



# Can the social trust promote corporate green innovation? Evidence from China

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Received: 13 November 2020 / Accepted: 3 May 2021 / Published online: 17 May 2021

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## Abstract

Corporate green innovation has played a crucial role in balancing profitability and environmental protection. The existing research on determinant factors of green innovation has its main defects in emphasizing excessively enterprise's formal institutional environment and neglecting the informal institutional environment, causing an incomplete understanding of the relationship between institutional environments and corporate green innovation. To bridge this gap, using a sample of Shanghai and Shenzhen A-share listed firms in manufacturing industry during the period of 2010–2016, we investigate how social trust, an important informal institutions, affects corporate green innovation. Our results show that social trust is positively associated with green innovation, remaining valid after applying endogenous and robustness tests. In addition, the positive relationship between social trust and green innovation is more prominent when the enterprise is non-state-owned or locates in a looser command-and-control (CAC) environmental regulations region. Further analysis shows that social trust boosts corporate green innovation via promoting knowledge sharing, decreasing financing constraints, and fulfilling more corporate social responsibility (CSR). This paper enriches the literature concerning social trust and green innovation and draws back more public attention on the role of informal institutions play in promoting green innovation.

**Keywords** Social trust · Corporate green innovation · Informal institutions · China

## Introduction

Though China's economy is booming, the extensive development model of high investment, high pollution, and high consumption has also caused serious environmental pollution problems. According to the 2018 Environmental Performance Index released by Yale University, China ranks fourth from the bottom in the ranking of environmental performance indexes among 180 countries. It is generally accepted that the corporation production and operation activities are primarily blamed for the environmental pollution and ecological destruction. By the contrast, corporate green innovation,

known as the ecological innovation, refers to new products, processes, services, or management systems that can be used to cope with environmental problems (Rennings 2000; Schiederig et al. 2012; Qiu et al. 2020). As a result, the manufacturing companies has viewed the development and diffusion of corporate green innovation as a pivotal reference to balance profitability and environmental responsibility (Schiederig et al. 2012; Lee and Min 2015; Zhao et al. 2019).

To date, scholars have devoted increasing attention to discussing determinant factors of corporate green innovation, including environmental regulations (Borsatto and Amui 2019; Stucki et al. 2018), stakeholders (Abbas and Sağsan 2019; Zhang and Zhu 2019), and innovation resources (Gauthier and Genet 2014; He and Jiang 2019). It can be seen that most of literatures cited above focus on the formal institutional constraints that companies universally face in the process of green innovation. According to Redding (2000), the institutional environment is divided into two broad categories: formal and informal institutions. And the informal institutions are also regarded as a key force influencing micro-enterprise behaviors (Estrin and Prevezer 2011; Dimaggio 2003). In particular, China in the “emerging and transitional” phase, where

Responsible Editor: Eyup Dogan

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the informal institutions play a more important role in the resources allotment, the compliance of contracts, and the maintainment of sustainable economic development (Allen et al. 2005; Greif and Tabellini 2010). It is a pity that few researches have affirmed the impact of informal institutions on the green innovation. Suppose that we verify the impact of informal institutions on the enterprise green innovations, our paper would be “the first stepping stone” to illuminate the micro mechanism by exploring how could the institutional factors affect enterprise green innovation in the Chinese context. So our research is of a critical theoretical research value.

Social trust reflects the tendency of people within one organization as a whole to cooperate to produce efficient outcomes (Wu et al. 2014; Li et al. 2017a, b) and has been an essential and widely discussed informal institutions (Arrow 1974; Lu et al. 2018). Numerous studies have indicated that social trust is served as an essential symbol of social norms and values, and the “lubricant” of social relations in which all companies’ economic behaviors are embedded and thus exert a fundamental role in guiding and assessing corporate behaviors (Gambetta 1988; Chen and Wan 2020). For example, social trust is capable of reducing transaction costs, promoting cooperation between individuals, and facilitating information sharing (Bjørnskov 2012; Ang et al. 2015; Dong et al. 2018). Consistent with the notions that social trust stimulates positive behaviors, we raise these questions: can social trust promote corporate green innovation? If yes, what factors will affect the relationship? What about its internal driving mechanisms?

The reasons for us to use China’s data are as follows. First, the informal institutions described as “the actual rules that are being followed” are of special significance in China, where the formal institutions are not transparent nor well-enforced (Allen et al. 2005; Greif and Tabellini 2010). Second, China is a diverse country and relation-based society with major differences in economic development, ethnicity, history, and cultural traditions across China’s regions and spawns different levels of social trust across China’s provinces (Wu et al. 2014; Dong et al. 2018). Third, manufacturing enterprises make a significant contribution to the economic growth in China. However, the development level of capital, technology, and human resources in Chinese manufacturing enterprises is uneven, and thus the level of green innovation terribly varies in the different enterprises.

Our study provides significant contributions in several ways. (1) Most of studies examine the impact of formal institutional environment on green innovation (Stucki et al. 2018; Borsatto and Amui 2019) but relatively ignore the role of informal institutional environment. We remedy the shortcomings of relevant studies and offer a new perspective for studying the antecedents of enterprise green innovation. (2) Existing studies focus on the macro-effect and micro-effect of social trust from different perspectives (Bjørnskov 2012; Dong et al. 2018) but overlook the impact on corporate green

innovation. Our study, by offering a direct evidence that social trust is positively associated with green innovation, complements the literature on the positive effects of social trust and thus promotes the integration of social trust and environmental economics. (3) With the method of mediating effect test, the linkage mechanism of social trust on green innovation is studied, including the knowledge sharings, financing constraints, and corporate social responsibilities. The conclusion helps people unfold the “black box” of how social trust promotes enterprise green innovation, which would provide much inspiration to build an environment-friendly society. (4) Whether there is a substitute or supplementary relationship between informal and formal systems still remains controversial. We find that social trust can prominently promote green innovation in corporates, which suffer less government interventions or locate in looser environmental regulations, that is, there exists a substitution relation between them. Not only does it reconcile the differences of previous studies but also enables people to further get the overall picture of the relationship between institutional environment and green innovation.

The rest of this paper is organized as follows. “Literature and hypothesis development” section provides a detailed literature review and proposes hypotheses. “Sample and empirical methodology” section refers to research design. “Empirical tests and results” section presents empirical results and discussion. “Further analyses” section provides additional analysis. “Conclusions and implications” section gives the conclusion and relative policy suggestions.

## Literature and hypothesis development

### Literature review

#### Green innovation

Green innovation is viewed as an important approach to minimize or eliminate the negative impact of their operations on the environment (Rennings 2000; Pujari 2010; Fernando et al. 2019). It is a form of technological and ecological innovation covering products, processes, organizational structures, or business models for the purpose of energy-saving, waste recycling, pollution-prevention, or improving energy efficiency (Rennings 2000; Schiederig et al. 2012), which in turn increases firms’ profits and sharpens their competitive edge (Chen et al. 2006; Chang 2011). Owing to the increasingly important role of green innovation in achieving environmental sustainability and improving environmental, social, and financial performance of companies (Dangelico and Pujari 2010), numerous factors that lead enterprises to the implementation of green innovation are investigated, including environmental regulations, stakeholders, and innovation resources (Popp 2019; Kammerer 2009; Lin et al. 2013).

(1) For studies on the environmental regulations, there is a growing number of researches discussing the impact of social trust applies on green innovation from the perspective of command-and-control (CAC) type environmental regulation, market-based incentives type environmental regulation, and voluntary environmental regulation (Rexhaeuser and Rammer 2014; Borsatto and Bazani 2020). These are also the mainstream study to explore the driving factors of green innovation. For example, Berrone et al. (2013) found that regulatory pressure is a fundamental factor in the decision of green innovation of enterprises. Stucki et al. (2018) found that different policy instruments such as taxes, energy-related regulations, voluntary agreements, or subsidies prompt firms to engage in green product innovation. Based on the literature review, Popp (2019) clearly pointed out that policy tools are an important driving factor of green innovation, and how to create the needs of implementing green innovation is a challenge for capturing the array of policy instruments. (2) For studies on stakeholders, it has been revealed that different stakeholders are distinguished as driving factors for green innovation decisions such as consumers, competitors, government, media, and other stakeholders (Kammerer 2009; El-Kassar and Singh 2019; Zhang and Zhu 2019). For example, Zhang and Zhu (2019) pointed out that consumer pressure is an essential driver of corporate green product and process innovation. Qi et al. (2013) found that foreign customers exert a positive influence on driving companies to implement green innovation. (3) For studies on innovation resources, scholars thought that the success of green innovation largely depends on the availability of different resources critical to its execution, such as knowledge, capital, material, and technology (Aragon-Correa and Leyva-De 2016). For example, Lin et al. (2013) pointed out that political capital hinders firms from carrying out green product and process innovation activities based on the resource-based views. Abbas and Sağsan (2019) noted that knowledge management enables firms to enhance green innovation. In addition, some scholars discussed the determinant factors of green innovation from the perspectives of corporate governance (Amore and Bennesen 2016) and high-speed rail (Huang and Wang 2020).

