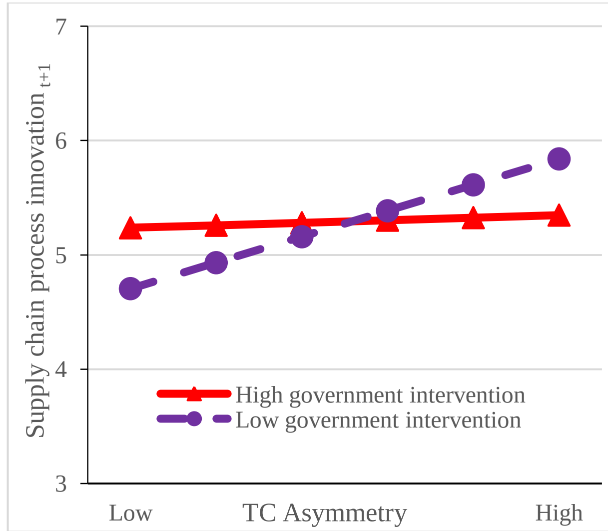
Table 3 TC strength/ asymmetry and supply chain process innovation

		DV= Supply chain process innovation $_{t+1}$									
		Model 1		Model 2		Model 3		Model 4		Model 5	
Variables		b	se	b	se	b	se	b	se	b	se
Buyer age		0.150†	0.124	0.134†	0.119	0.147*	0.116	0.123†	0.116	0.137†	0.111
Supplier age		0.086	0.118	0.107	0.116	0.099	0.114	0.123	0.114	0.113	0.109
Buyer size		-0.201*	0.050	-0.223*	0.049	-0.239**	0.048	-0.211*	0.048	-0.229**	0.046
Supplier size		-0.011	0.056	0.021	0.054	0.021	0.053	-0.022	0.054	-0.033	0.052
Buyer state ownership		0.208*	0.215	0.241**	0.208	0.223*	0.203	0.259**	0.204	0.240**	0.195
Supplier state ownership		-0.162†	0.291	-0.174†	0.284	-0.141	0.279	-0.157†	0.279	-0.112	0.268
Buyer foreign ownership		0.039	0.150	0.023	0.144	0.014	0.141	0.050	0.144	0.048	0.137
Supplier foreign ownership		0.101	0.145	0.096	0.140	0.083	0.137	0.145†	0.140	0.141†	0.134
Buyer concentration		-0.189*	0.063	-0.178*	0.061	-0.198**	0.060	-0.149*	0.060	-0.162*	0.058
Supplier concentration		0.216*	0.060	0.243**	0.058	0.246**	0.057	0.270**	0.058	0.280**	0.056
Prior exchange history		0.094	0.140	0.090	0.135	0.052	0.132	0.085	0.132	0.040	0.127
Supply chain process innovation $_t$		0.117	0.044	0.175*	0.048	0.181*	0.047	0.220*	0.048	0.242**	0.046
Government intervention (GovI)				0.052	0.071	0.124	0.072	0.029	0.070	0.107	0.069
Guanxi importance (GuaI)				-0.003	0.083	-0.022	0.081	-0.003	0.088	-0.022	0.085
TC strength (TCS)	**H1a**			-0.198**	0.111	-0.196**	0.109	-0.255**	0.119	-0.267**	0.114
TC asymmetry (TCA)	**H1b**			0.216**	0.148	0.243**	0.145	0.219**	0.145	0.251**	0.139
GovI * TCS	**H2a**					0.170*	0.085			0.226**	0.083
GovI * TCA	**H2b**					-0.156*	0.173			-0.168*	0.166
GuaI * TCS	**H3a**							-0.202*	0.129	-0.260**	0.126
GuaI * TCA	**H3b**							0.159*	0.188	0.194*	0.181
Industry dummies		Yes		Yes		Yes		Yes		Yes	
R^2		0.254		0.331		0.377		0.370		0.436	
Change in R^2				0.077**		0.046**		0.039*		0.105**	
Change in F				3.983**		4.960**		4.120**		6.140**	

