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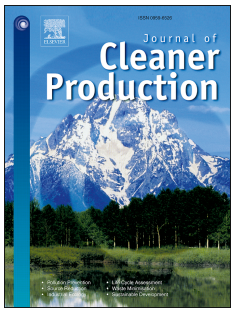

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PII: S0959-6526(17)33199-2

DOI: 10.1016/j.jclepro.2017.12.208

Reference: JCLP 11603

To appear in: *Journal of Cleaner Production*

Received Date: 17 May 2017

Revised Date: 14 November 2017

Accepted Date: 23 December 2017

Please cite this article as: Zhou Y, Hong J, Zhu K, Yang Y, Zhao D, Dynamic capability matters: Uncovering its fundamental role in decision making of environmental innovation, *Journal of Cleaner Production* (2018), doi: 10.1016/j.jclepro.2017.12.208.

Dynamic capability matters: Uncovering its fundamental role in decision making of environmental innovation

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Abstract

This study aims to explore organizations' intrinsic drivers of voluntarily adopting environmental innovations that are in early stage of diffusion. In particular, it investigates the vital role of dynamic capabilities in the decision-making process of adoption. Adopting a process-oriented model, this study focuses on the initiation (instead of implementation) process of innovation adoption and examines how dynamic capabilities can result in intention of adopting environmental innovation voluntarily. The findings show that dynamic capabilities have positive effects on organizational intention of adoption not only directly, but also indirectly through facilitating managers to interpret environmental innovations as an opportunity, rather than a threat. Furthermore, this partial mediating role of managerial interpretation between dynamic capabilities and environmental innovation adoption varies

depending on organizational social position. Compared to central firms, peripheral firms tend to be more responsive to managerial interpretation. The chain from dynamic capabilities, to interpretation of environmental innovation as an opportunity, and finally to the intention of adoption is stronger for peripheral firms than for central ones.

Key words

Dynamic capabilities; Emission trading scheme; Environmental innovation; Managerial interpretation; Social position

Funding

This work was supported by the National Natural Science Foundation of China [grant numbers 71171183, 71172213].

1. Introduction

With the emergence of environmental problems and broader social awareness of environmental issues, environmental regulations have become increasingly stricter. In order to offset the production costs incurred, firms are increasingly engaged in environmental innovation, which may help them to conform to environmental regulations without sacrificing competitiveness. Environmental innovation refers to "any product, process, organizational, social or institutional innovation that is able to reduce environmental impact of economic activity and resource use" (Borghesi et al., 2015, p. 669). It is much more than creating eco-friendly products and technologies; more broadly and critically, it is about making organizational management routines and production process greener (Antonioli et al., 2013; Berrone et al., 2013; De Marchi, 2012). Environmental innovation is multidimensional and complex, which can cause a more profound institutional change. Its primary goal is to protect environment; however, the results are often intangible, lagging, uncertain, and unpredictable, especially when it is in the early stage of development and diffusion.

The existing literature has predominately focused on the role of extrinsic factors that force firms to adopt environmental innovations, such as governmental regulations, social legitimacy and stakeholder pressure (Darnall et al., 2010; Hoogendoorn et al., 2015; Lee et al., 2016; Li et al ., 2016; Popp & Newell, 2012). In order to gain legitimacy, it is necessary that firms engage in environmental innovation to comply with regulations (Ashford & Hall, 2011), keep pace with technological environment at the industry level (Pondeville et al., 2013; Singh et al., 2015), respond to societal expectations and behave in accordance with norms prevalent in the institutional field (Bossle et al., 2016). Nevertheless, these extrinsic factors fail to explain what makes firms adopt an environmental innovation when it is in the early stage of diffusion and

has yet been adopted widely. Social legitimacy is effective and related regulations might be introduced only when an innovation is accepted wildly (Massini et al., 2005; Popp et al., 2011). In that sense, extrinsic factors might not be the only drivers of innovation adoption, and perhaps not the most fundamental ones, at least in the early stage of innovation diffusion. In fact, when an innovation emerges, all firms are embedded in the same external environment, face the same opportunity and therefore are regulated by the same extrinsic factors. However, some firms choose to adopt the innovation while others reject it. Mere extrinsic factors cannot explain this phenomenon. Instead, researchers should take factors from within into consideration. Therefore, in this study, we aim to fill this gap by examining intrinsic factors that may influence firms' environmental innovation adoption.

One intrinsic driver of environmental innovation adoption that we examine in this study is firms' dynamic capabilities. Given the unpredictability inherent in the outcomes of environmental innovation, simply accumulating "static" resources (e.g., a stock of technological assets and professionals, relative to corporate abilities to make timely responsiveness and effective redeployment of various resources) is insufficient to ensure the success of environmental innovation in the ever-changing environment (Teece et al., 1997; Teece, 2007). What is more important is to have difficult-to-imitate dynamic capabilities that can integrate, learn and reconfigure internal and external resources and knowledge to create and deploy environmental innovation in a rapidly changing competitive environment (Wilhelm et al., 2015). So far, little research has examined the fundamental role of dynamic capabilities in the adoption of environmental innovation.

Organizational innovation adoption does not happen overnight, but rather through a process (Birkinshaw et al., 2007; Birkinshaw et al., 2008; Rogers, 2003)

that can be divided into two sub-processes. First, initiation, which is a process of "information gathering, conceptualization, and planning for the adoption of an innovation, leading up to the decision to adopt" (Rogers, 2003, p. 420). Second, implementation, which includes "all of the events, actions, and decisions involved in putting the innovation into use" (Rogers, 2003, p. 421). In this study, we advocate such a process-oriented model of innovation adoption, but only focus on the initiation process, as no action would be taken without the decision of adoption. Specifically, we explore how dynamic capabilities shape the decision-making process that lead to the decision of environmental innovation adoption.

We explore the effect of dynamic capabilities by addressing two research questions. First, what is the process that dynamic capabilities lead to organization's decision of adopting environmental innovation voluntarily without any regulatory requirement? Specifically, we will examine the direct effect of dynamic capabilities, as well as their indirect effect through managerial interpretation of environmental innovation. Second, what is the boundary condition of this adoption mechanism driven by firms' dynamic capabilities? We will examine whether the proposed mechanism can apply to all organizations. The rest of the article is organized as follows. In Section 2, we present the research context of the study, Chinese Emission Trading Scheme (ETS) and discuss why voluntary intention of participating in ETS can be regarded as an environmental innovation. In Section 3, we develop four hypotheses and a structural model of the relationships between dynamic capabilities and intention of adopting environmental innovation. Section 4 presents how we collected data and measured the variables. We report our statistical methods and the results in Section 5. Finally, in Section 6, we discuss the findings and their theoretical and practical implications. We also discuss the limitations of this study and suggest

directions for further research.

