How fairness perceptions, embeddedness, and knowledge sharing drive green innovation in sustainable supply chains
An equity theory and network perspective to achieve sustainable development goals
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How fairness perceptions, embeddedness, and knowledge sharing drive green innovation in sustainable supply chains: an equity theory and network perspective to achieve sustainable development goals

Citation to this article:

Abstract:

The response to increasingly serious environmental issues is no longer limited to companies but is an important issue among supply chains. Green innovation is an essential segment of gaining a competitive advantage in the sustainable supply chain to achieve sustainable development goals. However, boosting sustainable supply chain development through green innovation is a complex network activity in which a large number of partners are embedded, and the need exists to transfer or share knowledge in an equal and reasonable exchange process. This study proposes a novel framework to explore perceptions of fairness that include procedural and distributive approaches as antecedents. We also examine embeddedness, knowledge sharing, and green innovation in the sustainable supply chain in terms of equity theory and a network scenario. This study contributes to the sustainable development goals (SDG’s) such as Decent Work and Economic Growth (SDG 8); Industry, Innovation and Infrastructure (SDG 9); Responsible Consumption and Production (SDG 12) and Climate Action (SDG 13). Useable sets of data were collected and used to test our theoretical hypotheses by surveying 225 firms in China’s manufacturing supply chain sectors. The research model is analysed by the partial least squares structural equation modelling (PLS-SEM) methodology. The empirical findings reveal that perceived fairness constructs that consist of procedural and distributive fairness have a highly positive linkage with embeddedness, while those that do not present significant effects on knowledge sharing directly. Moreover, both embeddedness and knowledge sharing demonstrate significant partial mediating impact on green innovation in the sustainable supply chain; knowledge sharing especially plays a key role in achieving green innovation. This study finds that firm size as a control variable presents a positive effect on green innovation. Finally, conclusions and practical implications are given.
Keywords: Sustainable supply chain; fairness perception; embeddedness; knowledge sharing; green innovation;

Sustainable development goals (SDG’s)
1. Introduction

Because of resource exhaustion and severe environmental pressure, the capture of green innovation abilities has already been considered as a pivotal means to integrate sustainable requirements into the supply chain. Further, green innovations can generate competitive advantages and improve an operation’s performance (Cheng, 2018; Zailani et al., 2015; Olugu et al., 2011). A number of extant literatures debate bilateral or alignment relationships and green innovation performance in supply chains; however, a well-defined embeddedness for proactively affecting green innovation within a network framework is still not well interpreted and explained. Some research discusses incorporating green innovation into sustainable supply chains from a perspective that focuses on tangible resources, but there is little consideration related to intangible capabilities. Knowledge sharing is one such intangible concept that underscores the theoretical argument about green innovation in supply chains. Hence, taking these two critical issues into account, we attempt to explore: how do embeddedness and knowledge sharing together influence green innovation in building a sustainable supply chain?

Unlike the cooperation relationship between upstream and downstream debated in current literature, the supply chain can be perceived as a business network of organizations including buyers, suppliers, and other participants involved in the process of a given company-centred firm (Mazzola et al, 2015). Moreover, some researchers indicate that sustainable supply chain networks provide the way for supply chain members to communicate with the goal of identifying qualified partners to build long-term relationships (Pagell & Wu, 2009; Darbari et al., 2019). Embeddedness from the network perspective is a clear element when one examines factors that contribute to green issues in supply chains (Stefano and Sancho, 2018; Tate et al., 2013; Penker, 2006). Embeddedness represents a kind of reciprocal relationship between partners; it is a type of investment that brings about mutual benefits by way of cooperation, trust, and learning from one another (Kim et al., 2011). In other words, a certain level of embeddedness means sufficient network capital has been generated in the supply chain, and this link is necessary for the mutual cooperation green innovation and sustainability demands (Tachizawa & Wong, 2015). Consequently, partners who cooperate closely and who form a better relationship are embedded in the network; hence, their partnership may actively drive improvements in innovation expected in a sustainable supply chain.

A sustainable supply chain is also defined as a network of linked and coadjuvant organizations that jointly and collaboratively aims to run, govern, and improve the flow of information from
suppliers to the end pipes (Christopher, 2016). Other researchers have suggested that knowledge sharing is a vital source to push green innovation in supply chains (Lim et al., 2017; Ryszko, 2016; Lee, 2015; Wong, 2013; Cheng et al., 2008). In essence, green innovation is a knowledge-intensive and high-risk operational activity. In addition to the need for strong tangible resources, intangible capabilities are also essential for constructing sustainable supply chains, and knowledge or information sources are among the most vital. Besides using internal knowledge, building green innovation within a supply chain requires all parties to jointly develop skills and knowledge; often, those skills may be different from an individual’s basic competencies (Ben et al, 2018; Fawcett et al., 2015). Firms need technologies and information continuously derived from partners, and coordination between those partners can help make up for a weakness or lack of ability from one element.

While embeddedness and knowledge sharing are clearly integral to promoting green innovation in sustainable supply chains, it is helpful to identify some fundamentals by which partners integrate their supply chain knowledge and recommit themselves to being embedded in the network. In short, we want to ascertain how partners can collaborate most effectively (Qin et al., 2016; Katok & Pavlov, 2013; Hornibrook et al., 2009). The equity theory (ET) states that fairness perception is specifically important in long-term relationships that seek to leverage each other’s competencies and resources in order to reach a common goal (Adams, 1966). Participants always evaluate their collaboration with partners not only in the light of distributive fairness related to the investment-reward ratio, but also dependent upon the procedures the partners design to promise rewards for contributions (Katok & Pavlov, 2013; Liu et al., 2012; Hornibrook et al., 2009). Many studies have applied ET to investigate multilateral relationships embedded in networks or cross-organization knowledge sharing in the context of the supply chain. For example, some studies have posited that fairness perceived by partners in the supply chain contributes to the ability to maintain stable and better embeddedness and to improve innovation performance (Kim et al., 2017; Wu et al., 2014; Griffith et al., 2006; Asree et al., 2018). Additional studies proposed the relatively adopted fairness perception can be beneficial to knowledge sharing between these actors who carry out innovation activities based on supply chain (Kim et al., 2017; Ziegler, 2015; Burg et al., 2013). According to these theoretical foundations of ET in a supply chain, we therefore focus on the prerequisites of embeddedness, knowledge sharing, and fairness perceptions that consist of distributive fairness and procedural fairness.