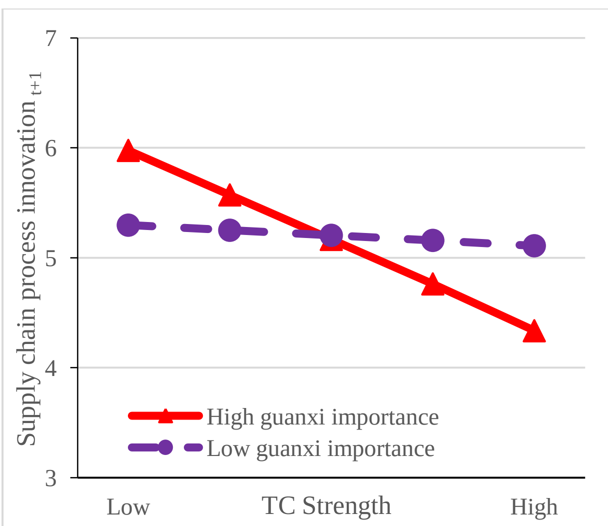
†$p < 0.10$, *$p < 0.05$, **$p < 0.01$ (two-tailed tests).
b = standardized coefficients, se = standard errors.



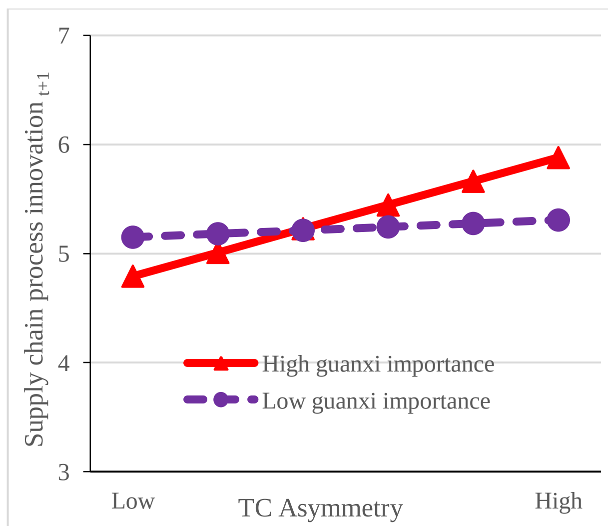
Panel A: Interaction between government intervention and TC strength (H2a)



Panel B: Interaction between government intervention and TC asymmetry (H2b)



Panel C: Interaction between guanxi importance and TC strength (H3a)



Panel D: Interaction between guanxi importance and TC asymmetry (H3b)