## Social trust

Trust is described as a common belief in maintaining positive expectations for cooperation with others without seeking any additional benefits (Gambetta 1988). Meanwhile, social trust is the general level of mutual trust among the members of a society and reflects the propensity of people to cooperate with

others within one organization to produce efficient outcomes (Wu et al. 2014). Hence, a high social trust region has individuals with a greater propensity to comply with social norms and honor an obligation, all of which facilitate productive and collective actions (Li et al. 2017a, 2017b; Jha and Chen 2015).

Many studies in different disciplines have found that regional social trust, as an alternative or supplement to the formal institutions, has a significantly positive impact on macro-economic activities and economic consequences at the firm level (Guiso et al. 2004; Cline and Williamson 2016). At the macro level, for example, Carlin et al. (2009) used a theoretical model to document the effect of social trust on venture economic growth. Guiso et al. (2008) found that social trust facilitates investors' participation in the capital market and is positively associated with financial development. Empirical evidence by Algan and Cahuc (2010) showed that inherited social trust has a significant effect on promoting economic growth. At the micro level of the enterprise, for example, Li et al. (2017a, 2017b) found that managers in regions with high social trust are more likely to disclose financial information in a timelier manner and therefore are associated with lower firm-specific crash risks. Ang et al. (2015) pointed out that foreign high-tech companies prefer to invest more in R&D in regions where local partners and employees are considered more trustworthy. Jha and Chen (2015) deemed that the firms in high social trust areas can be honest in financial reporting and consequently pay lower audit fees for their auditors.

Based on the above, although research findings on exploring the driving factors of green innovation are relatively abundant, there is a lack of systematic examination of the relationship between social trust viewed as the core of informal institutions and green innovation. Obviously, it is a significant omission. Therefore, our paper attempts to add a direct evidence on the effect of social trust on prompting green innovation at the firm level. In particular, against the background of China's vigorous development of eco-innovations, the analysis of the relationship between the two is undoubtedly of great significance.

## Hypothesis

Corporate green innovation is a high risk, high income, long-term investment activity that places high demands on the innovation environment. Social trust involved in the ethical framework and social norms plays an important role in guiding decision-making of firms. In this regard, we argue that social trust may facilitate the promotion of firms' green innovations.

First, social trust can prompt enterprises to engage in more CSR activities. Social trust is regarded as a set of values, norms, or beliefs widely recognized in society, which can guide individuals to behave honestly and cooperatively so as

to achieve social outcomes (Chen and Wan 2020). Studies point out that individuals in high social trust regions tend to abide by the values of honesty and altruism, observe the code of conduct within the community, and safeguard the interests of other stakeholders (Guiso et al. 2008; Chen and Wan 2020). If not, they will suffer more social condemnation and public opinion pressure. This further forces individuals to take actions in accordance with social ethics, such as the fulfillment of CSR. Therefore, in the business activities of enterprises, social trust can drive managers to internalize the commitment of CSR into personal code of conduct, and promote them to reduce their behaviors that will violate social norms, and undertake more CSR activities. Moreover, an environment with a high level of social trust can foster active social networks, leading to relatively frequent interactions and cooperations among stakeholders (Chow and Chan 2008). Strategic CSR theory posits that companies conducting more CSR activities would gain more strategic resources and reputational capital (Chen and Wan 2020). Therefore, in high trust regions, companies conducting more CSR activities could gain favor from other stakeholders and get more returns, which in turn would drive enterprises to undertake more social responsibilities, such as public utilities and environmental protection. As noted above, corporate green innovation is an important innovation activity, aiming at realizing the harmonious development of profits and clear production (Rennings 2000; Fernando et al. 2019). In the times of sustainable development, enterprises with a sense of social responsibility are prone to take the “green” and “low-carbon” claims as the production criterion and pursue energy conservation and emission reduction, invest heavily in R&D of low-carbon and environment-friendly products, so as to fit for the sustainable economic development put forward by The Times. In conclusion, in regions with a high level of social trust, enterprises would have more willingness to undertake more social responsibilities and engage in more green innovation activities.

Second, social trust can accelerate green innovative knowledge exchange and integration. In the practice of green innovation, there is an urgent need to share and integrate green innovative knowledge elements that cover multiple technical areas, such as green product design, recycling production, and energy conservation (Rennings 2000; Fernando et al. 2019). We hold that sufficient innovative knowledge brought by social trust will prompt the implementation of green innovation. For inter-organization, trust lays the primary foundation for exchange relations. The higher level of social trust among organizations, the less psychologically defensive against their partners and the more willingness to share knowledge, which enables organizations to reduce the cost of knowledge sharing and to enhance the timeliness and accuracy of inter-organization knowledge exchange. For intra-organization, social trust can promote more frequent communications among organization members. Consequently, employees are able to

break through knowledge barriers, integrate and converge knowledge elements, and thus broaden the knowledge boundaries of them. Furthermore, with the increase of knowledge stocks (including green innovation knowledge) of organization members, on the one hand, they can break through the fixed mindset, path dependence and strategic rigidity formed in corporate governance for a long time (Ocasio 1999), and effectively get rid of the shackles of green innovation under the old paradigm. On the other hand, the development, integration, and application of knowledge favor the generation of new thinking, inspiration, and new ideas, thus promoting green innovation of enterprises. Therefore, social trust brings more knowledge resources to support the green innovation activities of enterprises.

Finally, social trust can ease financing constraints. Considering that corporate green innovation requires massive funds, counting on the internal funds merely far insufficient, still need the external funds (Grazia et al. 2018). Hence, we deem that social trust can alleviate financing constraints and thus provide sustainable financial supports for enterprise green innovation. Specifically, (1) corporates in high social trust areas tend to improve financial reporting quality and disclose information in a timely manner, which contributes to reducing transaction costs and credit risks (Jha and Chen 2015; Zak and Stephen 2001). At this time, the willingnesses of banks and other capital providers to lend increase, and the credit cooperations between enterprises and investors enlarge, thus enterprises will obtain more long-term and large-scale financing from financial institutions at a lower cost. (2) The enterprises, customers, and suppliers, in a highly trusted environment, would be mutually trusted. Then, these enterprises could obtain the higher commercial credit (Wu et al. 2014), which is conducive to occupying more supply chain funds and obtaining more financial resources. (3) Social trust, functioning as social norms, can discipline managers from hiding investment risks or misappropriating project funds by using information advantages and suppress their opportunistic behaviors in green innovation activities. In this case, the managers would invest more limited financial funds into green innovation activities (Guiso et al. 2008; Li et al. 2017a, 2017b). It can be seen that in areas with high level of social trust, the financing constraints of enterprises can be greatly eased, such as reducing the credit costs, obtaining higher commercial credit, and investing more R&D inputs, which can ultimately provide sufficient financial support for enterprises to carry out green innovation activities. Hypothesis 1 is proposed:

Hypothesis 1: Social trust and corporate green innovation are significantly positively related.

As a typical formal institutions, CAC type environmental regulations depending on the environmental laws and policies can affect, for instance, market access, emission standards,

administrative penalties, and product bans, in order to achieve co-development between economy and environment (Testa et al. 2011). Based on the “Porter Hypothesis,” enterprises need to embrace new ideas of clean production, increase R&D investment inputs on green technology improvements, and improve their environmental performance, in response to CAC environmental regulations (Borsatto and Amui 2019; Porter 1991; Stucki et al. 2018). And if the regulations or rules are disregarded, firms will be subject to administrative punishment and strict inspection (Shen et al. 2020). Hence, enterprises would be more motivated to engage in green innovation to avoid both reputational and economic costs. In conclusion, CAC type environmental regulations can push forward green innovation (Stucki et al. 2018; Shen et al. 2020).

The motivation for carrying out green innovation of enterprises is complex and diverse. It may be a proactive behavior that enterprises conform to social norms, or an obsessive-compulsive behavior that enterprises are forced by environmental regulations. Thus, we believe that when CAC type environmental regulations are stricter, the legal constraints to which enterprises are subject are greater. Consequently, enterprises must abide by the laws and regulations and implement green innovative behaviors, to gain the legitimacy granted by the government. This, to some extent, reduces the compensation effect of social trust for green innovation. However, when the environmental regulations are looser, companies will have more discretion in carrying out green innovation activities. In this way, social trust can effectively play a supervisory role of social norms and the complementary role of innovation resources, thereby driving enterprises to push forward green innovation. At this moment, social trust can play a more positive role in green innovation. That is, there is a substitution relation between social trust and the CAC type environmental regulations. Hypothesis 2 is proposed:

Hypothesis 2: When other conditions remain unchanged, the role of social trust in promoting corporate green innovation is more pronounced in regions with looser CAC type environmental regulations.