As mentioned above, we propose that embeddedness, based on network and knowledge sharing, should be considered a key factor in promoting green innovation to achieve a sustainable supply chain.
Moreover, we also define that fairness perceptions between firms and supply chain partners is the vital antecedent of these two elements. Historically, several researchers have posited that green management and green technology innovation are important elements to examine green innovation via appropriate surveys. Our work offers insights from different dimensions; specifically, both green management and green technology indicators are referred to as measurements for green innovation which helps to achieve sustainability development goals (SDG’s). In addition, other studies on supply chain fields propose that firm characteristics, such as firm size and ownership, have an impact on possible effects on encouraging green innovation. This study thus applies firm size and ownership as control variables to our empirical analysis. Thus, according to these discussions, we provide a novel framework in exploring the relationship among fairness perceptions, embeddedness, knowledge sharing, and green innovation of sustainable supply chains. Finally, the partial least squares (PLS) technique makes latent variables be built as formative constructs and demands on sample size. But the PLS technique has no distributive assumptions within its parameter estimation purposes; its analysis of structural equation models as traditional significance testing and model evaluation are deemed inappropriate (Ringle et al., 2012). Therefore, we make full use of 226 investigation samples from manufacturing firms in 16 Chinese provincial areas by PLS-SEM method to testify our research hypotheses.

The remainder of this paper continues as follows: Section 2 presents the theoretical background by reviewing existing literature and then forming the hypotheses accordingly. Section 3 outlines the research design where questionnaires and main constructs are built in and data collection is shared. Section 4 analyses and discusses these results through our empirical research model. Section 5 summarises the conclusions, main contributions, and provides some practical implications due to empirical findings.

2. Theoretical framework and Hypothesis development

2.1 Green Innovation in the sustainable supply chain

The sustainable supply chain encompasses the flow of goods, information, and capital, and it includes interaction among firms along the supply chain. Ideally, sustainable goals involve all three dimensions – economic, environmental, and social – that emerge from the relevant partners’ demands (Marshall et al., 2015; Seuring & Muller, 2008; Mardani et al., 2020; Kannan, 2018; Mathivathanan et al., 2018). Das (2018) further reveals that sustainable supply chains blend the goals of corporate social
responsibility (CSR) and supply chain management, and this blending facilitates companies to finish their sustainability goals at a micro-level (Govindan et al., 2018). Different from the conventional supply chain, sustainable supply chains propose that the synthetical effect originating from economic, environmental, and social dimensions should be emphasized at both the manufacturing and flow processes (Marshall et al., 2015). Specifically, supply chain operations can decrease environmental damages and enhance the overall conditions of all supply chain members by facilitating innovation initiatives (De Gao et al., 2017; Geyi et al., 2019; Kannan et al., 2020)

Green innovation enables a double benefit for a business. One is that the company receives good rewards from creating sustainable products; the second is that it achieves practical financial benefits that improve its competitiveness and its business success (Robinson & Stubberud, 2013) to achieve SDG’s. Many definitions of green innovation have been suggested by scholars. Green innovation is defined as several actions of new ideas, commodities, processes, services, technologies, and management systems that deal with environmental issues (Chen et al., 2006). Similarly, green innovation refers to the improvements that follow ecological laws or principles, reduce resources and energy burden, and avoid, eliminate, or mitigate ecological environmental pollution or damage during production and management (Kemp & Pearson, 2007). It is also regarded as “the new introduction or significant product (good or service), process, organisational changes or marketing solution that cut down the natural consumption of resources and decrease the release of harmful substances across the overall life-cycle” (Ghisetti et al., 2017). Satisfying sustainability requires some essential green innovation in supply chain activities as a whole which must be adopted in different scientific ways.

Green innovation is categorised as involving several main components, namely green production, green process, green managerial innovation, and technology innovation (Qi, et al., 2010; Rennings, 2000). In fact, the manufacturing sectors have made great contributions to providing enough raw materials and semi-finished goods for production development and daily life. Still, there are critical, significant environmental problems, and firms often experience great pressure from governments and the public to focus on Climate Action goal (SDG 13) through use of technological innovations in the production. For example, the Coca-Cola Company developed the green technology to manufacture completely recyclable plastic bottles, of which 30% of the plastic is made from sugar cane (Dubois, 2011). The Lenovo Group reduced carbon dioxide by some 60,000 tons through innovative green management processes in the construction of a sustainable supply chain since 2008.

Therefore, this paper tests green managerial and technology innovation in current research (Lee et al., 2014; Zhu et al., 2012) which contributes to SDG 13. Green managerial innovation always identifies some changes on an organisational level. For example, organisational adjustments may include the foundation of a professional environmental department whose executives and specialists respond to environmentally-friendly concerns from external pressure (Chen et al., 2006; Rennings, 2000). Green technology innovation is improvement in the use of a series of new technologies that lead to no negative impact on the environment: low carbon, energy-saving, pollution prevention, and waste recycling in different utilisation degrees (Cheng et al., 2014; Chen et al., 2006) which contributes to achieving SDG 12 (i.e. Responsible Consumption and Production).

Firms that employ green innovation also attach vital attention to establishing better embeddedness and knowledge sharing as a means to successfully manage their sustainable supply chain. Activities that germinate green innovations require a huge amount of timely knowledge efforts and require the establishment of a relationship with partners in the supply chain. Two essential concerns, being embedded in the supply chain network and the sharing of knowledge, are defined as key mediators to explore the problem from literature. Thus, a set of successful information flows depend on good relations with actors embedded in the network as a platform due to long-term interactions. It is the view of this study that lock-in networks without an equal means to govern risky behaviours with members may create a problem with green innovation, especially if they are short of knowledge or information sharing. Therefore, for this goal, embeddedness and knowledge sharing aimed at enhancing green innovation of the supply chain should be borne in mind in this study.

2.2 Fairness perception and the sustainable supply chain

According to the equity theory, the perception of fairness or justice is clearly a vital element that must be addressed. Individuals and groups perceive their relationship with associated parties by comparing rewards they receive from their work, and this perception has a critical effect on their sense of justice (Adams, 1966). The perception of fairness also depends on the views of the cross-organisational boundary partner. That is, if individuals feel their consequences of input-output have been under-rewarded after comparison, they will feel unfairly treated or unbalanced. When individuals perceive someone as untrustworthy, especially the stronger they sense inequity, the more likely they are to end the relationship. That relationship may be terminated via several ways, including the reduction or distortion of their inputs and replacement of exchange objects. On the other hand, those who feel they have obtained equitable outcomes in an exchange are more likely to generate
affirmative feelings. The perception of fairness is central to strengthening relationships with each other (Katok & Pavlov, 2013).

Fairness perception always involves multiple dimensions that consist of distributive fairness, procedural fairness, and interaction fairness. Some authors have discussed that interactional justice is perceived in the process of procedural operations (Bies & Moag, 1986). Hence, in our study, we mainly focus on fairness through distributive and procedural justice, respectively. Distributive justice refers to an assessment regarding the degree to which participants receive returns. Their contributions (commitments, responsibilities) generate rewards that can be shown in tangible forms (such as profits or dividends) and in more intangible ways (such as reputation improvement or knowledge acquisition). Moreover, procedural justice focuses on the evaluation of the level to which the parties are independent in the procedures and standards that are transparent, adjustable, modifiable, unbiased, representative, and non-discriminatory, as well as being consistent with contractual terms for decision making and execution in the exchange process (i.e., treating bilateral equally). It includes the feeling of whether the parties are fair to the procedure in the relationship (Griffith et al., 2006).