Figure 2. Moderating effects of government intervention and guanxi importance

Appendix Ⅰ

Table A-1 Construct measurement and validity assessment

Construct	Item	FL	CR	AVE
Buyer technological capability *Source: supplier*	This buyer has strong technological capability for accomplishing relevant tasks in the cooperation process.	0.70	0.89	0.68
	This buyer is known for its technological capability for getting things done in the cooperation process.	0.89		
	This buyer has much technological knowledge about how to facilitate the cooperation.	0.87		
	We are very confident about this buyer's technological capability.	0.83		
Supplier technological capability *Source: buyer*	This supplier has strong technological capability for accomplishing relevant tasks in the cooperation process.	0.78	0.85	0.59
	This supplier is known for its technological capability for getting things done in the cooperation process.	0.76		
	This supplier has much technological knowledge about how to facilitate the cooperation.	0.82		
	We are very confident about this supplier's technological capability.	0.70		
Government intervention *Source: supplier*	The government regulations change frequently.	0.83	0.94	0.79
	The changes of government regulations greatly affect our business operation.	0.88		
	The changes of government regulations greatly affect our decision-making.	0.99		
	Relevant local authorities such as Bureau of Tax and Bureau of Industry and Commerce Administration have great influence on our business operation.	0.85		
Government intervention *Source: buyer*	The government regulations change frequently.	0.80	0.92	0.75
	The changes of government regulations greatly affect our business operation.	0.92		
	The changes of government regulations greatly affect our decision-making.	0.88		
	Relevant local authorities such as Bureau of Tax and Bureau of Industry and Commerce Administration have great influence on our business operation.	0.86		
Guanxi Importance *Source: supplier*	In this market, business depends on good connections with friends and family.	0.88	0.91	0.77
	In this market, Guanxi is still very important.	0.93		
	In this market, Guanxi is a requirement for success.	0.83		
Guanxi Importance Source: ***buyer***	In this market, business depends on good connections with friends and family.	0.93	0.92	0.79
	In this market, Guanxi is still very important.	0.92		
	In this market, Guanxi is a requirement for success.	0.82		
Supply chain process innovation t *Source: buyer*	In the collaboration process, how often do you and the supplier jointly (1= "very infrequently", 7= "very frequently")		0.98	0.94
	adopt novel production technologies and processes?	0.97		
	incorporate new product development skills and processes in the industry?	0.98		
	employ novel managerial and organizing approaches to facilitate innovation?	0.96		
Supply chain process innovation t+1 *Source: buyer*	In the collaboration process, how often do you and the supplier jointly (1= "very infrequently", 7= "very frequently")		0.92	0.79
	adopt novel production technologies and processes?	0.90		
	incorporate new product development skills and processes in the industry?	0.92		
	employ novel managerial and organizing approaches to facilitate innovation?	0.84		

Model fit: χ^2/df = 2.11, $p < 0.01$, CFI = 0.93, IFI = 0.93, RMSEA = 0.08.
If unspecified, the scales are anchored as 1= "strongly disagree", 7 = "strongly agree".
SFL =standardized factor loading; CR = composite reliability; AVE = average variance extracted.

Appendix Ⅱ

Table A-2 The first stage of the control function approach

	TC strength		TC asymmetry		Supply chain process innovation$_{t+1}$	
Variables	b	se	b	se	b	se
Buyer age	-0.027	0.090	0.066	0.068	0.147†	0.124
Supplier age	0.037	0.085	0.014	0.064	0.051	0.117
Buyer size	0.022	0.037	0.098	0.028	-0.173*	0.050
Supplier size	0.192*	0.040	0.025	0.031	-0.039	0.056
Buyer state ownership	-0.050	0.045	-0.098	0.034	-0.177*	0.063
Supplier state ownership	0.143	0.044	0.041	0.033	0.223**	0.060
Buyer foreign ownership	0.051	0.156	-0.144	0.118	0.200*	0.216
Supplier foreign ownership	-0.035	0.213	-0.055	0.160	-0.162†	0.294
Buyer concentration	0.018	0.109	0.027	0.082	0.038	0.151
Supplier concentration	0.024	0.105	0.027	0.079	0.108	0.145
Prior exchange history	-0.026	0.101	-0.031	0.076	0.145	0.140
Legal support strength	0.265**	0.050			-0.062	0.069
Legal support difference			0.226**	0.107	0.103	0.196
Industry dummies	Yes		Yes		Yes	
R^2	0.134		0.113		0.255	

b = standardized coefficients, se = standard errors
†$p < 0.10$, *$p < 0.05$, **$p < 0.01$ (two-tailed tests).