Chinese economy presents a typical “dual characteristic.” Primarily, the differences of state-owned and non-state-owned enterprises in the system environment and market status may affect the relationship between social trust and green innovation. Hence, state-owned enterprises are technically “controlled by the public” not only pursue the economic objectives of profit maximization but also pursue the social objectives, including creating employment, holding down prices, and developing laggard region (Ramamurti 1987; Cornett et al. 2010). It indicates that state-owned enterprises bear more social responsibilities and have more duties to engage in green innovation. In addition, executives of state-owned enterprises not only receive direct incentives for compensation but also

face implicit incentives for political advancement. And under the influence of Confucian culture such as “official rank standard,” they have a more strong demand for political promotion (Cao et al. 2019; Hung et al. 2012). Therefore, the ambitions, climbing the political ladder and accumulating political capital, fiercely ignite the flame of plentiful state-owned executives to swamp into green innovation. In view of this, we conjecture that green innovation of state-owned enterprises are more likely to be affected by external pressure of government and political promotion of managers, which sets a limit to the positive effect of social trust.

In contrast, the overriding objective of non-state-owned enterprises is profit maximization. These firms are free to decide whether and how to implement green innovation regardless of the possible political pressure and government interference. In this way, we predict the beneficial effect of social trust on green innovation can be more prominent. More importantly, non-state-owned enterprises are more difficult to enjoy the support of the government or financial institutions in the process of green innovation than state-owned enterprises and often fall into the dilemma of financing difficulties. At this time, social trust would play a more active role in easing financing constraints. In summary, we believe that the positive relationship between social trust and green innovation is more obvious in non-state-owned enterprises. Hypothesis 3 is proposed:

Hypothesis 3: When other conditions remain unchanged, the role of social trust in promoting corporate green innovation is more pronounced in non-state-owned enterprises.

## Sample and empirical methodology

### Sample

This study mainly selected the A-share manufacturing listed companies in Shanghai and Shenzhen from 2010 to 2016 as the initial sample. We filtered out the preliminary sample according to the following criteria: (1) ST or PT type listed enterprises were excluded. (2) Sample companies lacking important data were excluded. (3) Sample companies whose asset-liability ratios are greater than one were excluded. (4) Sample companies whose establishment time is less than 1 year were excluded. Our final sample comprises unbalanced panel data of 1985 companies that generate 9818 observations from 2010 through 2016. In terms of data sources, we obtained green innovation data from the Baiting patent network (<http://so.5ipatent.com/>). We collected social trust data from Chinese General Social Survey (CGSS) and the report of the China City Commercial Credit Environment Index (CEI). The other corporate data in our analysis were obtained from

CSMAR database. In addition, we also checked the financial statements and information announcements for suspicious data. To eliminate the influence of extreme values, we winsorized all continuous variables all scaled variables at the top and bottom 1% of each distribution.

## Measurements of variables

### Green innovation

Reference to the prior studies (Berrone et al., 2013; Li et al., 2016), we employed the green patent as an alternative indicator of corporate green innovation. By combing authoritative literature at home and abroad (Li et al. 2016; Cormier and Magnan 2015), we first summed up the key words representing the green innovation, such as “green,” “low carbon,” “environmental protection,” “energy saving,” “emission reduction,” “clean,” “recycling,” “saving,” “sustainable,” “ecological,” “environmental protection,” and “environmental pollution.” Then, using the text analysis and keyword search on full text of patent applications of sample enterprises over the years, we initially screened out the green patents. To avoid the excessive recognition of green innovation patents caused by the misuse of keywords, we conducted the second round of screening of green patent data by hand. In addition, to eliminate the interference of dimensionality on the research conclusions, we divided the obtained green patents by the total number of patents according to the method of Qi et al. (2018). The final ratio represents the level of corporate green innovation.

### Social trust

We use the following two methods to measure social trust by the survey. First, drawing on the methods of Lu et al. (2018) and Huhe (2014), we measured social trust by the provincial-level enterprise trustworthiness base to China General Social Survey (CGSS). CGSS is China’s first national, comprehensive, and continuous large-scale social survey project and is designed and implemented following the same procedure of General Social Survey in the US (Lu et al. 2018). The objective of CGSS is to collect and obtain quantitative data about measures of quality of life, social structure, and other aspects of society. The question related to social trust is mainly “Generally speaking, do you agree that the vast majority of people can be trusted in this society?,” which reflects the individuals’ perception of honesty and trustworthiness in the region. Then, we constructed our measure of social trust based on the response to the above question. The respondent can select one of the five choices: “strongly disagree,” “relatively disagree,” “cannot be said to agree or disagree,” “relatively agree,” and “strongly agree.” We score the five choices –2, –1, 0, 1, and 2 from the lowest trust “strongly disagree” to the highest trust “strongly agree,” respectively. Then, we

calculated the average of all respondents’ choices by provinces where they are located. The average score obtained was employed as an indicator of social trust (TRUST1). It is worth emphasizing that the timeline of the sample data in this article is from 2010 to 2016, but CGSS only has social trust data for 2010–2013 and 2015. Considering that social trust remains stable for a certain period and does not have much time series variation, we used 2013 and 2015 value of social trust to supplement 2014 and 2016, respectively.

Second, in referring to existing studies (Dong et al. 2018; Liu and Li 2019; Jia et al., 2017), we employed the China City Commercial Credit Environment Index (CEI) as the indicator measuring social trust. Meanwhile, the reason why we used CEI because that index was widely authoritative and approved in evaluate the states of domestic credit environment in China from seven dimensions, including credit delivery, credit system, government credit supervision, breach of trust violations, corporate credit management, and integrity education. Given that the index provides the magnitudes of social trust in 2010, 2012, 2013, 2015, and 2017, we used interpolation to fill in the data drawing on common research practices. For example, for 2011, we used the average CEI index at the provincial level of 2010 and 2012. In our paper, the natural logarithm of the CEI index at the province level was our proxy for social trust and we called it TRUST2. In the following robustness test, the natural logarithms of the CEI index at the city level were also used as a measurement of social trust.

### CAC type environmental regulations

We selected the number of local environmental laws and regulations promulgated by each region recorded in the “China Environmental Statistics Yearbook” as the index of CAC type environmental regulations (CAC). Simultaneously, CAC is equal to 1 when the number of local environmental laws and regulations is greater than the median and that is equal to 0 otherwise.

### Ownership type

SOE is an indicator variable for ownership type. It takes the value of 1 if the firm is a State-Owned Enterprise, and 0 if not.

### Control variables

Following the existing literature (Amore and Bennedsen 2016; Li et al. 2017a, 2017b; Stucki et al. 2018), we controlled the firm characteristic variables that have an impact on green innovation, including: return on assets (ROA), firm age (AGE), financial leverage (LEV), independent director ratio (IDR), firm growth (GR), and firm size (SIZE). In addition, considering that government intervention has long been playing a unique role in corporate green innovation (Lin

**Table 1** Definition of main variables

Variables name	Symbol	Variables declaration
Green innovation	GRINV	Ratio of green patents to total company patents (%)
Social trust	TRUST1	CGSS data of the province where the listed company is located
	TRUST2	The report of the China City Commercial Credit Environment Index
Return on assets	ROA	The ratio of net profit to average total assets
CAC type environmental regulations	CAC	It is equal to 1 when the number of local environmental laws and regulations is greater than the median and that is equal to 0 otherwise.
Ownership type	SOE	It takes the value of 1 if the firm is a State-Owned Enterprise, and 0 if not.
Firm age	AGE	Natural logarithm of firm age in years
Financial leverage	LEV	The ratio of total liabilities to total assets
Independent director ratio	IDR	The ratio of number of independent directors to total number of directors
Firm growth	GR	The growth rate of sales revenue
Firm size	SIZE	Natural logarithm of the total assets
Government subsidies	SSUBY	Natural logarithm of the amount of government subsidy
Market environment	MARKET	China’s Regional Marketization Index designed and developed by Fan Gang and Wang Xiaolu
Economic development level	GDP_GR	Natural logarithm of GDP of the province where the company is located

et al. 2014), we controlled firm’s government subsidies (GSUBY). Meanwhile, it cannot be neglected that the above positive relationship can also be driven by other regional factors. We thus included province-level marketization index (MARKET) and province-level GDP growth rate (GDP) in the analysis. Last, we also added industry-, year-, and regional-fixed effects to deal with omitted variables that are industry, time, and city specific. Table 1 lists and defines the variables used in the paper.

**Empirical models**

To test Hypothesis 1, the following regression model (1) was constructed:

$$GRINV_{i,t+1} = \gamma_0 + \gamma_1 Trust_{i,t} + \sum \gamma_k CV_{i,t} + \sum Ind + \sum Year + \sum Province + \varepsilon_{i,t} \tag{1}$$

On the basis of model (1), we introduced CAC (SOE), as well as the interaction between CAC (SOE) and Trust, to test Hypothesis 2 and Hypothesis 3. The models are as follows:

$$GRINV_{i,t+1} = \gamma_0 + \gamma_1 TRUST_{i,t} + \gamma_2 CAC_{i,t} + \gamma_3 TRUST_{i,t} \times CAC_{i,t} + \sum \gamma_k CV_{i,t} + \sum Ind + \sum Year + \sum Province + \varepsilon_{i,t} \tag{2}$$

$$GRINV_{i,t+1} = \gamma_0 + \gamma_1 TRUST_{i,t} + \gamma_2 SOE_{i,t} + \gamma_3 TRUST_{i,t} \times SOE_{i,t} + \sum \gamma_k CV_{i,t} + \sum Ind + \sum Year + \sum Province + \varepsilon_{i,t} \tag{3}$$

where the dependent variable,  $GRINV_{i,t+1}$ , stands for green innovation of firm  $i$ . The independent variable  $TRUST_{i,t}$  means the level of social trust in region where the firm  $i$  is located.  $CV_{i,t}$  denotes the control variable.  $\sum Ind$ ,  $\sum Year$ , and  $\sum Province$  represent dummy variables for industry, year, and region, respectively.  $\varepsilon$  is a random error.  $i$  and  $t$  respectively denote firm and year. All of the independent variables are lagged 1 year to alleviate the possible endogeneity issue. Based on the above assumptions, we expect that  $\gamma_1$  is significantly positive, and  $\gamma_3$  is significantly negative. It is important to point out that we adopt fixed effects regression models to analyze the impact of social trust on green innovation as well as the moderating role of SOE and CAC in these links after Hausman test<sup>1</sup>, so as to mitigate concerns on omitted correlated firm variables.