2. Research Setting

Environmental innovation is a multidimensional concept. As such, what can be conceived as environmental innovation remains ambiguous. Much literature, based on a result-oriented method, has used tangible environmental technological innovation (i.e., patents) to represent environmental innovation (Berrone et al., 2013; Oltra & Saint Jean, 2009; Wagner, 2007). We believe that environmental innovation is far more than merely technological innovation. It is any innovative means (often strategic) that firms use to produce products and services, which can reduce the impact on environment, and to become environmentally innovative (Bossle et al. 2016). It can be considered as a paradigm shift, which fundamentally challenges firms to adapt their corporate culture, strategies, routines, and organizational structure to keep functioning efficiently. From this point of view, we regard firms' voluntary participation in Chinese national Emission Trading Scheme (ETS) as a form of engaging in environmental innovation in this study.

ETS is a cap and trade system for carbon dioxide emissions. It aims to reduce the carbon emission by creating a carbon market where firms can buy and sell emission permits. Each firm that participates in the ETS is assigned a cap, which refers to a yearly permitted amount of emissions, depending on various factors such as the industry it belongs to, its production rates, technology in use, and the industrial structure of the city it is located in and so on. If a firm exceeds the assigned cap, it would be subject to monetary and/or administrative penalties. Alternatively, it can also purchase emission permits from other firms in a carbon market to evade penalties. On the contrary, if a firm's emission is below the cap, it can either save the permits for future use or sell them in a carbon market. In this way, ETS can help reduce the

carbon emission by increasing the firms' costs of making pollution. Hence, saving carbon emission permits can bring firms with additional resources for their production. Consequently, whether and how to reduce carbon emission to keep it below the cap becomes an important strategic decision for firms.

At the end of 2011, China launched pilot ETS in seven cities (i.e., Beijing, Shanghai, Shenzhen, Guangzhou, Tianjin, Chongqing, Hubei). The seven pilot ETSs involve about 2250 industrial firms that generate about 1.2 billion tons carbon permits every year, making them the second largest carbon market after the European ETS (Qi & Chen, 2015). In these pilot ETS regions, it is required that firms exceeding a threshold of yearly carbon emission participate in ETS, whereas others can choose to participate voluntarily.

ETS is a typical market instrument that has been developed in a bottom-up path in developed economies (Stavins, 2003). In those countries, the diffusion of ETS is driven by business firms. On the contrary, in China, a transition economy, it is a completely new concept and is imposed by the central government on business firms. This top-down approach makes it very challenging to implement ETS successfully among Chinese firms that have little experience with it. In the seven pilot regions, many firms were forced into a pilot ETS and have been struggling since then, whereas few other firms, if any, chose to participate in ETS voluntarily.

Chinese central government has declared that the national ETS will be launched in 2017 (Environomist, 2017). It means that ETS will have profound influence on Chinese firms' production and management (Zhou et al., 2016). Given its newness and challenges involved in ETS, a firm's voluntary participation in the national ETS can manifest its enormous commitment to an overhaul of the firm's operating and managing system. It means that the firm is willing to take the initiative to assume

environmental responsibility and to restrain its carbon emissions through not only technological and productive innovation, but rather a more complex change of corporate strategy, organizational culture and business philosophy in order to adapt to ETS (Borghesi et al., 2015). This is consistent with our concept of environmental innovation. Therefore, this research aims to explain firms' intention to adopt voluntarily the national ETS in China once it is launched.

3. Hypotheses Development

3.1. Direct effect of dynamic capabilities

Dynamic capabilities reflect firms' abilities to achieve new and innovative forms of competitive advantage (Teece et al. 1997). Teece et al. (1997) defined dynamic capabilities as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (p. 516). The concept of dynamic capabilities is built on and extends the resource-based view (RBV) (Barney, 1991) by incorporating the "evolutionary nature" of firms' capabilities in response to the dynamics in firms' external environments (Wang & Ahmed, 2007, p. 35). From the dynamic-capability view, the valuable, rare, inimitable and non-substitutable (VRIN) resources in RBV that give rise to firms' competitive advantage are routines and processes of renewing their knowledge and reconfiguring their resources as responses to changes in their external operating environment. These routines and processes are VRIN because they are developed over time along a path-dependent trajectory that embodied by a firm's history.

Dynamic capabilities in this study consist of three components: integrating capability, learning capability and reconfiguring capability (Y. Lin and Wu, 2014). Integrating capability refers to the abilities to incorporate and internalize external technologies and practices into internal production processes efficiently to maintain

congruencies and complementaries among processes and functionalities. Learning capability emphasizes firms' abilities to acquire, store, organize and share knowledge. Reconfiguring capability refers to firms' abilities to scan the environment, anticipate changes and redeploy resources to transform existing practices. These capabilities are embedded in organizational routines and can enhance organizational capabilities to innovate or to adopt radical innovation (H.-F. Lin et al., 2016).

Environmental innovation is a process more comprehensive than compliance with environmental regulations. It involves anticipating future regulations and social trends and designing or altering operations, processes, and products to prevent (rather than merely ameliorate) negative environmental impacts (Aragon-Correa & Sharma, 2003). ETS is a system that inevitable reshuffles market positions of participating firms. Participating in ETS can hurt firms' competitive advantage by increasing their production cost if they refuse to make any changes. On the other hand, it can also improve firms' competitiveness if they proactively adapt to it. We argue that firms with higher level of dynamic capabilities can better adapt to ETS thereby more likely to form the intention of voluntarily adopting it. They are more likely to anticipate the changes brought by ETS in terms of technology, policy and stakeholder demands, reevaluate the markets and competitors they face, calibrate the requirements for change and implement the changes. These changes can include seeking relevant knowledge about ETS, providing training to employees, investing in infrastructure and new technologies, restructuring production processes, and fostering an organizational culture to promote eco-friendly and energy-saving values and behaviors. The changing processes can incur great costs and are extremely uncertain and risky given the newness of ETS in China (Leonidou et al., 2013). Dynamic capabilities can help firms to navigate these processes by enabling them to constantly

collect necessary information, detect signals of problems, distribute the information across subunits, develop and articulate problem-solving strategies, and adjust and realign the production processes and operation routines accordingly in a timely fashion (Zollo & Winter, 2002). The higher possibilities of succeeding in participation in ETS should enhance firms' confidence, thereby enhancing the intention of adopting ETS voluntarily. Hence, our first hypothesis is:

H1: *Dynamic capabilities are positively related to firms' voluntary intention of adopting ETS.*

3.2. Mediating effect of managerial interpretation

It is conceivable that the decision of adopting an innovation ultimately depends on how key decision makers in firms perceive the innovation (Birkinshaw et al., 2007; Kennedy & Fiss, 2009; Rogers, 2003). Managerial interpretation of an innovation consists of a series of judgments and evaluations of the innovation made by managers. They can be mapped on a continuum with one pole as threat interpretation and the other as opportunity interpretation (Sharma, 2000). When managers perceive an innovation as a threat, they believe that their firms are unlikely to benefit from adopting the innovation, and they do not have a sense of control in terms of the results of adoption (Chattopadhyay et al., 2001). Conversely, when managers perceive an innovation as an opportunity, they believe adopting it can bring gains to their firms and they feel like having a strong sense of control over the situation (Chattopadhyay et al., 2001, p. 939; Dutton & Jackson, 1987, p. 80).