Further, several studies indicate that perception in fairness has a significant influence on innovations in the supply chain field (see Kim et al., 2017; Qiu et al., 2009). They postulate that innovation in the supply chain is a trial with great risks related to the introduction of new technology. Fairness perception is considered as a basic principle of maintaining a long-term exchange relationship between organisations. Thus, activities of the supply chain, including green management practices, have always been deemed as a series of collaborations along the whole spectrum (Vachon & Klassen, 2008). It can play an active role in reducing risks among cooperative members, reinforcing resource sharing, and maintaining relationship stability, thus promoting the long-term construction and maintenance of exchange relations (Dangelico et al., 2017; Robinson & Stubberud, 2013). Only when members perceive that fairness exists in exchanges can equity and trust ultimately turn into the opportunity of knowledge exchange. Consequently, in our study, fairness perception is the starting point for establishing various knowledge sharing relationships, and the result of the assessment directly affects the organisation's attitudes and behaviours toward green innovation.

2.3 Embeddedness and knowledge sharing in green innovation

There is a distinct development of network capital domains in which several principles of embeddedness are linked (Bernardes, 2010). When it is seen as a valuable asset, network capital is conducive to gaining access to and making resources available through social relations (Granovetter,
Based on this perspective, embeddedness, when applied to the supply chain, is regarded as the opportunity and capability of members to acquire knowledge, information, and other resources directly or indirectly absorbed from the network (Boons & Grenville, 2013). With stronger embeddedness in the network, including both relational and structural, network actors are more likely to respond in ways that contribute to others maintaining the relationship (Nahapiet & Ghoshal, 1998).

In some current supply chain and operation management studies, embeddedness has been widely used as a theoretical view to explain partnership issues in both the upstream and downstream (e.g., Peng et al., 2018; Kim et al., 2017; Li et al., 2014). Both synergism and cooperation emerge among actors in the supply chain network in which the firm is embedded. That is, neither the vertical bilateral collaborations nor horizontal dyad collaborations belong to network-based partnerships in their network. In comparison with the conventional dyadic relationship, which pays more attention to buyers and suppliers, the network in the supply chain also consists of other actors (Mazzola et al., 2015). Actually, some critical suppliers and universities have come to be among the most involved actors in terms of the green innovation effect. Thus, the other side of embeddedness implies that capital, such as heterogeneous resources, specific knowledge, and information (which are needed in the exchange) are embedded in the network (Ben et al., 2018). Being socially embedded is useful to prompt firms to gain richer access to resources and to gather precious information on each other. Embeddedness decreases information asymmetry, which raises the possibility of opportunistic action. Hence, it means that a wide range of resources could be received in a supply chain network in order to collaborate fruitfully.

Knowledge sharing is one of the critical factors resulting in exemplifying a competitive advantage for supply chains through promoting skills training. Knowledge sharing refers to a source and availability of receiving information, such as regulations and laws, and various knowledge including tacit and exploitative knowledge among various members of a supply chain (Ben et al., 2018) through green training which contributes to decent work and economic growth goal (SDG 8). Knowledge or information sharing by advanced telecommunication means will facilitate collaboration in supply chain operations and lead to better performance. Specifically, Mazzola et al. (2015) put forward that innovation in the supply chain is involved in the business network and not only in the manufacturing process but for using and exploiting knowledge or competencies from parties. Several kinds of literature have also investigated the role and importance of knowledge sharing among buyers and suppliers in innovation (Kim et al., 2017; Oke et al., 2013). Innovation is highly relevant to creating new knowledge and skills that are intangible assets, which is determinant.
for the competitiveness of firms and more globally for all actors in the network. Because of the flow and tacit nature of specific knowledge, besides internal competencies, a firm generally needs the opportunity of learning from other members and integrating those resources to innovate. Green innovation especially requires various ideas and knowledge (e.g., Lin & Chen, 2017; Medeiros et al., 2014), and these must create added value through managerial behaviours and technologies.

### 2.4 Development of Hypotheses

In line with our perspective and theoretical arguments, the goal of this study is to explore how to enhance the likelihood of green innovation in the sustainable supply chain. Specifically, we develop some various hypotheses regarding the influences between fairness perception, embeddedness, and knowledge sharing, respectively. We also pay more attention to analysing the relationship between embeddedness, knowledge sharing, and green innovation, and we test the mediation of knowledge sharing in the research process.

#### 2.4.1 Network embeddedness related to justice policies

The positive impact of fairness perception on the maintenance and progress of relations related to network capital has been of interest in literatures related to supply chain management (Kim et al., 2017; Katok & Pavlov, 2013; Hornibrook et al., 2009). Relations among a network’s actors are embedded in how interaction and interdependence emerge. Distributive fairness is referenced in the investment-reward ratio from an exchange, and procedural fairness may produce outcomes that are based on justice principles. Perceived justice consists of both distributional and procedural aspects; each may reveal the prerequisite factors for embeddedness between actors in the sustainable supply chain.

When a company wants to construct a stable relationship with its network partners, the administration of distributive fairness should be perceived. Successful embeddedness in the network always originates from how much the firm can acknowledge its partner’s trustworthiness, consistency, and reputation in the justice of distributive fairness (Kim et al., 2017). If a fair outcome or benefit distributed in the coordination means that a high level of interest is derived from partners, a strong motivation exists to develop interdependence and an embedded relationship. Further, a benefit will be derived from effective reciprocity in communication. In other words, the more impartiality is received in an exchange, the more significant the possibility to provoke a willingness of embeddedness between network actors.
On the other hand, studies indicate that perception in fairness has significant influence in the supply chain innovations field (Du et al., 2017; Janssen, 2004; Kim & Mauborgne, 2003). They postulate that innovation in the supply chain is a trial with high risks related to the introduction of new technology. If a lack of enough interaction exists at an early stage, little misunderstandings between members will likely occur. Furthermore, cooperation will be strained (Wu et al., 2012). To avoid such risks, the organisation must assess the uncertainties and risks that exist during the exchange process and proactively build in procedural fairness measures. Cooperation and calculated trust forms the basis of a long-term relationship among members of the sustainable supply chain. Therefore, such reasonable procedures and processes can be designed to guarantee maximum profit and to relieve risks among the members of the supply chain. Firms and their partners seek to form reliable cooperation on green activities. In line with some of the abovementioned insights, this reasoning brings forward the following hypothesis:

**H1a**: The level of distributive fairness in the sustainable supply chain is positively associated with embeddedness in the network for driving green innovation.

**H1b**: The level of procedural fairness in the sustainable supply chain is positively associated with embeddedness in the network for driving green innovation.

### 2.4.2 Knowledge sharing related to justice policies

There is an undeniable fact that knowledge generation and transformation such as initiating new situations, learning new techniques, and solving problems, constitute the foundation of innovation activities in the supply chain domain (Millán et al., 2016; Craighead et al., 2009; Sporleder & Moss, 2002). Knowledge sharing pays attention to an interactive process in which companies accumulate and absorb new knowledge (Pacheco et al., 2018). Further, augmenting a company’s internal capacities does not satisfy the need to balance the knowledge gap in the green innovation process. Besides acquiring corresponding green knowledge or information through a formal economic transaction implemented by rigorous contracts and rules, knowledge sharing can be integrated via an intangible exchange through a series of justice perception principles among members in collaboration.