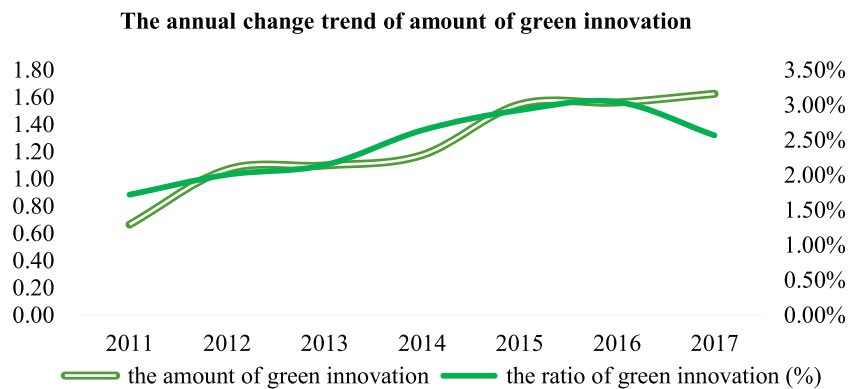
**Empirical tests and results**

**Descriptive statistics**

The annual change trend of the amount of green innovation is depicted in Fig. 1. The overall amount of green innovation patents fluctuates from 0.664 in 2011 to 1.625 in 2017, reaching the highest level in the 7 years of analysis. And, the ratio of green innovation also presents an overall trend toward rising fluctuations. These results indicate that more and more importance is attached to engaging in green innovation by enterprises.

<sup>1</sup> All Hausman tests reject the null hypothesis that individual effects are not related to explanatory variables. Finally, the fixed effect model is chosen.

**Fig. 1** Annual change trend of amount of green innovation



The summary statistics of the variables are shown in Table 2. The mean value of green innovation is 1.915 and the standard deviation is 6.534. This is similar to the results of Qi et al. (2018). It shows that the green innovation varies considerably among enterprises in the full sample. The average value of TRUST1 is 0.361, and the maximum and minimum values are 0.701 and 0.042, respectively. It shows that most interviewees agree that “the vast majority of people in society can be trusted,” and the level of social trust varies vastly among provinces in China. The average value of TRUST2 is 4.310, and the maximum and minimum values are 4.222 and 4.508, respectively. The mean value of IDR is 0.371 and is greater than 0.333.

## Analysis of regression results

### Main effects test

Columns (1) and (2) of Table 3 present the results of FE regressions for Hypothesis 1. As expected, the regression coefficients of TRUST1 and TRUST2 are significantly positive, indicating that social trust can promote enterprises to engage in corporate green activities. The possible reason is that social trust contributes to fostering reciprocal relationships, accelerating knowledge sharing, and easing the financing constraints of enterprises, which provides a resource basis for enterprises’ green innovation activities. More importantly, people in high social trust regions tend to abide by the values of honesty and trustworthiness and thus pay more attention to environmental protection and the fulfillment of CSR. The willingness of enterprises to carry out green innovation activities will be enhanced. Hypothesis 1 is well verified.

The above results may have potential endogeneity issues. More precisely, one potential concern is that some unobservable factors may affect the relation between social trust and corporate green innovation (the issue of omitted variables). Another potential concern is that social trust belongs to survey data, and there may exist measurement errors (the issue of measurement error). In this regard, we employed the fixed effect instrumental variables (FE-IV) models to address

possible endogeneity errors and selected the religion and culture and the voluntary blood donation as instrumental variables. As suggested by Kung and Ma (2014), we measured the religion and culture using the ratio of the number of temples to the regional population. Following Ang et al. (2015), blood donation was measured as the province-level per capita voluntary blood donation rate. The data for voluntary blood donation was obtained from the Chinese Society of Blood Transfusion. The data for the number of temples were taken from a list issued by the State Council of the People’s Republic of China in 1983. The data for the population of each province-year were obtained from CSMAR database.

- (1) Relevance of instrumental variables. The religion and culture plays an important role in shaping ethical values and constructing an environment of trust (Tan and Vogel 2008; Du 2014). Chinese Buddhist culture continues to thrive through multiple dynasties and has become an important part of Chinese traditional culture. The doctrines declared by the culture, such as “Pursuance of All Living Beings” and “Four Immeasurable Hearts,” can decrease self-interest and promote cooperation, which is conducive to the improvement of the level of social trust. In addition, blood donation can reflect the reciprocity, altruism, cooperation, and social morality, and these are the basics of the social trust (Ang et al. 2015; Li et al. 2017a, 2017b). Hence, the higher the voluntary blood donation, the more the public located in the province will abide by social norms such as honesty and trustworthiness. It is consistent with the values advocated by social trust (Guiso et al. 2004). Therefore, the two variables meet the correlation requirement of the instrumental variable. (2) The exogeneity of instrumental variables. It is known that the number of temples in the region and voluntary blood donations are regarded as pure exogenous variables. The two will not be affected by corporate green innovation, nor will they affect corporate green innovation through other paths. Therefore, the two variables meet the exogenous requirement of the instrumental variable.



**Table 2** Describes statistics of main variables

Variables	Observed	Mean	S.D.	Median	Minimum	Maximum
GRINV	9818	1.782	5.988	0.000	0.000	50.000
TRUST1	9818	0.361	0.158	0.373	0.042	0.701
TRUST2	9818	4.310	0.062	4.290	4.222	4.508
CAC	9818	0.560	0.496	1.000	0.000	1.000
SOE	9818	0.326	0.469	0.000	0.000	1.000
ROA	9818	0.044	0.054	0.041	-0.265	0.212
AGE	9818	2.713	0.347	2.773	1.609	3.466
LEV	9818	0.391	0.204	0.376	0.049	0.998
IDR	9818	0.371	0.053	0.333	0.286	0.571
GR	9818	0.174	0.374	0.120	-0.433	2.499
SIZE	9818	21.803	1.147	21.642	18.927	25.775
SSUBY	9818	16.131	2.012	16.187	0.000	20.424
MKR	9818	7.916	1.639	8.055	3.480	9.950
GDP	9818	28.767	0.663	28.799	24.650	29.721

Columns (3) and (4) of Table 3 report the results of the second stage of 2SLS. The results of Kleibergen-Paap rk LM statistics (*P* value less than 1%), Cragg-Donald Wald F statistics (greater than the critical value), and Hansen J statistics (*P* value greater than 10%) show that there is no weak instrumental variable problem, satisfying the two preconditions of relevance and exogeneity. This indicates that the selected instrumental variables are reasonable and effective. The regression results show that the regression coefficients of TRUST1 and TRUST2 remain positive and statistically significant at the 5% level. Although the regression coefficient has improved, the conclusions are generally valid. Our results are robust when controlling for the endogeneity issue.

**The effect of CAC type environmental regulations**

Table 4 reports the regression results of Hypothesis 2. It can be found that whether it is FE or 2SLS, the regression coefficients of CAC are all positive and significantly in addition to the column (3). It indicates that CAC type environmental regulations are capable of stimulating the development of green innovation. Furthermore, the regression coefficients on the all interaction terms are all significantly negative, which shows that the implementation of CAC type environmental regulation tools weaken the promoting effect of social trust on green innovation. Hypothesis 2 is well verified.

The reason is that when environmental laws and regulations are insufficient, social trust, serving as a potential driving force, makes up for the shortcomings of formal institutions and consequently helps promote corporate green innovation. In the case of relatively complete environmental regulations, firms are subject to stricter regulations and have more statutory obligations to engage in green innovation, which will weaken the guiding role

of social trust. Consequently, this result not only reconciles the research differences between formal and informal systems as to whether they are “complementary relation” or “substitution relation” but also explains the paradox that the amount of green innovation patents of firms in loose environmental regulations areas remains high.