Participating in the national ETS involves great level of uncertainty for Chinese firms, as ETS is still a new concept in China. Few firms at this point have enough experience that ensure their success once the national ETS is launched. In this context,

managerial interpretation of ETS plays a vital role for firms' intention of adoption. If managers view ETS mostly as a threat to their firms' operations, which introduces uncertainties out of their control, they will likely be risk-averse and choose not to participate in ETS in order to seek to minimize losses rather than maximize gains (Sitkin & Pablo, 1992). On the contrary, if managers perceive ETS more as an opportunity, from which their firms can benefit (e.g., economic gains; become a greener firms to appeal to customers who cares about environmental issues; become a leader in the industry, etc.), they will tend more to lead their firms to participate.

Then what makes the management of a firm perceive ETS as a threat or as an opportunity? We claim that firms' dynamic capabilities can help facilitate managers to interpret participating in ETS as an opportunity. The threat-opportunity categorization of ETS depends on three attributes of managerial reaction to it: emotional associations, loss or gain consideration, and a sense of control (Sharma, 2000). First, dynamic capabilities can generate positive emotional associations from participating in ETS. In a firm with high level of dynamic capabilities, managers (as well as employees) are more likely to recognize the increasing concern for the environment in the society and hence are more likely to integrate environmental protection into their corporate identity and social responsibility (Scherer & Palazzo, 2011). Consequently, they tend more to view participating in ETS as consistent with their corporate identity, thereby generating positive emotional associations (Sharma, 2000). Second, dynamic capabilities can channel managerial attention to the gains of participating in ETS. Since ETS is a new concept in China, fair amount of uncertainties can ensue from ETS participation. Firms with low level of dynamic capabilities tend to focus on short-term economic consideration. They are unlikely to sense ETS as a future business trend, actively seek and acquire knowledge about it, or act prompt to

reconfigure their routines to adapt to it; they will in general perceive it as a threat to current operations. Firms with high level of dynamic capabilities, however, can better handle the uncertainties and will be more likely to find solutions to increase profit while participating in ETS. Moreover, they might also be more far-sighted and able to see other non-monetary gains, such as being recognized as an "environmental leader", and improving status in the industry. Third, dynamic capabilities can provide managers with a strong sense of control. Firms with high level of dynamic capabilities can keep themselves updated with the changes brought about by ETS and related regulations promulgated by various levels of government, and react promptly to them by reconfiguring available resources and practices efficiently. With these capabilities, managers will be more confident that they have the control over any situation. The above arguments suggest a mediating effect of managerial interpretation between dynamic capabilities and intention of voluntary adopting ETS. Specifically, we derive the following two hypotheses:

H2: *The higher level of dynamic capabilities a firm has, the greater the likelihood that its managers will interpret ETS as an opportunity rather than as a threat.*

H3: *The greater the degree to which a firm's managers interpret ETS as an opportunity, the greater intention the firm has to adopt ETS voluntarily. Conversely, the greater the degree to which its managers interpret ETS as a threat, the lower intention a firm has to adopt ETS voluntarily.*

3.3. Moderating effect of social position

We further explore whether the above-proposed mechanism will hold for all firms that dynamic capabilities result in intention of voluntary adoption of environmental innovation through managerial interpretation. Prior research that

examined the effects of managers' interpretation of environmental issues has yielded mixed results (e.g., Sharma, 2000; Chattopadhyay et al., 2001; Haney, 2015, etc.). For example, Sharma and colleagues have found that managers' opportunity interpretation of environmental issues often led to innovation and entrepreneurship (Sharma, 2000; Sharma et al., 1999). Others, however, suggest that threat interpretation can also lead to firms' innovative responses (Chattopadhyay et al., 2001), especially in the early stage of issue understanding when firms focus more broadly on their social responsibility and when they are driven by moral legitimacy in the context of environmental and social changes (Haney, 2015). Given the inconsistent results in the existing research, the contingency-based view criticizes the relationship between managerial interpretation and organizational innovation decision for its ill-defined boundary conditions (Chang & Chen, 2013; Chattopadhyay et al., 2001). It argues that to assess the effect of managerial interpretation researchers should consider organizational characteristics including firm size, market share, and brand reputation, etc. (Chattopadhyay et al., 2001; Shimizu, 2007). These features are represented by the social structure of a field in which firms are embedded (Compagni et al., 2015). Research on early adopters of innovation found that in contrast to central actors, peripheral actors tend to pioneer an emerging innovation, driven by a search for social gains that constitute them as "exemplary users" influential to others, despite the presence of persistent uncertainty about the focal innovation's technical or economic benefits (Compagni et al., 2015, p. 242; Kennedy & Fiss, 2009). Given the insights, we hypothesize the moderating role of social position on the relationship between managerial interpretation and voluntary adoption of ETS.

We mentioned earlier that firms with high level of dynamic capabilities might be more able to see the benefits from participating in ETS, especially those not directly

related to monetary gains. The perceived benefits increase the chances that firms adopt ETS voluntarily. However, these potential benefits seems to be more valuable for peripheral firms than for central ones. By voluntarily participating in the national ETS before it becomes mandatory, peripheral firms may achieve huge improvements in its relative standing within the social structure of the field, becoming leaders related to environmental issues and innovations so that can exert influence on others in the same field (Compagni et al., 2015). In contrast, those located in the very central position of the field have little, if any, space for improvements in terms of social position. It means that the (social) gains associated with participating in ETS perceived by managers are more conducive to the subsequent intention of participation for peripheral firms than for central firms.

In addition, the influence of threat interpretation on resistance of participating in ETS is also stronger for peripheral firms than for central firms. Peripheral firms are usually new and small, which are often struggling with survival. Therefore, they would be more sensitive to threat interpretation of ETS; they would be much less likely to participate in ETS if the managers view it as a threat. However, it is possible for central firms to adopt ETS voluntarily even when they regard it as a threat, as found by Compagni et al. (2015) in their study on the diffusion of robotic surgery. Central firms are willing to do so for keeping the prominent position. Some informants from leading hospitals in Compagni et al. (2015) mentioned that adopting robotic surgery is their duty. Similarly, in the case of participating in ETS, it is likely that central firms perceive it as their obligation in order to be a role model for others in the field. They might also fear that if they are not among the first to participate, they will lose the exemplar status in the field and are replaced by their competitors. This suggests that due to the desire to maintain the reputation and the prominent

social position in a field, central firms will voluntarily adopt ETS even if they regard ETS as a threat. Hence, we reach the following hypothesis:

H4: *The positive relationship between managerial interpretation and voluntary intention of adopting ETS is stronger for firms with lower social position (e.g. peripheral firms) and weaker for those with higher social position (e.g. central firms).*

The above four hypotheses form our theoretical model shown in Fig. 1. As a summary, we first hypothesize that dynamic capabilities have positive effect on the voluntary intention of adopting ETS. Next, we further look into the process and propose that the above effect of dynamic capabilities is mediated by managerial interpretation of ETS. Finally, we explore the boundary conditions of this process and speculate the moderating effect of firms' social positions in a field.