Fairness is considered as an antecedent of knowledge or information sharing (Kim et al., 2017; Wu et al., 2014). In real conditions, because network actors belong to a distinct entity, they prefer to hold their idiosyncratic knowledge to maintain their advantage; hence, to their particular benefit,
sharing their private knowledge is always delayed. When fairness perceptions exist and cooperation is dominant (such as focusing on how to distribute output equally), a better benefit expectancy is planted in the ongoing knowledge sharing and its ending. In other words, if reciprocity and profit are added to each other, sincere distributive fairness encourages more extensive knowledge sharing between network members and further improves the advantage of knowledge. Therefore, distributive justice adopts favourable attitudes and actions to realise knowledge sharing with network members.

Moreover, a greater willingness to share knowledge with members reduces opportunistic behaviours and mitigates potentially illegal and immoral actions between information symmetry. Specifically, with greater procedural fairness that may include standard, reliable behaviour regulations, duties and governance mechanisms, sustainability supply chain partners would be more open and honest in sharing knowledge without worrying about leaked knowledge or inappropriate information. As a result, fairness perceptions can overcome some of the difficulties associated with information asymmetries that occur in inter-organization exchanges; these fairness perceptions can accelerate sincere knowledge sharing among network members. According to those views, this paper posits the following hypotheses:

**H2a:** Distributive fairness in the sustainable supply chain is positively related to knowledge sharing for driving green innovation.

**H2b:** Procedural fairness in the sustainable supply chain is positively related to knowledge sharing for driving green innovation.

### 2.4.3 Embeddedness, knowledge sharing, and green innovation

Effective knowledge sharing presents a social-technical question that contains the use of information transformation for knowledge exchange and coordination of the different business partners within the supply chain (Cheng, 2011). Accordingly, the active or passive embedding of enterprises in the network, that is, the formation of different forms of interaction, has a profound impact on knowledge sharing. Much research has examined how embeddedness represents the possibility of learning from other network members and integrating innovations with resources and also reflects the ability and opportunity for companies to access knowledge, information, and other resources directly or indirectly from the network (Cainelli et al., 2015; Li et al., 2014; Sporleder & Moss, 2002). Developing higher-specific relationship assets and coordination conflicts through continuous ties can effectively promote the formation of knowledge sharing mechanisms. Companies
effectively integrate different types of network relationships with diverse participants to improve the richness of knowledge in the network. When attracted by these benefits, partners will be more willing to build cooperative, stable, and long-term relationships with enterprises and to share knowledge.

In a similar vein, a robust structural embeddedness in the network means many degrees of power and interdependence among partners (Peng et al., 2018). As a result, companies that occupy a good position in the network can fully mobilise the enthusiasm of partner knowledge sharing by leveraging multiple bilateral relationships. In particular, a core firm with greater network power is the maker of network rules, which dictates that it has more resources to influence knowledge sharing opportunities and the recipients to which it is sent (Ramia et al., 2018). Based on these insights, the positive influence of embeddedness on knowledge sharing of sustainability SCM should be acknowledged among firms (Rossoni et al., 2014). Thus, the following hypothesis is proposed:

**H3**: Embeddedness in the sustainable supply chain is positively related to the knowledge sharing for driving green innovation.

Next, several sustainability researchers have demonstrated that embeddedness should play a critical role in influencing the development of sustainable practices as network context may promote or limit it under different collaborative constructions (Zhu et al., 2017; Tate et al, 2013; Chiou et al., 2011; Vachon & Klassen, 2006). Diverse typologies of relations in the network may be built, such as alliances or collaborations, co-creation, outsourcing, joint ventures and so on, which lead to a better availability of sustainable cooperation among members (Burg et al., 2013). Meanwhile, sufficient integrity and trust exist in affirmative and honest relational embeddedness, which should encourage the firm to implement and expand green innovation in the sustainability supply chain (Stefano & Montes, 2018).

Green innovation means that some challenges and skills from burgeoning technology lead to market uncertainties for a firm. Widespread solutions, specific technical standards, or policies that will stimulate green performance simply may not be available (Dangelico et al., 2017; Ziegler, 2015). Stakeholders and those embedded in the firm will proactively seek green innovation for the sustainable supply chain; they recognize that the goal of sustainability is beneficial to win competitive advantage and to satisfy customers’ demands for change. Thus, it leads to the hypothesis below:

**H4**: Embeddedness in the sustainable supply chain positively affects green innovation.

### 2.4.4 Knowledge sharing and green innovation
Undoubtedly, knowledge sharing is a crucial step in driving green innovation in the supply chain (Abbas & Sağsan, 2019; Chen et al., 2014; Marchi & Grandinetti, 2013). Knowledge sharing is the source and co-creator for learning sustainability-oriented innovations and it presents reciprocity in the resource exchange process (Wong, 2013; Sporleder & Moss, 2002). Through actions of sharing and exchange, firms connect their skills and knowledge with complementary competencies of other network members. These actions encourage knowledge transfer rooted in organisational routines and stimulate new knowledge creation to update organisational capacities. Thus, profiting from knowledge sharing with network actors, firms need to exchange knowledge, information, and other competencies to minimise uncertainties and to efficiently implement progress of green innovations required to meet sustainability necessities.

Knowledge sharing with network members reduces the costs and risks of developing new methods to enhance green management and technology innovation and avoids suffering from tremendous market failure. More specifically, with an expanded supply of tacit knowledge (such as market information, innovation experience, and others derived from partners), difficulties in facing new issues regarding green innovation are decreased (Craighead et al., 2009; Sporleder & Moss, 2002). Hence, green innovation depends upon cooperation among members; it is more important than any other type of innovation (Cuerva et al., 2014; Halila & Rundquist, 2011; Wagner, 2008). Based on the above discussion, this study posits the following hypothesis:

**H5:** Knowledge sharing in the sustainable supply chain positively affects green innovation.

Based on the arguments above, we present a novel framework of the impacts of both requisite factors under a network background of significant importance for green innovation: embeddedness and knowledge sharing. We also discuss how fairness perceptions, procedural and distributive, can encourage firms to interact with their partners or suppliers and exchange their green knowledge. Knowledge sharing performs a strong mediating role in the relationship between embeddedness and green innovation. Meanwhile, a second order construct is proposed for observing green technology innovation and green management innovation whose influence is even greater. A pictorial pattern in **Figure 1** depicts a research model. The below discussions provide the fundamental theoretical foundations and research hypotheses.
3. Research Design

Our research data primarily comes from utilising the collected questionnaire which draws on some extant literature and was investigated in some manufacturing sectors in China over eight months through sending e-mails to senior managers. To identify the concept precisely, some modifications were made in the back-translation by other academics. We achieved 225 reliable samples from an initial 2000 surveys.