Appendix Ⅱ

Table A-3 The second stage of the control function approach

	DV= Supply chain process innovation $_{t+1}$					
	Model 1		Model 2		Model 3	
Variables	b	se	b	se	b	se
Buyer age	0.150†	0.124	0.094	0.123	0.089	0.115
Supplier age	0.086	0.118	0.116	0.118	0.139	0.111
Buyer size	-0.201*	0.050	-0.239**	0.051	-0.229*	0.048
Supplier size	-0.011	0.056	0.073	0.065	0.037	0.060
Buyer state ownership	0.208*	0.215	0.318**	0.230	0.324**	0.216
Supplier state ownership	-0.162†	0.291	-0.181†	0.299	-0.134	0.280
Buyer foreign ownership	0.039	0.150	0.006	0.148	0.043	0.139
Supplier foreign ownership	0.101	0.145	0.098	0.142	0.157*	0.135
Buyer concentration	-0.189*	0.063	-0.158†	0.069	-0.152†	0.065
Supplier concentration	0.216*	0.060	0.289**	0.066	0.348**	0.063
Prior exchange history	0.094	0.140	0.117	0.137	0.068	0.129
Supply chain process innovation $_t$	0.117	0.044	0.228*	0.051	0.311**	0.049
Government intervention (GovI)			0.035	0.071	0.076	0.069
Guanxi importance (GuaI)			-0.001	0.083	-0.004	0.085
TC strength -1st stage residual			0.378	0.456	0.518†	0.438
TC asymmetry-1st stage residual			-0.405	0.674	-0.362	0.628
TC strength (TCS)			-0.592*	0.443	-0.819**	0.438
TC asymmetry (TCA)			0.644*	0.656	0.639*	0.610
GovI * TCS					0.204**	0.083
GovI * TCA					-0.171*	0.164
GuaI * TCS					-0.299**	0.127
GuaI * TCA					0.197**	0.179
Industry dummies	Yes		Yes		Yes	
R^2	0.254		0.349		0.458	
Change in R^2			0.095**		0.109**	
Change in F			3.309**		6.567**	

b = standardized coefficients, se = standard errors
†p < 0.10, *p < 0.05, **p < 0.01 (two-tailed tests).

Appendix Ⅲ

Table A-4 Robustness check: Calculating TC strength/asymmetry based on the standardized scores of buyer and supplier TC

	DV= Supply chain process innovation $_{t+1}$					
	Model 1		Model 2		Model 3	
Variables	b	se	b	se	b	se
Buyer age	0.150†	0.124	0.134†	0.119	0.137†	0.111
Supplier age	0.086	0.118	0.107	0.116	0.113	0.109
Buyer size	-0.201*	0.050	-0.223*	0.049	-0.229**	0.046
Supplier size	-0.011	0.056	0.021	0.054	-0.033	0.052
Buyer state ownership	0.208*	0.215	0.241**	0.208	0.240**	0.195
Supplier state ownership	-0.162†	0.291	-0.174†	0.284	-0.112	0.268
Buyer foreign ownership	0.039	0.150	0.023	0.144	0.048	0.137
Supplier foreign ownership	0.101	0.145	0.096	0.140	0.141†	0.134
Buyer concentration	-0.189*	0.063	-0.178*	0.061	-0.162*	0.058
Supplier concentration	0.216*	0.060	0.243**	0.058	0.280**	0.056
Prior exchange history	0.094	0.140	0.090	0.135	0.040	0.127
Supply chain process innovation $_t$	0.117	0.044	0.175*	0.048	0.242**	0.046
Government intervention (GovI)			0.052	0.071	0.104	0.069
Guanxi importance (GuaI)			-0.003	0.083	-0.019	0.084
TC strength (TCS)			-0.198**	0.064	-0.267**	0.065
TC asymmetry (TCA)			0.216**	0.063	0.251**	0.059
GovI * TCS					0.226**	0.048
GovI * TCA					-0.167*	0.071
GuaI * TCS					-0.260**	0.072
GuaI * TCA					0.193*	0.077
Industry dummies	Yes		Yes		Yes	
R^2	0.254		0.331		0.436	
Change in R^2			0.077**		0.104**	
Change in F			3.983**		6.140**	

b = standardized coefficients, se = standard errors

†$p < 0.10$, *$p < 0.05$, **$p < 0.01$ (two-tailed tests).