**The effect of nature of property right**

Table 5 reports the regression results for Hypothesis 3. The regression results show that whether it is OLS or 2SLS, the regression coefficients of *SOE* are all significantly positive, showing that the level of green innovation of state-owned enterprises is higher than that of non-state-owned enterprises. In addition, all interaction terms have a negative and significant impact on green innovation, suggesting that the positive association between social trust and green innovation is more prominent for non-state-owned enterprises. The possible reasons for this finding are as follows. Although state-owned enterprises can obtain more credit and other resource support, they also undertake more social goals and are subject to more administrative constraints. This limits the guiding role of social trust in corporate green innovation activities. On the contrary, non-state-owned enterprises have much privilege in the discretion, while little in the resources allotment. At this time, the innovation compensation effect of social trust will play a bigger role. Hypothesis 3 is verified.

**Robustness test**

In order to ensure the validity of the model estimation results in this paper, we conducted several additional tests to check the robustness of our results.

(1) Replace green innovation variable. For one thing, in referring to existing studies (Amore and Benedsen 2016), we identified and counted the annual number of green patents of enterprises using the patent classification number published by the State Intellectual Property Office (SIPO). Specifically, we collected all the patents from SIPO. Then, we identified which patents could be considered green patents using the International Patent Classification (IPC) codes. Last, we calculated the number of green patents by year, and the ratio of annual green patents to all annual patents of enterprises was employed to measure corporate green innovation. For another thing, we also used green management innovation to replace the above green technological innovation. With reference to the practices of Searcy et al. (2012) and Li et al. (2018), we used the ISO14001 certification as a proxy variable for green management innovation. We employed the fixed effects model and Logit model to repeat the above tests, respectively. The regression results are shown in columns (1)–(4) of Table 6. The coefficients of TRUST1 and TRUST2 remain significantly positive, indicating that the aforementioned conclusions are robust.

**Table 3** Social trust and corporate green innovation

Variables	FE (1)	FE (2)	FE-IV (3)	FE-IV (4)
TRUST1	2.154*** (3.50)		25.988** (2.21)	
TRUST2		7.569** (2.21)		66.354** (2.15)
ROA	1.799* (1.67)	1.813* (1.69)	1.936* (1.78)	2.060* (1.95)
AGE	-2.991** (-1.98)	-2.910* (-1.92)	-3.702** (-2.24)	-2.719* (-1.80)
LEV	0.824 (1.12)	0.725 (0.99)	1.220 (1.51)	0.268 (0.34)
IDR	0.577*** (2.82)	0.589*** (2.87)	0.485** (2.34)	0.551*** (2.81)
GR	0.221 (1.17)	0.239 (1.26)	0.106 (0.51)	0.314* (1.65)
SIZE	-0.304 (-1.46)	-0.320 (-1.54)	-0.250 (-1.14)	-0.407* (-1.87)
SSUBY	0.009 (0.27)	0.004 (0.12)	0.064 (1.39)	0.009 (0.24)
MKR	0.042 (0.20)	-0.034 (-0.16)	0.543* (1.68)	-0.349 (-1.18)
GDP	2.968** (2.21)	2.516* (1.87)	4.529*** (2.60)	0.174 (0.10)
Constant	-71.520* (-1.83)	-89.500** (-2.21)	—	—
Kleibergen-Paap rk LM statistics	—	—	124.915 [0.000]	209.756 [0.000]
Cragg-Donald Wald F statistics	—	—	63.016 {19.93}	189.722 {19.93}
Hansen J statistics	—	—	0.496 [0.481]	1.019 [0.313]
Year/industry/city	Control	Control	Control	Control
Observations	9818	9818	9420	9420
R <sup>2</sup>	0.009	0.008	0.153	0.023

Note: (1) The value in [] is the *P* value of the corresponding statistic. {} Is the critical value at the 10% level of the Stock-Yogo test. (2) Anderson canon. Corr. LM statistics are used to test the correlation between instrumental variables and endogenous variables. If the null hypothesis is rejected, the selected instrumental variables are reasonable. (3) The Cragg-Donald Wald F statistic is used to test whether the instrumental variable is weakly recognized. If the null hypothesis is rejected, the selected instrumental variables are reasonable. (4) Hansen J statistic is used to test whether there is an over-identification problem. (4) t-Stats are reported in parentheses and are based on robust standard errors. \*, \*\*, \*\*\* denote significance level at 10%, 5%, and 1%, respectively

(2) Replace social trust variable. We used the mean value of CEI\_City of all cities in each province to measure the social trust of region where firms are located in. We re-estimated our model in column (3) of Table 6 and found that the regression coefficient for CEI\_City is significantly positive. This suggests that the key finding of this paper remains robust.

## Further analyses

It can be seen from the above discussion that several mechanisms through which social trust affects corporate green

innovation, including enhancing knowledge sharing, easing financing constraints, and assuming more social responsibility of enterprises. In this section, we will verify whether the above three paths exist.

## Knowledge sharing path

The knowledge sharing path considers that social trust is regarded as the basis of social exchange relations can remove a key barrier of knowledge sharing among organizations. Then, it will help to enhance the knowledge stock of organization members, and then lays a

**Table 4** The effect of CAC type environmental regulations

Variables	FE		FE-IV	
	(1)	(2)	(3)	(4)
TRUST1	2.294*** (3.68)		34.622*** (2.61)	
TRUST2		9.482*** (2.82)		164.748** (2.16)
TRUST1*CAC	-2.113** (-2.10)		-21.120** (-2.07)	
TRUST2*CAC		-4.878 (-1.25)		-39.090* (-1.90)
CAC	0.521*** (2.68)	0.592*** (3.01)	0.299 (1.11)	1.077*** (3.52)
ROA	1.785* (1.67)	1.814* (1.70)	1.740 (1.57)	1.852* (1.71)
AGE	-2.939* (-1.95)	-2.860* (-1.90)	-3.762** (-2.15)	-2.068 (-1.21)
LEV	0.895 (1.22)	0.770 (1.05)	1.577* (1.82)	-0.072 (-0.08)
IDR	0.549*** (2.96)	0.559*** (3.01)	0.463* (1.90)	0.650*** (2.60)
GR	0.216 (1.14)	0.238 (1.26)	0.035 (0.15)	0.373* (1.65)
SIZE	-0.305 (-1.47)	-0.323 (-1.56)	-0.220 (-0.94)	-0.531** (-2.00)
SSUBY	0.010 (0.30)	0.005 (0.16)	0.073 (1.46)	-0.015 (-0.29)
MKR	0.100 (0.48)	-0.010 (-0.05)	1.448** (2.32)	0.467 (1.08)
GDP	2.342* (1.71)	2.035 (1.50)	2.951* (1.65)	-8.118 (-1.56)
Constant	-54.465 (-1.40)	-85.171** (-2.13)	—	—
Year/industry/city	Control	Control	Control	Control
N	9818	9818	9420	9420
R <sup>2</sup>	0.011	0.010	0.328	0.393

Note: t-Stats are reported in parentheses and are based on robust standard errors. \*, \*\*, \*\*\* denote significance level at 10%, 5%, and 1%, respectively

knowledge foundation for green innovation activities. Therefore, the first path is social trust-knowledge sharing-green innovation. Following the procedures suggested by Baron and Kenny (1986), we use the mediating effect model to verify the path. The specific model is as follows:

$$GRINV = a_0 + a_1 TRUST + Control + \varepsilon \quad (\text{PathA})$$

$$KS = \beta_0 + \beta_1 TRUST + Control + \varepsilon \quad (\text{PathB})$$

$$GRINV = \lambda_0 + \lambda_1 KS + \lambda_2 TRUST + Control + \varepsilon \quad (\text{PathC})$$

where *KS* stands for the intensity of knowledge sharing. The remaining variables are consistent with the above. Many studies have shown that industry-university-research cooperation can give rise to knowledge spillovers from interactions of participants, increase

the speed and depth of knowledge transfer, and acquire external knowledge to advance new technologies, which helps enhance firms’ innovation ability (George et al. 2002; Santoro and Gopalakrishnan 2000). So, it is reasonable to use the industry-university-research cooperation in the region where the company is located as a proxy for KS. Following previous studies, we measure the industry-university-research cooperation by using the proportion of enterprise funds in the total research funds of universities and research institutions.