3.1 Survey measurements

A self-administrated questionnaire was designed as a research approach to test these hypotheses. As presented in Appendix A, all questionnaire items were measured on a 5-point Likert scale, from 1 (extremely disagree) to 5 (strongly agree). Additionally, because the questionnaire survey needs to be implemented by Chinese respondents, editing some words and sentences was required to improve comprehensibility. Consequently, back-translation occurred among bilingual Chinese and English scholars to guarantee conceptual equivalence. All items in the questionnaire were thus revised by two researchers in this aspect, employing the best utilisation of words. The reviewed questionnaire was tested in a small group of postgraduates to assure that the questions were scutable and close to practice in China, and questions were adjusted as needed.

For control variables, some studies have proved that differently-sized firms not only may have diverse degrees of green capacities and efforts, but also may face different green innovation-related circumstances (Martínez-Ros and Kunapatarawong, 2019; Dai et al., 2015). Ownership is regarded as
another critical effect on firm actions. In fact, Chinese central or local government controls a huge number of resources and access that is often deemed as “grabbing hand” by regulating the market. The government tries to guarantee state-owned enterprises to carry out green or sustainable targets by nominating senior management due to the overwhelming state share (Gao & Hafsi, 2015). On the contrary, non-state-owned enterprises rely on their entrepreneurial spirits and internal competencies to advance their business goals under more limited resources (Yang et al., 2019). Given these implications, we recognize these differences in their condition for green innovation in supply chains. In this study, the scale of the enterprise and its nature of ownership are referred to as control variables (Wu and Chang, 2012). The firm size is an essential factor for influencing the capacity and performance of green innovation and is measured by implementing the total number of employees in the company. It is distinguished from three sizes (large, medium, and small), based on their difference in sales volume which originate from the National Bureau of Statistics on Issuing the Measures for Classification of Large, Medium, Small and Miniature Enterprises for the Purpose of Statistics in China². We also consider that ownership structure consists of two types, state-owned and non-state.

3.2 Research Methodology

According to Ringle et al. (2012) and Lin et al. (2016), an important multivariate analysis method, partial PLS-SEM, is a popular structural equation modelling technique. This method adopts a component-oriented access on estimation process to minimize the limitation on residual distributions. Covariance-based SEM (CB-SEM) indicates theoretically reasonable cause-effect relationships and does not focus on significance tests or interval estimations. The PLS technique has the ability to handle pertinent issues (like small sample, non-normal data, and formatively latent measurements). Because the dependent variable with its built-in formative indicators via a second-order factor is appropriate for this study, this methodology has been chosen for our research purposes.

3.3 Samples and data collection

The primary data for the research instrument was collected in China, including fifteen provinces in east, middle, and west areas, and we tested the hypotheses through surveying operating firms that were chosen randomly as the study sample. Every questionnaire packaged as an attachment was sent

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via an available email address to 2000 senior managers, each representing one company. The whole data collection process lasted eight months; it started in July 2016 and ended in February 2017. In total, 230 adequately responded questionnaires were returned. After deleting questionnaires that lacked critical information and missed data, we finally obtained 225 questionnaires, leading to an effective response rate of 11.25%. Table 1 depicts the sample summaries.
Table 1 Basic informants of demographics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Industry</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petroleum and natural gas extraction</td>
<td>9</td>
<td>4.1</td>
</tr>
<tr>
<td>Coal mining and dressing</td>
<td>19</td>
<td>8.2</td>
</tr>
<tr>
<td>Metals mining and dressing</td>
<td>18</td>
<td>7.8</td>
</tr>
<tr>
<td>Non-metals mining and dressing</td>
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<td>4.6</td>
</tr>
<tr>
<td>Other non-metal minerals mining and dressing</td>
<td>15</td>
<td>6.8</td>
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<tr>
<td>Coking, gas, and coal processing</td>
<td>6</td>
<td>2.7</td>
</tr>
<tr>
<td>Smelting and pressing of metals</td>
<td>46</td>
<td>20.6</td>
</tr>
<tr>
<td>Raw chemical materials and chemical products</td>
<td>97</td>
<td>42.9</td>
</tr>
<tr>
<td>Production and supply of electric power, steam, and hot water</td>
<td>5</td>
<td>2.3</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th><strong>Firm size (sales volume)</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 20 million</td>
<td>50</td>
<td>22.4</td>
</tr>
<tr>
<td>20-400 million</td>
<td>82</td>
<td>36.5</td>
</tr>
<tr>
<td>More than 400 million</td>
<td>93</td>
<td>42.1</td>
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<table>
<thead>
<tr>
<th><strong>Ownership structure</strong></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>State-owned</td>
<td>37</td>
<td>16.4</td>
</tr>
<tr>
<td>Private</td>
<td>188</td>
<td>83.6</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Region</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The east</td>
<td>28</td>
<td>12.4</td>
</tr>
<tr>
<td>The middle</td>
<td>158</td>
<td>70.2</td>
</tr>
<tr>
<td>The west</td>
<td>39</td>
<td>17.4</td>
</tr>
</tbody>
</table>

4. Results

To examine our theoretical framework in an empirical analysis, this study checks the reliability and validity level of data by enabling some scientific means; specific details are shown below. Additionally, the PLS-SEM technique is implemented to distinguish the actual statistical significance and relationship of structural models built on hypotheses. The main findings and arguments are unfolded and discussed in several conclusive pieces of evidence.

4.1 Non-response bias and common method bias. In order to avoid seemingly low response rates raising concerns about non-response bias, we also examined whether response bias exists in the questionnaire samples (Armstrong & Overton, 1977). Assuming that the group of last respondents highly resembles the non-respondent group, the first 25% of the respondents and the last 25% of the respondents were compared for significant differences in the response sample by SPSS 22.0. Utilising the different organisational characteristics that involve enterprise size and corporate property, both
groups were compared for their correlation analysis with a t-test, which bears out no different significance at a .05 level ($t$ value = .78 and .55). Therefore, there is no significant non-response bias in the sample, indicating that there is no response bias in this study.

Because all questions which contain explanatory and dependent variables are completed by the same rating method in the questionnaire survey process, this is easy to bring about the risk of common method bias. Harman’s single test is used widely as the method of testing for the presence of common method bias (Podsakoff et al., 2003). Every item from every construct is implemented for factor analysis to judge whether the majority of variance may come from a general factor before being rotated. In this study, the results reported a small portion of the variance (33%) occupied by the first principal component obtained, and when it is not rotated it does not account for the bulk. It guarantees that there is no common method bias and will not damage the conclusion of the study.

4.2 Scale validation and reliability

This study performed the standard two-step approach for evaluating model analysis. In the first step, the assessment of items’ reliability, construct reliability, average variance extricated (AVE) convergent, and discriminant validity related to the indicators as the measurement of latent variables, was implemented. Additionally, the second step evaluated the structural model that is utilised to observe the causality specified by the installed model in line with the survey data.