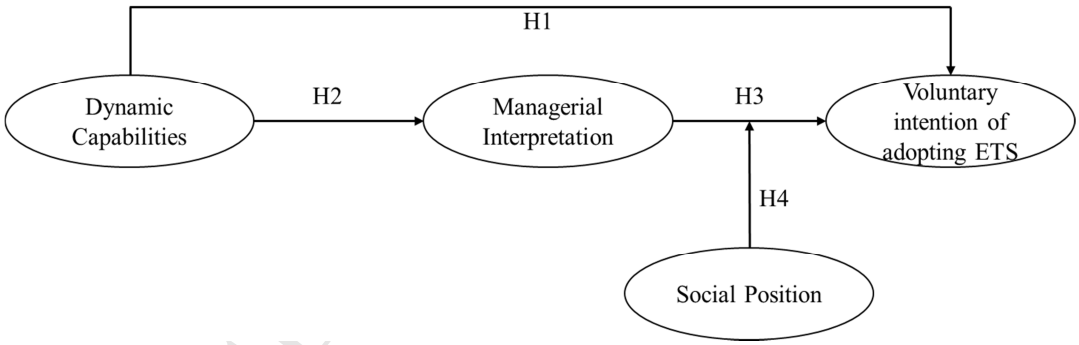

Fig. 1 Theoretical Model

4. Data and Measures

4.1. Data

The data-collection process of this study comprised two phases. First, qualitative field interviews were conducted to learn about routine activities relevant to the three types of dynamic capabilities and their potential implications for innovation adoption,

as well as to test the intelligibility of a preliminary survey questionnaire. It is followed by a large-scale survey.

4.1.1. Field interviews

The fieldwork included 44 interviews with top-level managers who were students from an Executive Master of Business Administration (EMBA) program of University of Science and technology of China (USTC). Each interview lasted between 30 and 45 minutes and consisted of three parts. In the first part, we asked managers to elaborate on types of routine activities for adapting their firms to changes in the external environment. What they said to a large degree were consistent with the three dimensions of dynamic capabilities. In the second part, we scrutinized the four hypotheses developed in Section 3 by asking managers how critical these activities are for their interpretation and adoption of ETS. There was considerable agreement that routines reflecting strong dynamic capabilities can help to form a positive managerial interpretation of ETS, which often leads to the final decision of adoption. In the final part of the interviews, managers were asked to fill out a preliminary version of the questionnaire that would be used in the subsequent survey study and to provide feedback on the clarity of the items as well as difficulties in responding to them. As a result of this process, several questionnaire items were reworded or eliminated.

4.1.2. Sample and data collection

Our target sample was Chinese firms in manufacturing industries. We collaborated with China-Beijing Environmental Exchange. This institution is well known for its executive training programs, especially the training on ETS and low carbon development concepts. From the institution, we obtained a sampling pool that

included 790 firms. Then, we employed a professional survey research firm to distribute our surveys. For each firm, one senior executive, who had attended training programs on ETS, was identified to serve as a key informant and asked via email to take the survey. It is a standard and common practice to use senior executives or ‘‘key informants’’ as the data source for organizational studies (e.g., Liu et al., 2010; Schilke, 2014). In this study, we chose senior executives as respondents for three reasons. First, they had participated in ETS training and most of their firms were covered by the seven Chinese pilot ETSs (i.e., in Beijing, Shanghai, Shenzhen, Guangzhou, Tianjin, Chongqing, Hubei), and thus were knowledgeable about the issues under study. Second, as senior executives, they should have a fairly good understanding of the dynamic capabilities and social positions of their firms, as well as their firms' responses to ETS. Finally, with their positions at the top of organizational hierarchy, they played an active role in making strategic decisions for their firms. In that sense, their (perceived) adoption intention is more meaningful, as it should be able to better predict their firms' subsequent adoption action.

Out of 790 questionnaires, 302 were returned, including 80 incomplete ones that were discarded. As a result, we obtained 222 usable questionnaires, with a response rate of approximately 28%. This sample size is in line with those in other strategy studies (Phelan et al., 2002) and exceeds the commonly recommended threshold for advanced statistical analyses (MacCallum et al., 1999).

Characteristics of the informants and their firms in the sample are shown in Table 1. To verify the appropriateness of respondents, we included items to ask about informants' tenure and expertise on ETS (Kumar et al., 1993). Overall, 63.5 percent of the participants in the final dataset have been serving their current firms for ten years or longer. We also assessed respondents' self-reported knowledge of ETS and their

perception of firms' knowledge of ETS on a five-point scale ranging from 1 (poor) to 5 (excellent). The means of the two scales are 4.14 ($SD = 0.85$) and 4.15 ($SD = 0.83$), respectively, suggesting that the informants and their firms were very well informed about ETS.

Table 1 Sample composition

	N	Percentage
Ownership		
State-owned	80	18.9
Non-state-owned	141	51.4
Firm size		
< 50 employees	8	3.6
50 – 99 employees	11	4.9
100 – 299 employees	44	19.8
300 – 499 employees	69	31.1
500 – 999 employees	46	20.7
1000 – 1999 employees	28	12.6
≥ 2000 employees	16	7.2
Firm age (years)		
≤ 5	4	1.8
6 – 10	40	18.0
11 – 25	131	59.0
26 – 50	41	18.5
> 50	6	2.7
Tenure of respondent in firm (years)		
≤ 5	15	6.8
5 – 10	66	29.7
11 – 15	100	45.0
16 – 20	30	13.5
> 20	11	5.0
Respondents' self-reported knowledge of ETS[1]		
1	2	0.9
2	7	3.2
3	33	14.9
4	96	43.2
5	84	37.8
Respondents' perception of firms' knowledge of ETS[1]		
1	4	1.8
2	3	1.4
3	29	13.1
4	106	47.7
5	80	36.0
Firm location		
Non-pilot region	44	19.8
Pilot region[2]	178	80.2

Note: [1] Scores range from 1 (poor) to 5 (excellent).

[2] The seven Chinese ETS pilot regions are Beijing, Shanghai, Shenzhen, Guangzhou, Tianjin, Chongqing, Hubei.

Following previous studies, we employed several methods to check whether nonresponse bias was present. First, we compared the early and late respondents (Armstrong & Overton, 1977). The t-test results on the means of all constructs indicated no significant differences ($p > 0.05$) between the early and late respondents. Second, we singled out the firms that returned incomplete surveys but with the complete information on firm ownership, size and age and compared them with those in our sample on these three firm attributes (Schilke, 2014). The results of t-tests revealed no significant differences between the two sets of firms on any of the attributes ($p > 0.05$). These findings provide consistent evidence that nonresponse bias is unlikely a problem.