The results are presented in Table 7. As shown in columns (1) and (3), the coefficients of TRUST1 and TRUST2 are positive and statistically significant at the 1% level, which is consistent with our prediction that social trust is conducive to sharing knowledge. As shown

**Table 5** The effect of property right nature

Variables	FE		FE-IV	
	(1)	(2)	(3)	(4)
TRUST1	2.315*** (3.68)		22.929** (2.02)	
TRUST2		7.528** (2.20)		61.185** (2.02)
TRUST1*SOE	-2.880*** (-2.93)		-16.189*** (-3.26)	
TRUST2*SOE		-5.871* (-1.69)		-13.443*** (-2.85)
SOE	0.927* (1.76)	0.852* (1.65)	1.295** (2.35)	0.871* (1.67)
ROA	1.751 (1.63)	1.795* (1.68)	1.867* (1.74)	1.998* (1.89)
AGE	-2.927* (-1.94)	-2.965* (-1.96)	-2.913* (-1.81)	-2.134 (-1.42)
LEV	0.809 (1.10)	0.663 (0.91)	1.253 (1.57)	0.389 (0.49)
IDR	0.591*** (2.88)	0.591*** (2.86)	0.581*** (2.61)	0.671*** (3.09)
GR	0.234 (1.23)	0.249 (1.31)	0.185 (0.90)	0.360* (1.86)
SIZE	-0.310 (-1.48)	-0.317 (-1.52)	-0.318 (-1.43)	-0.453** (-2.03)
SSUBY	0.013 (0.37)	0.007 (0.21)	0.061 (1.35)	0.012 (0.30)
MKR	0.063 (0.30)	-0.018 (-0.09)	0.581* (1.81)	-0.236 (-0.81)
GDP	2.844** (2.12)	2.393* (1.77)	3.585** (2.16)	-0.229 (-0.13)
Constant	-68.940* (-1.81)	-86.859** (-2.17)	—	—
Year/industry/city	Control	Control	Control	Control
<i>N</i>	9818	9818	9420	9420
<i>R</i> <sup>2</sup>	0.010	0.009	0.123	0.033

Note: t-Stats are reported in parentheses and are based on robust standard errors. \*, \*\*, \*\*\* denote significance level at 10%, 5%, and 1%, respectively

in columns (2) and (4), the coefficients of TRUST1 and TRUST2 are significantly positive. However, the positive effect of social trust on green innovation significantly decreases after KS entered into the model, compared with the results of columns (1) and (2) of Table 3. We further use the Sobel test to explore whether the indirect effect is significant. The product of the coefficient  $\beta_1$  of social trust and the coefficient  $\lambda_2$  of knowledge sharing represents the indirect effect. The results show that the *Z* statistics are 2.16 and 2.51, respectively, which are both greater than the critical value of 0.97 ( $P < 5\%$ ). Combined with these findings, we can see that knowledge sharing mediates the relationship between social trust and green innovation. The path of knowledge sharing has been verified.

### Financing constraints path

The financing constraint path holds that social trust can reduce transaction costs and credit risk and thus provide financial support for corporate green innovation. Therefore, the second path is social trust-financing constraints-green innovation. We follow the above mediation effect model to test. For the measurement of financing constraints (FC), we draw on the ideas of Whited and Wu (2006) and use GMM to estimate the parameters of the investment Euler equation. The results are shown in Table 8. In columns (1) and (2), we find that the coefficients of TRUST1 and TRUST2 are significantly negative, showing that social trust is conducive to alleviating financing constraints. As shown in columns (2) and (4), the regression

**Table 6** Robustness test

Variables	Replace green innovation				Replace trust
	FE		Logit		FE
	(1)	(2)	(3)	(4)	(5)
TRUST1	0.050*** (2.86)		1.534*** (3.77)		
TRUST2		0.213** (2.02)		7.293*** (7.00)	
CEI_City					6.782** (2.37)
ROA	-0.021 (-1.00)	-0.021 (-0.97)	-0.292 (-0.90)	0.324 (1.21)	1.725 (-1.59)
AGE	0.029 (0.74)	0.030 (0.75)	0.176* (1.69)	0.134 (1.44)	-3.288** (-2.15)
LEV	0.020 (0.93)	0.018 (0.82)	-0.201 (-0.97)	-0.271 (-1.53)	0.706 (0.93)
IDR	-0.008 (-1.35)	-0.008 (-1.38)	-0.049 (-0.69)	-0.030 (-0.51)	0.624*** (2.98)
GR	0.002 (0.43)	0.002 (0.51)	-0.102 (-1.15)	-0.178** (-2.23)	0.250 (1.27)
SIZE	-0.007 (-1.12)	-0.007 (-1.13)	0.271*** (6.27)	0.211*** (5.79)	-0.300 (-1.36)
SSUBY	0.000 (0.08)	-0.000 (-0.04)	0.031 (1.30)	0.026 (1.29)	0.008 (0.22)
MKR	0.012* (1.71)	0.010 (1.38)	0.164 (1.46)	-0.317*** (-3.82)	-0.031 (-0.14)
GDP	0.039 (0.94)	0.029 (0.70)	-0.542 (-1.35)	-0.124 (-0.37)	2.157 (1.57)
Constant	-1.085 (-0.95)	-1.688 (-1.36)	7.306 (0.65)	15.320 (1.03)	-75.441* (-1.94)
Year/industry/city	Control	Control	Control	Control	Control
N	5042	5042	9626	9626	9347
Pseudo R <sup>2</sup> /R <sup>2</sup>	0.032	0.031	0.380	0.380	0.008

Note: t-Stats are reported in parentheses and are based on robust standard errors. \*, \*\*, \*\*\* denote significance level at 10%, 5%, and 1%, respectively

coefficients of TRUST1 and TRUST2 have decreased after controlling financing constraints, and the regression coefficients of FC are negative and statistically significant at the 5% level. In addition, the Sobel test shows that the Sobel Z values are 1.41 and 1.81, and their absolute values are both greater than 0.97. Overall, the above results prove that the impact of social trust on corporate green innovation could be partially explained by easing financing constraints. The path of financing constraint has been verified.

**Corporate social responsibility path**

The corporate social responsibility path considers that companies in high level of social trust areas pay more

attention to complying with social norms, serving the society, and fulfilling corporate social responsibility. This has a positive role in promoting green innovation. Therefore, the third path is: social trust-corporate social responsibility-green innovation. Similarly, the mediation effect is adopted for testing. Following the existing literature (Chen and Wan 2020), the CSR information disclosure of sample companies is mainly acquired from the Rankins CSR rating database, which has been adopted widely in the literature to measure CSR disclosure and performance of Chinese listed companies. The results of mediation effect test are shown in Table 9. In columns (1) and (3), TRUST1 and TRUST2 are both positively and significantly associated with CSR. In columns (2) and (4),

**Table 7** Mechanism test: knowledge sharing

Variables	FE	FE	FE	FE
	KS	GRINV	KS	GRINV
	(1)	(2)	(3)	(4)
KS		9.037*** (2.74)		8.451** (2.54)
TRUST1	0.009*** (3.51)	2.071*** (3.38)		
TRUST2			0.205*** (16.66)	5.839* (1.70)
Control variable	Control	Control	Control	Control
Constant	1.088*** (6.21)	-81.351** (-2.07)	0.469*** (2.83)	-93.466** (-2.30)
Year/industry/city	Control	Control	Control	Control
<i>N</i>	9818	9818	9818	9818
<i>R</i> <sup>2</sup>	0.418	0.010	0.441	0.009
Sobel <i>Z</i> values	Z = 2.16,  Z  > 0.97		Z = 2.51,  Z  > 0.97	

Note: t-Stats are reported in parentheses and are based on robust standard errors. \*, \*\*, \*\*\* denote significance level at 10%, 5%, and 1%, respectively

the regression coefficients on CSR are both significantly positive, and the regression coefficients of TRUST1 and TRUST2 remain significantly but have decreased after controlling CSR. Moreover, the Sobel test shows that the Sobel *Z* absolute values are both greater than 0.97. Judging from this, our findings reveal that CSR mediates the relationship between social trust and green innovation. The corporate social responsibility path has been confirmed.

**Table 8** Mechanism test: financing constraint

Variables	FE	FE	FE	FE
	FC	GRINV	FC	GRINV
	(1)	(2)	(3)	(4)
FC		-0.255** (-2.06)		-0.245** (-1.98)
TRUST1	-0.259* (-1.96)	2.146*** (3.49)		
TRUST2			-2.390*** (-4.52)	6.984** (2.04)
Control variable	Control	Control	Control	Control
Constant	10.594** (2.57)	-68.840* (-1.77)	17.942*** (3.93)	-85.111** (-2.12)
Year/industry/city	Control	Control	Control	Control
<i>N</i>	9818	9818	9818	9818
<i>R</i> <sup>2</sup>	0.064	0.010	0.067	0.009
Sobel <i>Z</i> values	Z = 1.41,  Z  > 0.97		Z = 1.81,  Z  > 0.97	

Note: t-Stats are reported in parentheses and are based on robust standard errors. \*, \*\*, \*\*\* denote significance level at 10%, 5%, and 1%, respectively

**Table 9** Mechanism test: CSR

Variables	FE	FE	FE	FE
	CSR	GRINV	CSR	GRINV
	(1)	(2)	(3)	(4)
CSR		0.043*** (3.53)		0.043*** (3.55)
TRUST1	1.860* (1.74)	2.051*** (3.33)		
TRUST2			16.862** (2.01)	6.510* (1.89)
Control variable	Control	Control	Control	Control
Constant	44.177 (0.64)	-43.590 (-1.34)	-4.338 (-0.06)	-62.460* (-1.86)
Year/industry/city	Control	Control	Control	Control
<i>N</i>	9818	9818	9818	9818
<i>R</i> <sup>2</sup>	0.061	0.011	0.062	0.010
Sobel <i>Z</i> values	Z = 1.56,  Z  > 0.97		Z = 1.74,  Z  > 0.97	

Note: t-Stats are reported in parentheses and are based on robust standard errors. \*, \*\*, \*\*\* denote significance level at 10%, 5%, and 1%, respectively

## Conclusions and implications

As the carrying capacity of China's ecological environment close to the limit, implementing enterprise green innovation increasingly become a crucial way out of the dilemma for balancing the development between ecological environmental protection and economic growth. Made in China 2025 has also taken enterprise green innovation as an important measure to solve environmental problems. Against this background, we systematically examine whether social trust is associated with more corporate green innovation activities of firms. Using a sample of Chinese A-share manufacturing listed firms over the period 2010–2016, we find the strong evidence that social trust is significantly positively associated with the green innovation. Our results are robust to the use of the endogenous and other robustness tests. In addition, the positive and significant association between social trust and green innovation is diminished in state-owned enterprises and enterprises located in the region where the CAC type environmental regulations are stricter. Further research shows that social trust is positively related to knowledge sharing and corporate social responsibility, and negatively related to financing constraints, which leads to more corporate green innovation in the future. This suggests that knowledge sharing, financing constraints, and corporate social responsibility are mediation mechanisms that social trust affects corporate green innovation.