This section is used to examine construct validity. As for all standardized factor loading values of constructs, relevant sufficient validity and convergent validity are tested in Table 2. Concerning the measurement model, sufficient reliability of all constructs is observed by both Cronbach’s $\alpha$, and composite reliability was usually larger than 0.70, and even the stricter threshold value of 0.80 (Chin, 1998). Nevertheless, convergent validity would be assessed by the following criterions: (1) standardised loading ($\lambda$) greater than 0.70 and statistical significance; (2) AVE higher than 0.50. All standardised items loadings range from 0.742 to 0.953, while composite reliability for each construct is at least 0.903. The calculated AVE of every construct is beyond 0.608 and Cronbach’s $\alpha$ of all variables is well above 0.830. The estimated loading values of each indicator on assumed constructs are significant. These results also give positive information on the unidimensionality and convergent validity of all constructs.

In Table 3, the correlations between the latent variables are presented at the lower half of the matrix. For discriminant validity, if the root of the AVE for each construct is larger than the correlations among other constructs, then overall, it shows that each construct connects more closely to its measures than to others (Fornell & Larcker, 2006). It is clear that all values of the square root
of AVE (in bold) for each construct fulfil this as they are significantly larger than their correlations with all possible pairs of all other constructs. Seen from the above statements, these imply a highly admissible level of reliability, convergent, and discriminant validity on measurement indicators.

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Label</th>
<th>Standardised loading</th>
<th>Composite reliability</th>
<th>AVE</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedural perception</td>
<td>PP1</td>
<td>0.953</td>
<td>0.921</td>
<td>0.853</td>
<td>0.835</td>
</tr>
<tr>
<td></td>
<td>PP2</td>
<td>0.910</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PP3</td>
<td>0.893</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distributive</td>
<td>DP1</td>
<td>0.835</td>
<td>0.912</td>
<td>0.775</td>
<td>0.856</td>
</tr>
<tr>
<td>perception</td>
<td>DP2</td>
<td>0.894</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DP3</td>
<td>0.788</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ED1</td>
<td>0.767</td>
<td>0.903</td>
<td>0.608</td>
<td>0.871</td>
</tr>
<tr>
<td></td>
<td>ED2</td>
<td>0.807</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embeddedness</td>
<td>ED3</td>
<td>0.783</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ED4</td>
<td>0.817</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ED5</td>
<td>0.803</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EKS1</td>
<td>0.855</td>
<td>0.939</td>
<td>0.661</td>
<td>0.926</td>
</tr>
<tr>
<td>Knowledge sharing</td>
<td>EKS2</td>
<td>0.850</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EKS3</td>
<td>0.843</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EKS4</td>
<td>0.773</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EKS5</td>
<td>0.802</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GMI1</td>
<td>0.742</td>
<td>0.902</td>
<td>0.652</td>
<td>0.861</td>
</tr>
<tr>
<td>Green management</td>
<td>GMI2</td>
<td>0.890</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>innovation</td>
<td>GMI3</td>
<td>0.886</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GMI4</td>
<td>0.884</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GMI5</td>
<td>0.797</td>
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<tr>
<td></td>
<td>GMI</td>
<td>3.818</td>
<td>1.015</td>
<td>0.597</td>
<td>0.807</td>
</tr>
<tr>
<td></td>
<td>GTI1</td>
<td>0.895</td>
<td>0.933</td>
<td>0.838</td>
<td>0.952</td>
</tr>
<tr>
<td>Green technology</td>
<td>GTI2</td>
<td>0.904</td>
<td></td>
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<td></td>
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<tr>
<td>innovation</td>
<td>GTI3</td>
<td>0.925</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GTI4</td>
<td>0.936</td>
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<tr>
<td></td>
<td>GTI5</td>
<td>0.917</td>
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</tbody>
</table>

Note FZ, Firm size; OP, Ownership property; PP, Procedural perception; DP, Distributive perception; ED, Embeddedness; KS, Knowledge sharing; GMI, Green management innovation; GTI, Green technology innovation. Diagonal elements in bold: the squared root of AVE. Non-diagonal value (non-bold): correlations among constructs. *p<0.05, **p<0.01, ***p<0.001 imply significance of the correlation between constructs.

### 4.3 Hypotheses testing
This study establishes a structural model that is assessed by three steps (Chin, 1998), using PLS to test each hypothesis. The green innovation construct is measured by a second-order factor with formative indicators. PLS is utilized for this part due to a bootstrapping analysis conducted with 1000 sub-samples to calculate path coefficients, parameters, and their significance. All results of path coefficients in the model are summarized in Figure 2. First, the estimation of path coefficients should be needed to indicate statistical significance for the affected path. Then, R squared ($R^2$), which represents the coefficient of determination, can be calculated to evaluate their predicted contribution for endogenous constructs. Finally, it is worth testing the relative importance of the first-order indicators for the second-order variable in light of value weights.

According to the outcomes of relations of embeddedness and fairness perception, these indicate that procedural and distributive justice are defined as the key antecedents in a significantly high level ($p<0.001$). Their path coefficients are 0.439 and 0.386, respectively. They collectively contribute to 38.6% of the variance in explaining embeddedness ($R^2=0.386$). H1a and H1b are thus acceptable. However, in the knowledge sharing, fairness perception that involves both procedure and distribution are not a significant prerequisite ($p>0.05$). H2a and H2b are not accepted with coefficients. Next, this research proves that embeddedness has a hugely significant influence on knowledge sharing with a path coefficient of 0.480 ($p<0.001$). H3 is then acceptable. The two antecedents related to fairness and embeddedness jointly account for the explanation of 57.3% of the variance in knowledge sharing ($R^2=0.573$). Embeddedness and knowledge sharing are crucial in influencing green innovation ($P<0.001$) with path coefficients of 0.378 and 0.501. H4 and H5 are thus acceptable. The explanation of 59.7% in variance corporately results from both variables in green innovation of the sustainable supply chain ($R^2=0.597$).

As our results essentially imply that embeddedness has two direct and indirect effects on green innovation and by a mediator of knowledge sharing, we can enable the evidence through examining the initial model against a set-up competitor model that removes a path from embeddedness to green innovation (Baron and Kenny, 1986). Firstly, when we focus on the original research model, both path parameters for embeddedness and knowledge sharing to green innovation are significant at the different weights ($\beta=0.378$ and 0.501, path coefficient). Secondly, the $R^2$ on green innovation is 0.597 in the original hypothetical model as compared to 0.414 in the competing model. In a certain way, this step, similar to stepwise linear regression, was operated to check the difference in $R^2$ among two models. Their results present an obvious difference between them: it demonstrates that a partial mediating effect of knowledge sharing exists in green innovation while embeddedness is proven to
have a direct impact on green innovation. Moreover, we indicate that the relative importance of the formative indicators in endogenous latent variables, namely, both green management innovation and green technology innovation, are significant in constructing green innovation ($w=0.464$ and $0.596$ weight score). Finally, regarding control variables, firm size reflects the positive correlation in green innovation, whereas ownership structure is not correlated with green innovation in the sustainable supply chain anymore.