Our sample includes firms from the seven Chinese pilot ETS regions as well as from non-pilot regions. To make sure the relationships we found are not spurious due to the differences among firms across regions on our key independent variables, we conducted a one-way analysis of variance (ANOVA). The results showed no significant difference among these regions on all constructs except for voluntary adoption of ETS ($p > 0.05$). It suggests that the variance in voluntary adoption intention is not likely a region effect. We therefore controlled for firm location by including a dummy variable in the following data analysis.

4.2. Measures

Table 2 lists the measurement of variables included in our theoretical model. Multi-item scales were used to measure these variables. All scales are adopted from prior studies.

4.2.1. Dependent and independent variables

Our dependent variable is *intention of voluntary adoption of ETS*. We treat it as

behavioral intention that can accurately predict actor's behavior. To achieve this, we took Ajzen's (2005) approach and constructed the intention scale by including four elements – action, target, context, and time-frame – in each of the items. We adopted the scale of adoption intention from Liu et al. (2010) and modified the items to reflect the current target (ETS), and time-frame (once the national ETS is established).

To capture a firm's *dynamic capabilities*, we adopted the scales used by Y. Lin and Wu (2014), who suggested a three-dimensional, second-order structure of the construct, with the underlying dimensions of (1) integrating capability, (2) learning capability, and (3) reconfiguring capability.

The measurement for *managerial interpretation of ETS* included three items adapted from Sharma (2000). These items were designed to capture executives' perception of participating in the national ETS as an opportunity or a threat by asking them to assess the issue from aspects such as expected outcomes and a sense of controllability. The higher the raw scores on these items, the more likely that managers tend to perceive ETS as a threat.

We developed a scale to measure a firm's *social position*. Campagni et al. (2015) categorized organizations' social positions as central or peripheral. They found that informants' perceived their organizations as being "one of the most important", "prominent", or "central" on the one hand, or "peripheral", "marginal", or "small" on the other. Informants' perceptions substantially converged with scholar's beliefs based on objective organizational demographic indicators. This provides us with confidence of capturing firms' social positions with a self-reported scale. Following the insights provided in Compagni et al. (2015), we formulated five items (e.g., "My firm is one of the most important firms in the field") and ask informants to score each of them on a five-point scale with 1 as "strongly disagree" and 5 as "strongly agree". The average

of the five scores represents a firm's social position; the higher the score, the more central the firm is.

4.2.2. Control variables

Firm ownership. We coded firm ownership as 1 for state-owned firms and 0 for non-state-owned ones. In China, state-owned firms are controlled by the central government. Most of the top managers in state-owned firms are government officials and appointed by the central government (Calza et al., 2014; Chen et al., 2011). Since ETS is an institutional innovation promoted by the Chinese government, we suspect that state-owned firms might be more willing to adopt it. Therefore, we controlled for firm ownership in our data analysis.

Firm size. Prior research has found that firm size can influence firm's innovation (Soh & Subramanian, 2014). In order to exclude plausible alternative explanations of firms' intention of innovation adoption, we controlled firm size in our analysis. Firm size was assessed based on a firm's total number of full-time employees using a 7-point scale that ranges from 1 for firms having fewer than 50 employees to 7 for firms having 2,000 or more employees.

Firm location. Our sample includes firms that are in the seven Chinese ETS pilot regions as well as other non-pilot regions. It is conceivable that firms located in the ETS pilot regions might be more aware of the system and its implications, which can influence their intention of adopting national ETS. In order to control for the regional differences in terms of intention of adoption, we included a dummy variable that indicates whether a firm is located in a pilot region (coded as 1) or in a non-pilot region (coded as 0).

Firm age. Firm age has been found to influence organizational innovation (Aldrich & Auster, 1986; Sorenson & Stuart, 2000), and likely the intention of

innovation adoption. We measured firm age in years since the establishment of a firm, coding firm age using a 5-point scale that ranges from 1 for firms that are 5 years or younger to 5 for firms that are older than 50 years (Schilke, 2014).

5. Method and Results

We used structural equation modeling (SEM) to test our theoretical model, as it is often used to test structural relationships in a postulated model (Alexiev et al., 2016; H.-F. Lin et al., 2016). Specifically, we conducted partial least squares (PLS) structural equation analysis using the software package Smart-PLS 2.0. Following the recommendation of J. C. Anderson and Gerbing (1988), we analyzed our data in two steps. First, we conducted a confirmatory factor analysis (CFA) to test whether the questionnaire items well captured the corresponding latent constructs. This established the measurement model which was then used to assess convergent and discriminant validity of the constructs. Second, after obtaining a satisfactory measurement model, we conducted a path analysis to test the hypothesized relationships in our theoretical model. This established the structural model.

5.1. Measurement model testing

Table 2 reports the factor loadings, Cronbach's alpha (α) coefficients, composite reliabilities (CR), and average variances extracted (AVE) of the study's first-order, multi-item constructs. The values of these indices ($factor\ loadings > 0.7, \alpha > 0.7,\ CR > 0.7, AVE > 0.5$) suggest reasonable reliability and validity of the constructs in our model. Following the method used by Fornell and Larcker (1981), we assessed the discriminant validity of all the factors in the model. We found that the square root of AVE of each factor was larger than the absolute values of the correlations between that factor and all the other factors in the model, except for the three dimensions of dynamic capabilities (enclosed by dashed boxes in

Table 3). It indicated that the discriminant validity of these three first-order constructs (i.e., integrating capability, learning capability and reconfiguring capability) was not satisfactory. Hence, we followed the method in C.-P. Lin and Chiu (2011) to check if dynamic capabilities should be used as one second-order construct or the combination of three first-order constructs. To do so, we first conducted an exploratory factor analysis. The result showed that only one factor was generated from the three first-order constructs according to the eigenvalue-greater-than-one rule. It means that it is reasonable to introduce dynamic capabilities as one single construct in our model. Next, we assessed the validity and reliability of the construct of dynamic capabilities, which showed satisfactory values (see Table 2 and Table 3 outside the dashed boxes).

After assessing the constructs individually, we performed a CFA among the four main constructs (i.e., dynamic capabilities, managerial interpretation, social position and intention of voluntary adoption), using AMOS 21.0 (Arbuckle, 2012) and the maximum likelihood (ML) procedure (Hair, 2009). The model was tested by the following fit indices: the ratio of x^2 to degree of freedom, the Comparative Fit Index (CFI), the Goodness-of-Fit Index (GFI), the Normed Fit Index (NFI), the Tucker-Lewis coefficient (TLI) and Root Mean Square Error of Approximation (RMSEA). The indices of goodness of fit showed satisfactory values ($x^2 = 88.46$; $df = 59$; $x^2/df = 1.50$; $CFI = 0.98$; $GFI = 0.94$; $TLI = 0.97$; $NFI = 0.94$; $RMSEA = 0.05$). Therefore, we can conclude that the measurement model have adequate reliability, convergent validity, and discriminant validity.