Our findings have important practical implications. First, our findings suggest that the social trust, an important informal institutions, not only exerts a subtle influence on the perception and behaviors of participants but also can increase

knowledge sharing, reduce financing costs, and fulfill more social responsibilities. And consequently, it has been regarded as an external driving force behind companies upgrading corporate green technology and management innovation. Our analysis verifies the importance of improving the level of social trust in the process of implementing green innovation and promoting sustainable social development. As it is known in China, an emerging and transitional economy, the establishment, construction, and implementation of the formal system remain to be improved. Moreover, the development level of the social trust varies handsomely among regions, attributing to the terribly unbalanced development in the politics, economy, and culture. Given that, it is still an extremely urgent task to enhance the level of corporate social trust and further magnify the synergistic role it plays in the corporate green innovation activities. Specific measures are as follows. For government regulators, it is of huge importance for the government authorities exert administrative authority and public power to optimize the trust environment, aiming at increasing the level of mutual trust among members of the society. For some specific examples, the relevant departments can construct a favorable social credit system to advocate and promote the values of integrity, consequently improve and standardize business environment. Only in this way can our society provide a good social trust environment for green innovation of enterprises. Moreover, it is necessary for the government to cooperate with the public and online media to intensify supervision and apply a more severe punishment, aiming at raising the cost of losing credit. Consequently, the dishonest acts of individuals and enterprises are decreasing, and the excellent “trust soil” for the green innovation in enterprises can form.

For companies, not only do they need to pursue advanced technology and normative system but, more significantly, actively absorb the core nutrients of social trust in the operation and management. On the one hand, by enhancing the credibility and reliability of the market, enterprises need actively to seek the knowledge, credits, and other resources which are integral to green innovation, aiming at building and maintaining good business relations. On the other hand, the prevailing social norms such as “honesty and trustworthiness” and “altruism” in the code of social trust can be integrated into the construction of corporate culture, so as to enhance employees’ awareness of green environmental protection, promote employees to actively fulfill their social responsibilities, and guide their green innovation behaviors. In fact, it is not uncommon to see these companies that regard “integrity” and “altruism” as the corporate cultures at present, such as Google, Apple, Berkshire Hathaway, and Huawei, and they have already got generous returns from applying the green innovations into production. To sum up, in the growing practice process of enterprises green innovation in China, the social trust has played a quite auxiliary or even a guiding role nowadays. The government and enterprises need to continuously

improve the level of social trust by putting the suggestions as mentioned above into operation, so as to ensure the enterprise economy and external environment to develop together coordinately

Second, we further find that the positive relationship between the social trust and the enterprise green innovation is more prominent in those enterprises, which is of less government intervention or looser CAC type environmental regulations. It indicates that when formal institutions are absent or weak in the society, social trust can reduce the social cost caused by the imperfection of formal institutions to a certain extent and thus greatly promote green innovation of enterprises. These findings provide more sufficient empirical evidence for the alternative relationship between the informal and formal institutions. In view of this, for one thing, the relevant departments should focus on the different impacts generating by the social trust on the green innovation between the private and state-owned enterprises respectively and improve the level of social trust in private enterprises according to local conditions, so as to give full play to the maximum effect of social trust in promoting green innovation of enterprises. At the same time, the relevant departments should also continuously improve the financial service system, enriching the financing channels for enterprises, especially private enterprises. Only in this way can the green innovation enterprises fundamentally “quench the thirst” of financing and reduce the risk of low green innovation level owing to the lack of social trust of some private enterprises in their local areas.

For another thing, relevant departments should also pay more attention to the development and improvement of the formal system while enhancing the level of social trust. Put in another way, the formal system and informal system neither can be neglected. It is necessary for the relevant departments to, from two aspects of formal and informal system, build a fair, transparent, efficient, and trustworthy business environment, aiming at improving the transmission efficiency of information and knowledge and enhancing the cooperations between enterprises. In the end, the problems posing in the green innovation, such as financing constraints and knowledge sharing obstacles, are alleviated, and thus the internal vitality of the enterprise green innovation can be genuinely stimulated. So that in the near future, the sustainable development of the environment can be conducted.

This paper inevitably presents some limitations. First, the creation of social trust has been investigated main at the province level. However, the level of social trust in different cities among the same province may vary greatly due to histories, cultures, and customs. It would be important for future research to extend our study to further explore the effects of social trust at the city level. Second, it is a research trend that the determinant factors of green innovation are transitioning from formal to informal institutions. Our paper begins this shift from the perspective of social trust, a critical element of

informal institutions, as an important attempt. Chinese culture is profound and has a long history. We hope that future studies could explore the impact of other informal institutions such as traditional Confucian culture or “guanxi” on green innovation in the setting of China. Finally, we set our study in the Chinese culture featuring high collectivism, so research conclusions may not be applicable to other countries. Future researchers could establish a comparison with other countries of distinct cultures.

**Acknowledgements** We would like to thank the anonymous referees for their helpful suggestions and corrections on the earlier draft of our paper, upon which we have improved the content.

**Author contribution** Pan Zicheng focuses on the conceptualization, methodology, writing-original draft, and writing-review and editing. Liu Liang focuses on the investigation, validation, and formal analysis. Shuyuan Bai focuses on the investigation, validation, and writing-original draft. Ma Qianting focuses on methodology, writing-original draft, and writing-review and editing.

**Funding** The study and collection, analysis, and interpretation of data were supported by the National Natural Science Foundation of China (71472091; 71372031).

**Availability of data and materials** The datasets generated and/or analyzed during the current study are not publicly available due to privacy or ethical restrictions but are available from the corresponding author on reasonable request.

## Declarations

**Ethics approval** The manuscript does not report on or involve the use of any animal or human data.

**Consent to participate** Not applicable.

**Consent for publication** Not applicable.

**Competing interests** The authors declare no competing interests.

## References

- Abbas J, Sağsan M (2019) Impact of knowledge management practices on green innovation and corporate sustainable development: a structural analysis. *J Clean Prod* 229:611–620
- Algan Y, Cahuc P (2010) Inherited trust and growth. *Am Econ Rev* 100(5):2060–2092
- Allen F, Qian J, Qian M (2005) Law, finance, and economic growth in China. *J Financ Econ* 77(1):57–116
- Amore MD, Bennesen M (2016) Corporate governance and green innovation. *J Environ Econ Manag* 75:54–72
- Ang JS, Cheng Y, Wu C (2015) Trust, investment, and business contracting. *J Financ Quant Anal* 50(3):569–595
- Aragon-Correa JA, Leyva-De DI (2016) The influence of technology differences on corporate environmental patents: a resource-based versus an institutional view of green innovations. *Bus Strateg Environ* 25(6):421–434
- Arrow KJ (1974) *The limits of organization*. W.W. Norton, New York
- Baron RM, Kenny DA (1986) The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol* 51(6):1173–1182
- Berrone P, Fosfuri A, Gelabert L (2013) Necessity as the mother of “Green” inventions: institutional pressures and environmental innovations. *Strateg Manag J* 34(8):891–909
- Bjørnskov C (2012) How does social trust affect economic growth? *South Econ J* 78(4):1346–1368
- Borsatto S, Amui L (2019) Green innovation: unfolding the relation with environmental regulations and competitiveness. *Resour Conserv Recycl* 149:445–454
- Borsatto JMLS, Bazani CL (2020) Green innovation and environmental regulations: a systematic review of international academic works. *Environ Sci Pollut Res* 1–18
- Cao X, Lemmon M, Pan X, Qian M (2019) Political promotion, CEO incentives, and the relationship between pay and performance. *Manag Sci* 65(7):2947–2965
- Carlin BI, Dorobantu F, Viswanathan S (2009) Public trust, the law, and financial investment. *J Financ Econ* 92(3):321–341
- Chang CH (2011) The influence of corporate environmental ethics on competitive advantage: the mediation role of green innovation. *J Bus Ethics* 104(3):361–370
- Chen X, Wan P (2020) Social trust and corporate social responsibility: evidence from China. *Corp Soc Responsib Environ Manag* 27(2):485–500
- Chen YS, Lai SB, Wen CT (2006) The influence of green innovation performance on corporate advantage in Taiwan. *J Bus Ethics* 67(4):331–339
- Chow WS, Chan LS (2008) Social network, social trust and shared goals in organizational knowledge sharing. *Inf Manag* 45(7):458–465
- Cline BN, Williamson CR (2016) Trust and the regulation of corporate self-dealing. *J Corp Finan* 41:572–590
- Cormier D, Magnan M (2015) The economic relevance of environmental disclosure and its impact on corporate legitimacy: an empirical investigation. *Bus Strateg Environ* 24(6):431–450
- Cornett MM, Guo L, Khaksari S, Tehranian H (2010) The impact of state ownership on performance differences in privately-owned versus state-owned banks: an international comparison[J]. *J Financ Intermed* 19(1):74–94
- Dangelico RM, Pujari D (2010) Mainstreaming green product innovation: why and how companies integrate environmental sustainability. *J Bus Ethics* 95(3):471–486
- Dimaggio PJ (2003) Culture and cognition. *Annu Rev Sociol* 23(1):263–287
- Dong W, Han H, Ke Y, Chan KC (2018) Social trust and corporate misconduct: evidence from China. *J Bus Ethics* 151(2):539–562
- Du X (2014) Does religion mitigate tunneling? Evidence from China. *J Bus Ethics* 125(2):299–327
- El-Kassar AN, Singh SK (2019) Green innovation and organizational performance: the influence of big data and the moderating role of management commitment and HR practices. *Technol Forecast Soc* 144:483–498
- Estrin S, Prevezer M (2011) The role of informal institutions in corporate governance: Brazil, Russia, India, and China compared. *Asia Pac J Manag* 28(1):41–67
- Fernando Y, Jabbour C, Wah WX (2019) Pursuing green growth in technology firms through the connections between environmental innovation and sustainable business performance: does service capability matter? *Resour Conserv Recycl* 141:8–20
- Gambetta D (1988) Can we trust trust? In: Gambetta D (ed) *Trust: making and breaking cooperative relations*. Blackwell, New York, pp 213–237
- Gauthier C, Genet C (2014) Nanotechnologies and green knowledge creation: paradox or enhancer of sustainable solutions? *J Bus Ethics* 124(4):571–583