![Figure 2](image_url)

**Note:** ***significant at the 0.001 level; ** significant at the 0.01 level

**Figure 2** Results of path coefficients in the structure model

### 4.4 Discussions and findings

As seen in **Figure 2**, this finding of the study is inconsistent with the insight that fairness perception-based variables all have positive significance in influencing embeddedness in the supply chain (Kim et al., 2017), while those that include distributional and procedural justice reflect a non-significant link with knowledge sharing. More specifically, among the fairness perceived antecedents, procedural justice has a stronger impact on embeddedness in the supply chain than distributive justice while compared to distributive fairness. Some reasons can be discussed below. In building and enhancing the level of embeddedness between partners, a relatively equable procedure and mechanism created or maintained in the network may be the premier prerequisite of participants to be willing to expand relations under less risk produced in complex situations. Without constructing
some specific fair procedures for partners’ relations, distributive fairness and other essential actions in resource exchange would possibly not be realised. Accordingly, a high degree of procedural justice is the imperative requirement to form embeddedness in green innovation strategy to achieve sustainable supply chain management.

The empirical findings demonstrate a meaningful relationship between embeddedness and knowledge sharing, and furthermore, it is more obvious than the relationship between embeddedness and green innovation in the sustainable supply chain. Subsequently, the positive effect of knowledge sharing imposing on green innovation is proved. We are confident that knowledge sharing plays a critical mediating role in stimulating green innovation in the sustainable supply chain via the antecedent of embeddedness. The evidence for showing the mediator of knowledge sharing is a key contribution to driving green innovation, which is consistent with some previous studies (Ben et al., 2018; Ghisetti et al., 2013; Wong, 2013). That being said, only relying on embeddedness in the supply chain may not exert enough effect on achieving green innovation in a direct path. This also reveals that promotion and encouragement of knowledge sharing are necessary for green innovation in order to deal with environmental pressures in the supply chain. The meditation effect among three key constructs, embeddedness, knowledge sharing, and green innovation are specifically described in Figure 3.

![Figure 3 Relations between three critical variables](image_url)

Figure 3 Relations between three critical variables

On the other hand, fairness perception is not directly significant for knowledge transfer through embeddedness, which means that embeddedness plays a full mediating role. In line with Li et al. (2014), embeddedness should be considered as an essential part of influencing the willingness of partners; it builds trust and stable knowledge sharing between sustainable supply chain actors. Also, many firms that attempt to set up green innovation pay more attention on how to control risks and uncertainties than on how to generate benefits in the sustainable supply chain. A company might be capable of sufficient capacities and power and ready for the development of green innovation. But if
their partners lack a relatively advanced occupation, it may be difficult to negotiate with equal knowledge sharing of green innovation in an embedded relationship.

Next, this study is in agreement with the view that embeddedness and knowledge sharing are both significant in affecting green innovation of the supply chain in different aspects (Cainelli et al., 2015). Members who experience long-term transactions and communication form stable ties, including receiving a wide range of partners and enjoying highly frequent interactions, mechanisms, and common rules. These interactions will result in the production and execution of green innovation strategies (Stefano and Sancho, 2018). Some examples might be cleaner production practices, market change, or other contemporary technologies related to green issues. When network actors are more content with embeddedness and knowledge sharing practices, they will take effective actions to develop green innovation, including green management and technology innovation for the reduction of waste and pollution. In this issue, both green management innovation and technical innovation are significantly expected from two antecedents.

Similar to studies by Ben et al. (2018) and Wong (2013), this result also reports a manner that knowledge sharing process may play a determinant factor for driving the green innovation and outcomes based on good network construction in the supply chain, as shown in Figure 3. A possible motivation is that knowledge or information sharing between supply chain partners may be regarded as a trigger for each other and could have contributed strongly to driving green innovation. Indeed, knowledge flows in the supply chain based on the network may play an important enabler in green innovation among partners. When a firm in the sustainable supply chain tends to prepare for their knowledge or information practices to implement green innovation, that firm is typically ready to reach a consensus for their knowledge sharing. These may involve amplifying the range of various members for a cooperative knowledge gathering, or perhaps strengthening the place any actor occupies in the network between knowledge sharing.

Meanwhile, when we carefully concentrate on the empirical results of green innovation in this study, green technology innovation illustrates a larger weight coefficient than green management in achieving a sustainable supply chain. It means that executives in firms have realised the importance of driving green technical or process innovation based on long-term considerations, e.g., renewable energy in material and production flows, or a low carbon emission manufacturing process. They also may show a series of reasonable changes in green technology innovation benefitting from maintaining the management innovation profits over a longer period. Since top managers attempt to adopt a set of
green management behaviours, such as green strategy orientation, green cognition in managers and a green cooperation mechanism with partners, they should be more aware of the enhancement of taking green technology into account in a scientific and correct manner that facilitates the impact of green innovation in the sustainable supply chain.

Finally, some findings of the control variables are important to narrate. Firm size defines a significant positive correlation with green innovation in the sustainable supply chain, while ownership property does not. The adjustment of business strategies or decisions in supply chain management depends largely on the matter of the scale of the firm. In other words, internal capacities or resource attributes that measure the level of companies (such as firm size) are more vital in affecting the possibility of green innovation achievement than the nature of property rights that represents to whom a company belongs, such as owning property (Wu et al., 2014).

5. Conclusions and implications

By equity theory and network context, this study aims to explore the relationship among perceived fairness, embeddedness, knowledge sharing, and green innovation in the sustainable supply chain on the hypothesised development. The research model is tested by utilising the survey data from 225 manufacturing companies in China and implementing the PLS-SEM technique. The empirical results of this study indicate that fairness perceptions that are formed in procedural and distributive perception have a positive impact on embeddedness in the sustainable supply chain, while they do not significantly affect knowledge sharing between partners. The findings of this research also reveal that embeddedness and knowledge sharing are important mediators in developing green innovation and that they should be strengthened by more insight by actors in the network. Knowledge sharing can further play a larger mediation effect on improving green innovation through the driver of embeddedness in a network and the exchange of beliefs of justice. In particular, larger manufacturing companies are more able to adopt green innovation of sustainable supply chains than small-medium enterprises because they have the resources and competencies to perform complex operations by integrating partners.

Our conclusions contribute to the extant research in several fields. Firstly, by analysing the effect of fairness perception and embeddedness in green innovation of sustainable supply chain, we extend current focus on the perspective of nature resource-based views (RBV) in individual companies to network context. In contrast to emphasizing RBV that illustrate the higher level of capabilities from the inside to push green innovation, we elaborate on the insight that a better situation in embeddedness
between firms and partners can actually stimulate more green innovation throughout the supply chain. This result may be because multilateral cooperation is effective to improve trust and to provide more resource ranges in achieving green innovation. We further demonstrate that fairness, perceived positively, improves embeddedness in a network. This implies the level of fairness perception widely determines the intention of members to establish relationships within the network, which may in turn influence the realization of green innovation in sustainable supply chains.