In addition, since our data were self-reported measures collected from a single source at one point in time, common method bias might be a threat to the validity of the study. To safeguard against this possibility, we performed Harman's one-factor test by loading all indicators (except for control variables) into an exploratory factor

analysis (Liu et al., 2010; Schilke, 2014). Results revealed that four factors were extracted in total which were consistent with our hypotheses, and no single factor explained more than 30 percent of the total variance in the variables. It suggests that common method bias is unlikely to be a serious problem in this study. In addition, we also compared our model with a single-factor model to test common method variance (Mossholder et al., 1998). We forced all variables to be loaded on one factor and compared the model fitness of this single-factor model with that of the proposed four-factor model. The result showed that the single-factor model had a significantly worse goodness of fit ($x^2 = 401.56; df = 65; p \leq 0.001$). As such, common method variance is unlikely to affect the validity of our results.

Table 2 Measurement scales

Items	Factor Loadings	α	CR	AVE	Mean/SD
Dynamic capabilities[1]		0.93	0.94	0.56	
Integrating capability		0.82	0.88	0.65	
1a Customer information collection and potential market exploration	0.76				3.92/0.99
1b Specialized organization to collect industry information for managerial decision	0.73				3.86/1.10
1c Integrating industry related technologies to develop new products	0.73				4.00/0.98
1d Recording and integrating historical methods and experiences in handling firm issues	0.71				4.03/0.98
Learning capability		0.81	0.87	0.63	
2a Frequent anticipating industrial knowledge learning program	0.78				4.05/0.91
2b Frequent internal educational training	0.72				4.06/0.96
2c Knowledge sharing and learning groups establishment	0.75				3.92/1.02
2d Frequent internal cross department learning program	0.70				3.92/0.99
Reconfiguring capability		0.85	0.89	0.68	
3a Clear human resource re-allocation procedure	0.76				3.89/1.05
3b Rapid organizational response to market changes	0.79				4.05/0.98
3c Rapid organizational response to competitor's actions	0.75				3.98/0.98
3d Efficient and effective communication with cooperative organization	0.75				4.08/0.97

Table 2 *(Continued)*

Managerial interpretations of ETS[2] *('Strongly disagree' [1] to 'strongly agree' [5])*		0.76	0.86	0.67	
4a Our firm is likely to lose rather than gain by actions to participate in ETS.	0.89				3.14/1.14
4b Any actions that our firm may take for ETS are constrained by others in the organization.	0.79				2.90/1.16
4c Our firm lack the technical knowledge to reduce the environmental impact of company operation.	0.76				3.04/1.31
Social position *('Strongly disagree' [1] to 'strongly agree' [5])*		0.85	0.89	062	
5a My firm is one of the most important firms in the field.	0.82				3.91/0.84
5b My firm is prominent in the field.	0.82				3.72/0.88
5c The development of my firm can represent the industry development trend.	0.75				3.88/0.90
5e The brand of my firm is valuable with a long history.	0.75				3.97/0.87
5d The scale of my firm is large.	0.79				3.79/0.84
Intention of voluntary adopting ETS[3] *('Strongly disagree' [1] to 'strongly agree' [5])*		0.80	0.87	0.62	
6a My firm plans to be engaged in learning know-how about ETS after the national ETS is established.	0.77				4.09/0.80
6b My firm is contemplating to participate in ETS after the national ETS is established.	0.79				4.08/0.77
6c My firm is likely to participate in ETS after the national ETS is established.	0.75				4.20/0.81
6d My firm is expecting to participate in ETS after the national ETS is established.	0.82				4.17/0.82

Note: CR, composite reliabilities; AVE, average variances extracted; SD, standard deviation; ETS, emission trading scheme.

[1] Respondents were asked to rate each of the items using the following scale: [1] "Our firm is not familiar with it or we have not done it." [2] "We are trying to do it." [3] "We do it sometimes." [4] "We often do it." [5] "We have set it as our one of routines."

[2] These three items are reverse items and were recoded before data analysis.

[3] It is ensured that respondents were aware before rating the items that participation in the national ETS is voluntary in this situation.

Table 3 Descriptive statistics and discriminant validity [1]

Factor	Scale range	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1 Dynamic capability (DC)[2]	1-5	3.98	0.75	**0.75**										
2 Integration capability (DCI)	1-5	3.95	0.82	N/A	**0.81**									
3 Learning capability (DCL)	1-5	3.99	0.77	N/A	.77**	**0.80**								
4 Reconfiguration capability (DCR)	1-5	4.00	0.82	N/A	.76**	.82**	**0.82**							
5 Managerial interpretations	1-5	3.03	0.99	.35**	.32**	.32**	.33**	**0.82**						
6 Social position	1-5	3.85	0.69	.62**	.59**	.55**	.57**	.27**	**0.79**					
7 Intention of voluntary adoption	1-5	4.14	0.63	.55**	.52**	.52**	.50**	.37**	.57**	**0.79**				
8 Firm location	0/1	0.80	0.40	-.02	.08	.06	.02	-.12	-.02	-.06	N/A			
9 Firm size	1-7	4.27	1.42	.13**	.30**	.22**	.24**	-.02	-.23**	-.01	-.06	N/A		
10 Firm age	1-5	3.02	0.74	.15**	.25**	.15*	.22**	-.04	.21**	.02	.06	.26**	N/A	
11 Firm ownership	0/1	0.36	0.48	.19	.05	.07	0.03	0.15	.21	.31**	-.12	-.01	.12	N/A

Note: [1] N=222; numbers on the diagonal show square roots of AVE, numbers below the diagonal show correlations; AVE not available for single-item constructs.

[2] As analyzed above, DC is the second-stage construct of DCI, DCL and DCR.

**. Significant at $p < 0.01$ (2-tailed); *. Significant at $p < 0.05$ (2-tailed)

5.2. Structural model testing

Our conceptual model in Fig. 1 was tested using SEM. SEM can simultaneously examine the paths between latent factors. We expanded the number of the original sample from 222 into 5000 through bootstrapping method, and estimated parameters with the software package AMOS 21.0. Fig. 2 presents the results of the analysis. For the sake of simplicity, the observed variables and the correlations between the error terms of the observed variables are not shown in Fig. 2.