- George G, Zahra SA, Wood DJ (2002) The effects of business-university alliances on innovative output and financial performance: a study of publicly traded biotechnology companies. *J Bus Ventur* 17(6):577–609
- Grazia C, Nicoletta C, Luisa MM (2018) Financial constraints and public funding of eco-innovation: empirical evidence from European SMEs. *Small Bus Econ* 54(1):285–302
- Greif A, Tabellini G (2010) Cultural and institutional bifurcation: China and Europe compared. *Am Econ Rev* 100(2):135–140
- Guiso L, Sapienza P, Zingales L (2004) The role of social capital in financial development. *Am Econ Rev* 94(3):526–556
- Guiso L, Sapienza P, Zingales L (2008) Trusting the stock market. *J Financ* 63:2557–2600
- He X, Jiang S (2019) Does gender diversity matter for green innovation? *Bus Strateg Environ* 28(7):1341–1356
- Huang Y, Wang Y (2020) How does high-speed railway affect green innovation efficiency? A perspective of innovation factor mobility. *J Clean Prod*, In press. <https://doi.org/10.1016/j.jclepro.2020.121623>
- Huhe N (2014) Understanding the multilevel foundation of social trust in rural China: evidence from the China General Social Survey. *Soc Sci Q* 95(2):581–597
- Hung M, Wong TJ, Zhang T (2012) Political considerations in the decision of Chinese SOEs to list in Hong Kong. *J Account Econ* 53(1–2):435–449
- Jha A, Chen Y (2015) Audit fees and social capital. *Account Rev* 90(2):611–639
- Kammerer D (2009) The effects of customer benefit and regulation on environmental product innovation: empirical evidence from appliance manufacturers in Germany. *Ecol Econ* 68(8–9):2285–2295
- Kung JK, Ma C (2014) Can cultural norms reduce conflicts? Confucianism and peasant rebellions in Qing China. *J Dev Econ* 111:132–149
- Lee KH, Min B (2015) Green R&D for eco-innovation and its impact on carbon emissions and firm performance. *J Clean Prod* 108:534–542
- Li D, Huang M, Ren S, Ning L (2016) Environmental legitimacy, green innovation, and corporate carbon disclosure: evidence from CDP China 100. *J Bus Ethics* 150(4):1089–1104
- Li X, Wang SS, Wang X (2017a) Trust and stock price crash risk: evidence from China. *J Bank Financ* 76:74–91
- Li D, Zheng M, Cao C, Chen X, Ren S, Huang M (2017b) The impact of legitimacy pressure and corporate profitability on green innovation: evidence from China top 100. *J Clean Prod* 141:41–49
- Li D, Zhao Y, Zhang L, Chen X (2018) Impact of quality management on green innovation. *J Clean Prod* 170:462–470
- Lin RJ, Tan KH, Geng Y (2013) Market demand, green product innovation, and firm performance: evidence from Vietnam motorcycle industry. *J Clean Prod* 40:101–107
- Lin H, Zeng SX, Ma HY, Qi GY, Tam VWY (2014) Can political capital drive corporate green innovation? Lessons from China. *J Clean Prod* 64:63–72
- Liu X, Li M (2019) Social trust and audit pricing: empirical evidence based on CGSS survey data. *Bus Manage J* 10:143–161
- Lu JW, Song Y, Shan M (2018) Social trust in subnational regions and foreign subsidiary performance: evidence from foreign investments in China. *J Int Bus Stud* 49:761–773
- Ocasio W (1999) Institutionalized action and corporate governance: the reliance on rules of CEO succession. *Adm Sci Q* 44(2):384–416
- Popp D (2019) Environmental policy and innovation: a decade of research. CESifo Working Paper
- Porter ME (1991) America's Green Strategy. *Sci Am* 264(4):193–246
- Pujari DD (2010) Mainstreaming green product innovation: why and how companies integrate environmental sustainability. *J Bus Ethics* 95(3):471–486
- Qi G, Zeng S, Tam C, Yin T, Zou H (2013) Stakeholders' influences on corporate green innovation strategy: a case study of manufacturing firms in China. *Corp Soc Responsib Environ Manag* 20(1):1–14
- Qi S, Lin S, Cui J (2018) Do environmental rights trading schemes induce green innovation? Evidence from listed firms in China. *Econ Res J* 12:129–143
- Qiu L, Jie X, Wang Y, Zhao M (2020) Green product innovation, green dynamic capability, and competitive advantage: evidence from Chinese manufacturing enterprises. *Corp Soc Responsib Environ Manag* 27(1):146–165
- Ramamurti R (1987) Performance evaluation of state-owned enterprises in theory and practice. *Manag Sci* 33(7):876–893
- Redding G (2000) The thick description and comparison of societal systems of capitalism. *J Int Bus Stud* 36(2):123–155
- Renning K (2000) Redefining innovation-eco-innovation research and the contribution from ecological economics. *Ecol Econ* 32(2):319–332
- Rexhaeuser S, Rammer C (2014) Environmental innovations and firm profitability: unmasking the porter hypothesis. *Environ Resour Econ* 57(1):145–167
- Santoro MD, Gopalakrishnan S (2000) The institutionalization of knowledge transfer activities within industry–university collaborative ventures. *J Eng Technol Manag* 17(3–4):299–319
- Schiederig T, Tietze F, Herstatt C (2012) Green innovation in technology and innovation management—an exploratory literature review. *R&D Manage* 42(2):180–192
- Searcy C, Morali O, Karapetrovic S, Wichuk K, McCartney D, McLeod S, Fraser D (2012) Challenges in implementing a functional ISO 14001 environmental management system. *Int J Qual Reliab Manag* 29(7):779–796
- Shen C, Li S, Wang X, Liao Z (2020) The effect of environmental policy tools on regional green innovation: evidence from China. *J Clean Prod*, In press. <https://doi.org/10.1016/j.jclepro.2020.120122>
- Stucki T, Woerter M, Arvanitis S, Peneder M, Rammer C (2018) How different policy instruments affect green product innovation: a differentiated perspective. *Energ Policy* 114:245–261
- Tan W, Vogel C (2008) Religion and trust: an experimental study. *J Econ Psychol* 29(6):832–848
- Testa F, Iraldo F, Frey M (2011) The effect of environmental regulation on firms' competitive performance: the case of the building & construction sector in some EU regions. *J Environ Manag* 92(9):2136–2144
- Whited TM, Wu G (2006) Financial constraints risk. *Rev Financ Stud* 19(2):531–559
- Wu W, Firth M, Rui OM (2014) Trust and the provision of trade credit. *J Bank Financ* 39:146–159
- Zak PJ, Stephen K (2001) Trust and growth. *Econ J* 111(470):295–321
- Zhang F, Zhu L (2019) Enhancing corporate sustainable development: stakeholder pressures, organizational learning, and green innovation. *Bus Strateg Environ* 28(6):1012–1026
- Zhao S, Jiang Y, Wang S (2019) Innovation stages, knowledge spillover, and green economy development: moderating role of absorptive capacity and environmental regulation. *Environ Sci Pollut Res* 26(24):25312–25325

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