Secondly, previous research discussing tangible or slack resources often includes finance and operational performance. Our results address the greater importance of knowledge on green innovation in building a sustainable supply chain. More specifically, our results demonstrate that reliable and frequent knowledge sharing within firms and network partners is beneficial to encourage green innovation. Additionally, it partially plays a mediating role in embeddedness and supply chain’s green innovation due to the bridge function of knowledge interaction. Accordingly, we emphasize the theory on knowledge sharing between network members and green innovation as vital to constructing a sustainable supply chain.

There is a variety of meaningful implications for green innovation of sustainable supply chain practices. The empirical findings of the effect of fairness, embeddedness, and knowledge sharing on green innovation in the sustainable supply chain is necessary and vital. These exploited actions may include three considerable concerns: non-coercive risk prevention in fair relationships, development of embeddedness in the supply chain, and better knowledge sharing mechanism. First, to comply with the rules of fairness standards for green innovation within the network, firms actively resist the opportunistic relation that undermines trust mechanisms. They should attach importance to the equal market position of the parties in collaboration and should consciously abide by the contractual roles or shared goal of hydracids rather than the conventional standard of fairness based solely on firm size. Especially in the development of major exploratory green innovations, partners strengthen distributive fairness feedback and improve procedural justice of control in risks.

In the next place, firms also actively maintain open and comprehensive multilateral links with the actors in the supply chain from the network perspective. More participate in and promote long-term effective, embedded green innovation strategic cooperative actions and alliance building, and form a stable interactive network mechanism of green innovation across organisational boundaries. Additionally, companies should develop differentiated green innovation capabilities to occupy prominent positions in embedded relationships which contributes to Industry, Innovation and
Infrastructure goal (SDG 9). Depending upon theoretical and empirical findings in networks and their capital, firms should further build fair relationships based on value orientation and find collaborative partners in the supply chain that conform to the corporate culture and business strategy.

Ultimately, companies should strive to adopt appropriate knowledge sharing strategies from partners in the process of pushing green innovation in sustainable supply chains. As such, top managers should notice that well-constructed technological communication abilities will be more likely to generate successful green innovation. Specifically speaking, we also suggest that using inter-organisational information technologies is beneficial for making knowledge sharing a priority for different green innovation activities within the supply chain context. IT systems are always treated as the strategic importance of capturing competitiveness by integrating low-order competencies that can be coordinated and leveraged to high-order resource capacities. More importantly, green technologies or knowledge, including green transportation, green raw materials, green transportation, and green manufacturing processes, should be promoted on a larger scale and to the extent that it is faster to build sustainable supply chains. At last, this study contributes to the sustainable development goals such as decent work and economic growth (SDG 8); industry, innovation and infrastructure (SDG 9); responsible consumption and production (SDG 12) and climate action (SDG 13).

Although some useful results have been demonstrated empirically, there are some limitations to our research. First, this research only examines embeddedness at the overall level as an important predictor of green innovation of the sustainable supply chain in sampled manufacturing firms. To the further extent of discussing embeddedness specifically, its effect on green innovation needs to be distinguished from multi-dimensions that consist of relational, structural, and cognitive dimensions related to embeddedness in the network. Therefore, follow-up research may construct a more detailed analysis of embeddedness and investigate its effect on green innovation. Second, this research does not consider the moderating effect related to internal capacity. Subsequent research should focus on identifying the moderations relevant to the studied context and exploring different moderators, according to the resource-based view. Possible paths might include the green absorptive ability of a firm and external dynamism, and legitimacy perspective and contingency theory such as environmental regulation pressure from informal and non-formal sources. Future research also needs to examine the relationships of capital from networks, green innovation, and performance or competitive advantages. Such a topic might explore dynamic or cause and effect relationships and might clearly investigate the development of dynamic hypotheses with a variety of empirical data sources from multiple informants in order to increase benefits due to a lack of longitudinal data.
## Appendix A. Construct items

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Label</th>
<th>Items</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Procedural</strong></td>
<td>PP1</td>
<td>Partners have fair policies regarding those they deal with in the supply chain</td>
<td>Griffith, et al., 2006; Liu et al., 2012</td>
</tr>
<tr>
<td></td>
<td>PP2</td>
<td>Partners do not discriminate against us in the supply chain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PP3</td>
<td>Partners take our concerns and feedback in the supply chain</td>
<td></td>
</tr>
<tr>
<td><strong>Distributive</strong></td>
<td>DP1</td>
<td>Our and partners’ gain is proportionate to our performance in the supply chain</td>
<td>Liu et al., 2012</td>
</tr>
<tr>
<td></td>
<td>DP2</td>
<td>Our and partners’ gain is commensurate with role and responsibilities in the supply chain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DP3</td>
<td>Our gain is comparable to partners’ gain in the supply chain</td>
<td></td>
</tr>
<tr>
<td><strong>Embeddedness</strong></td>
<td>ED1</td>
<td>Network ties generate significant influences on partners’ behaviour during cooperation in the supply chain</td>
<td>Kim et al., 2011; Lin et al., 2009</td>
</tr>
<tr>
<td></td>
<td>ED2</td>
<td>Firm and its partners interact with a high frequency in the supply chain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ED3</td>
<td>Between partners interaction duration is long network in the supply chain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ED4</td>
<td>It is believed that all partners act with high transparency in the supply chain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ED5</td>
<td>Firm and partners reach a clear consensus on cooperation and shared norms in the supply chain</td>
<td></td>
</tr>
<tr>
<td><strong>Knowledge sharing</strong></td>
<td>EKS1</td>
<td>Share green knowledge obtained from all sources with partners in the supply chain</td>
<td>Kale &amp; Perlmutter, 2000; Lee, 2001; Möller &amp; Svahn, 2004</td>
</tr>
<tr>
<td></td>
<td>EKS2</td>
<td>Share each other’s know-where and know-whom in the supply chain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EKS3</td>
<td>Partners jointly organise green training to enhance each other’s knowledge in the supply chain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EKS4</td>
<td>Sharing new technology and ideas with each other in the supply chain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EKS5</td>
<td>Share successful knowledge with partners in the supply chain</td>
<td></td>
</tr>
<tr>
<td><strong>Green management innovation</strong></td>
<td>GMI1</td>
<td>Environmental compliance and auditing programs</td>
<td>Zhu et al., 2012</td>
</tr>
<tr>
<td></td>
<td>GMI2</td>
<td>Supplier environmentally friendly practice evaluation exists</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GMI3</td>
<td>Support for GSCM from managers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GMI4</td>
<td>Cross-functional cooperation for environmental improvements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GMI5</td>
<td>ISO 14001 certification</td>
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</tr>
<tr>
<td><strong>Green technology innovation</strong></td>
<td>GTI1</td>
<td>Collaboration with customers for cleaner production</td>
<td>Zhu et al., 2012; Lee et al., 2014</td>
</tr>
<tr>
<td></td>
<td>GTI2</td>
<td>Collaboration with suppliers for sustainable design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GTI3</td>
<td>Collaboration with customers for green packaging</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GTI4</td>
<td>Investment recovery (sale) of excess inventories/materials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GTI5</td>
<td>New technology is always used in the process</td>
<td></td>
</tr>
</tbody>
</table>
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Reference