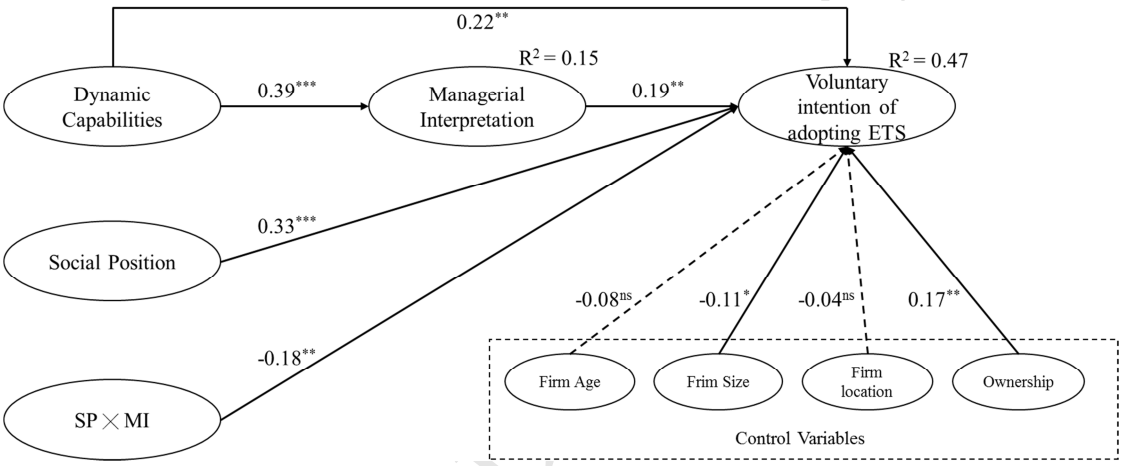

Fig. 2 Results of structural equation model testing
Notes: SP × MI, interaction term of social position and managerial interpretation.
*** $p < 0.001, t > 3.29$; ** $p < 0.01, t > 2.58$; * $p < 0.05, t > 1.96$; ns non-significant.

As shown in Fig. 2, the overall performance of the model provided strong support to the theoretical specification. All paths, except for two control paths, achieved statistical significance at least at the level of 0.05 and the directions of the coefficients of all significant paths were as expected. The overall model shows that firms' dynamic capabilities play an important role in the initiation process of innovation adoption, which ultimately leads to the decision of voluntary adoption of ETS. Dynamic capabilities have a direct effect on intention of adoption. Firms with higher level of dynamic capabilities have higher tendency to adopt ETS voluntarily ($\beta = 0.22, t = 2.65$). They also have an indirect effect through managerial

interpretation. Firms with higher dynamic capabilities are more likely to interpret it as an opportunity ($\beta = 0.39, t = 7.84$), thereby contributing to forming the intention of adoption ($\beta = 0.19, t = 2.80$). These findings support Hypotheses 1, 2 and 3.

In order to test the mediating effect of managerial interpretation, we conducted PLS-SEM analysis of a model without the mediating variable (i.e., managerial interpretation) and compared it with our proposed model. The model without managerial interpretation presents a significantly positive relationship between dynamic capabilities and adopting intention of ETS, and explains 44.2% of the variance in adoption intention. The model with the mediating variable shows that both dynamic capabilities and managerial interpretation significantly and positively influence corporate intention to adopt ETS voluntarily, and explains 46.8% of the variance in adoption intention. The inclusion of managerial interpretation increases the explained variance by 2.6% ($\Delta R^2 = 2.6\%, p < 0.01$). It suggests that managerial interpretation of ETS partially mediates the effect of dynamic capabilities on voluntary adoption of ETS (Baron & Kenny, 1986). Corporate dynamic capabilities have a significant indirect effect on voluntary adoption of ETS through managerial interpretation ($\beta \approx 0.39 * 0.19 \approx 0.8$), in addition to the direct effect ($\beta = 0.22, t = 2.65$). Therefore, the total effect of dynamic capabilities on voluntary adoption of ETS is 0.30 ($t = 3.89$).

An interaction term between social position and managerial interpretation was introduced in Smart-PLS 2.0 to test the moderating effect of social position on the link between managerial interpretation and adoption intention of ETS. The path coefficient of the interaction term in Fig. 2 shows that social position significantly and negatively moderates the positive relationship between managerial interpretation and adoption intention of ETS ($\beta = -0.18, t = 2.80$). Hypothesis 4 thus is supported. Fig. 3

illustrates this moderating effect. It shows that the effect of managerial interpretation on intention of adopting ETS is stronger for peripheral firms than for central firms.

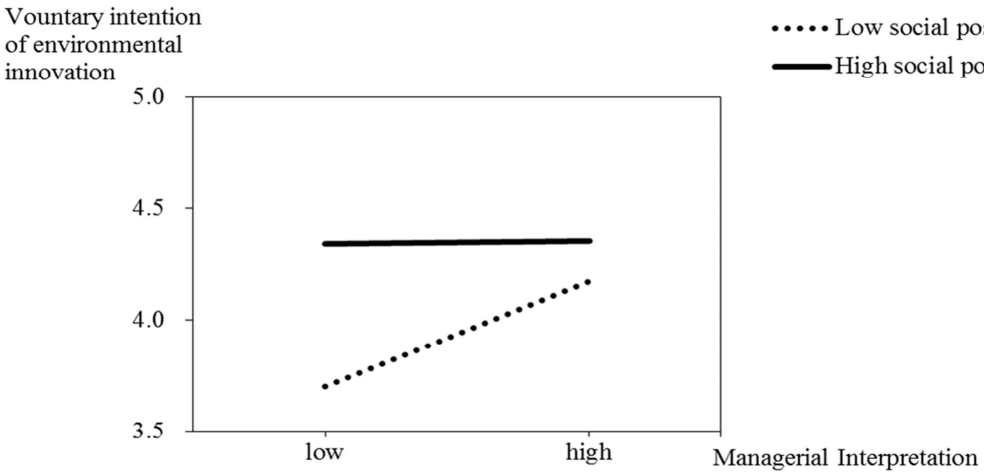

Fig. 3 Moderation effect of social position

The effects of some control variables are interesting. We found a positive effect of firm ownership (β = 0.17, t = 2.88), which suggests that state-owned firms are more willing to adopt ETS voluntarily than non-state-owned firms. We also found a negative effect of firm size (β = -0.12, t = 2.02). It means that large firms are more hesitant to adopt ETS than small firms; this finding resonates with that in Soh and Subramanian (2014).

6. Discussion and Conclusion

In this study, we focused on the initiation process of environmental innovation adoption and aimed to explain how organizations form the intention of adopting environmental innovation voluntarily. We investigated the effects of dynamic capabilities, an important intrinsic driver, on organizations' intention of voluntary adoption. Using a sample of 222 Chinese firms, we found the answers to the two research questions put forward at the beginning of the article. First, dynamic capabilities can enhance firms' intention to adopt environmental innovation both directly and indirectly. With high level of dynamic capabilities, firms are more likely

to be willing to adopt environmental innovation voluntarily even when it involves great uncertainties and risks. In addition, firms with high level of dynamic capabilities tend more to interpret environmental innovation as an opportunity rather than a threat, and thereby more likely to voluntarily adopt it. Second, we found that one of the boundary conditions of the process, in which dynamic capabilities lead to intention of voluntary adoption through managerial interpretation, is firms' social positions. Peripheral firms with higher tendency to interpret environmental innovation as an opportunity are more likely to adopt it voluntarily in the early stage of its diffusion than central firms. It suggests that the initiation process of innovation adoption we found holds stronger for peripheral firms than central firms.

6.1 Theoretical implications

This study has several contributions. First, it focuses on firms' intrinsic drivers of environmental innovation adoption. Previous research has explained adoption mostly by examining extrinsic drivers, such as government regulations, social legitimacy and stakeholder pressure (Darnall et al., 2010; Hoogendoorn et al., 2015; Lee et al., 2016; Popp & Newell, 2012). However, extrinsic factors cannot explain why facing the same external environment some firms choose to adopt environmental innovation, whereas others do not (Antonioli et al., 2013; Borghesi et al., 2015; De Marchi, 2012; Wagner, 2007). Extrinsic factors also fail to explain what makes firms adopt an environmental innovation when pressure from external environment is lacking or weak (e.g., when an innovation just emerges and is still in the early stage of diffusion). Our study has filled this gap by examining firms' intrinsic factors. Specifically, we examined how firms' dynamic capabilities and managerial interpretation affect their intention of adopting environmental innovation voluntarily.

Second, this study introduces the concept of dynamic capabilities into the

environmental innovation literature and examines how dynamic capabilities can affect firms' voluntary adoption of environmental innovations that are in the early stage of diffusion. We argue that dynamic capabilities can facilitate firms to adopt such environmental innovations. Dynamic capabilities can help firms to collect relevant information, identify potential advantages and disadvantages of adoption, acquire related knowledge, integrate new technologies and practices into routines, and reconfigure organizational resources and operation processes in a timely fashion to combat uncertainties involved in the adoption of environmental innovation (e.g., Barreto, 2010). With higher level of dynamic capabilities, firms are more confident that they can manage the changes brought about by adopting environmental innovation. Our empirical analysis confirms the proposed effect of dynamic capabilities. Our findings are also consistent with previous studies that dynamic capabilities are positively related to the adoption of other types of innovation, such as management innovation (Battisti and Iona, 2009; H.-F. Lin et al., 2016), multinational corporations' subsidiary innovation (Michailova and Zhan, 2015), and eco-innovation (Bossle et al., 2016), thus generalizing the positive link between dynamic capabilities and innovation into the field of environmental innovation.

Third, by adopting a process model, this study examines the process in which dynamic capabilities facilitate firms to form the intention of adopting environmental innovation. We argue that managerial interpretation plays an important role in the middle. Dynamic capabilities can help firms to capture the opportunity to become environmental leaders by engaging in environmental innovation, offer them with confidence that they can manage the associated uncertainty, and provide them with a strong sense that engaging in environmental innovation is controllable. This leads firms' managers more likely to view environmental innovation as an opportunity,

rather than a threat, thereby enhancing their adoption intention. Our finding that managerial interpretation partially mediates the effect of dynamic capabilities is consistent with this argument. It suggests the critical role of dynamic capabilities in the adoption of environmental innovation. Dynamic capabilities can intensify firms' intention of environmental innovation adoption not only directly, but also by shaping the perception of environmental innovation as an opportunity that can bring about economic and social gains.

Lastly, this study reconcile the debate regarding the effect of managerial interpretation and environmental innovation by exploring the moderating effect of firms' social position. We believe that the inconsistent conclusions in prior research is due to the lack of consideration of organizational characteristics. We argue that peripheral firms are more sensitive to their interpretation of an environmental innovation. Compare with central firms, they are more likely to be willing to adopt an innovation if it is perceived as an opportunity to gain economic and social status, and more likely to resist adopting an innovation if it is perceived as a threat to current operations and survival. The results of our empirical analysis are consistent with this argument. This might suggest that firms with different social positions reach the decision of adopting environmental innovation through different processes. The link from dynamic capabilities, to managerial interpretation and then to intention of innovation adoption is stronger for peripheral firms, but less informative to explain central firms' intention.

6.2. Practical implications

This study offers several important insights for managerial practices. We focus our discussion on improve adoption rate of China's national ETS.

Firstly, given the important role of dynamic capabilities, organizations should

intentionally build and enhance their dynamic capabilities in order to survive the changes brought about by the national ETS. Even though the national ETS starts as an optional practice, it will eventually become mandatory for all firms. ETS is relatively new concept with only limited adoption in China, but it will profoundly transform Chinese firms' managerial and operational practices, as well as industrial structures. Firms have no choice but managing to survive in this wave of changes. Enhancing dynamic capabilities is one thing to do. Organizations could set up a department or a group of people that are in charge with collecting information related to ETS and communicating it with the rest of the organizations. They could also actively participate in any ETS training programs provided by the government in order to equip themselves with the necessary skills and knowledge to operate in the carbon market. Finally, they should keep the organizational structure flexible and organic with the use of teams so that resources and talents can be redeployed easily when needed.

Secondly, the mediating effect of managerial interpretation also suggest its direct effect on firms' intention of adopting ETS. Apart from firms building their dynamic capabilities in order to adapt to ETS, government could also help shape managers' interpretation of the national ETS as an opportunity. For example, government could provide firms with training programs and assistance to participate in ETS. These programs not only offer necessary knowledge, technologies, and skills, but also educate firms about the urgency of environmental issues, and help them to build a corporate identity that is committed to environmental innovation. With the value of caring about environment and the necessary skills to take action, firms are more likely to generate positive emotional association with ETS, to identify potential advantages of participation, and to have a stronger sense of control, thereby more likely to

interpret participating in ETS as an opportunity. This positive perception of ETS can ultimately intensify firms' willingness to participate.

Lastly, the moderating effect of social position on the relationship between managerial interpretation and intention of adopting ETS implies that we probably should look for other methods to motivate central firms to adopt ETS, in addition to improving their dynamic capabilities, as central firms are not as sensitive as peripheral firms to the interpretation of participating in ETS.

6.3. Limitations and future research

This study aims to fill a research gap by exploring the effects of firms' intrinsic drivers to adopt environmental innovation. It has made several contributions that have theoretical and practical implications. However, it is not without limitations.

First, intention of adopting an emerging environmental innovation can be a result of multiple intrinsic factors, of which dynamic capabilities are only one. Others could include organizational culture, power structure, leadership, etc. Further studies could further explore the effects of other intrinsic factors individually or as a combination on firms' intention of engaging in environmental innovation.

Second, managers' interpretation of an environmental innovation may depend on many factors, in addition to firms' dynamic capabilities, such as managers own characteristics including personal beliefs and values, educational background, prior working experience, views on environmental concerns and social norms (Borland et al., 2016; Flannery and May, 2000. It means that the path from dynamic capabilities to managerial interpretation and finally to firms intention of adoption is just one of many possible other paths. We do not intend to be comprehensive in this study, but hope that other researchers will continue to explore other possible mechanisms that lead to

firms' adoption of environmental innovation in the future.

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- This study focuses on firms' intrinsic drivers of environmental innovation adoption.
- Dynamic capabilities have positive effects on organizational intention of adoption not only directly, but also indirectly through facilitating managers to interpret environmental innovations as an opportunity, rather than a threat.
- This partial mediating role of managerial interpretation between dynamic capabilities and environmental innovation adoption varies depending on organizational social position.