Climate-entrepreneurship in response to climate change

Lessons from the Korean emissions trading scheme (ETS)

Su-Yol Lee
College of Business Administration, Chonnam National University, Gwangju, South Korea, and

Young-Hwan Ahn
Climate Change Research Division, Korea Energy Economics Institute, Ulsan, South Korea

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Abstract

Purpose – This study aims to explore South Korean firms' reactions to climate change issues and the Korean emissions trading scheme (ETS) from the perspective of proactive climate-entrepreneurship. Differences in attitude toward the Korean ETS, implementation of carbon management practices and performance regarding operations, market and emission reductions are also investigated.

Design/methodology/approach – A research model was developed to investigate the differences in corporate perception of climate change. Using a cluster analysis and analysis of variance with 94 South Korean companies subject to the Korean ETS, the study identified carbon strategies and examined differences in characteristics among the strategies. This study undertook a robustness test by comparing the results from a large sample (n = 261) with those of the original sample (n = 94).

Findings – The study identifies four different carbon strategies based on climate-entrepreneurial proactivity: the "explorer," "hesitator," "attempter" and "laggard." The "explorer" cluster is likely to have a proactive stance toward the Korean ETS regulation, while the "laggard" cluster shows resistance to this new climate policy. Entrepreneurial proactivity in carbon strategies is related to the actual adoption, implementation and effectiveness of carbon management practices.

Originality/value – This research is one of the few studies to explore differences in corporate response to climate change from the perspective of entrepreneurship. The study provides a theoretical foundation for extending the literature on the strategic management of climate change issues.

Keywords Climate change, Operational performance, Carbon management practices, Climate-entrepreneurship, Emissions reduction performance, The Korean ETS

Paper type Research paper

1. Introduction

Climate change has emerged as one of the most critical issues that may completely transform a competitive business environment (Howard-Grenville *et al.*, 2014; Lash and Wellington, 2007; Kolk and Pinkse, 2005). The Paris Agreement, which was adopted in 2015 and came

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into force in 2016, has urged firms to take a more proactive stance toward a low-carbon economy. South Korea, the world's seventh largest emitter of greenhouse gases (GHG) as of 2010, announced its own voluntary medium-term mitigation goal to reduce GHG emissions by 37 per cent of the "business-as-usual" level by 2030. As one of the key measures to achieve the national goal, South Korea launched an emissions trading scheme (ETS) in 2015, which is the second nationwide "cap-and-trade" scheme in operation after that for Kazakhstan in Asia.

This new policy involves energy-intensive and high-polluting sectors, including general industry, power utility, water supply, waste management, building and mining that collectively account for more than 75 per cent of the country's GHG emissions. Transportation, residential, agriculture, forestry and fisheries, construction and other public sectors were excluded from the Korean ETS, as the number of entities belonging to those sectors was too large to be monitored effectively and as they accounted for a smaller portion of the emissions.

Firms have shown different reactions in addressing climate change issues. While some companies, such as Exxon-Mobile, one of the major emitters in the USA (hereinafter the USA), strongly opposed unfavorable climate regulations, others, such as Pacific Gas and Electric, Ford Motors and Du Pont, took a proactive stance by lobbying for stringent climate change policies in the USA (Delmas *et al.*, 2016; Jones and Levy, 2007). Previous research attempted to gain a better understanding of how firms differ in response to climate change by describing their different reactions (Lee, 2012; Jeswani *et al.*, 2008; Kolk and Pinkse, 2005; Levy and Kolk, 2002). However, the literature is limited in the following ways.

First, few studies have analyzed firms' responses to climate change from a managerial interpretation perspective. Corporate environmental strategies may differ even though they are in the same competitive context (Delmas and Toffel, 2008). Managerial perceptions of environment-related risks and opportunities, organizational capabilities and the availability of slack resources within an organization influence management decision-making, which in turn determines the range and level of corporate response to climate change (Lee and Klassen, 2016; Banerjee, 2001). However, the topic of how firms differ in sensing potential impacts of climate change on their business, seeking business opportunities from climate change, and integrating climate change issues into the strategic decision-making process, has not been explored. Second, there is a limited understanding of how firms' proactive stance toward climate change, which is conceptualized as "climate-entrepreneurial proactivity" in this study, influences the levels of adoption and implementation of climate change management practices across industries. Third, only limited research has examined the effects of corporate response to climate change on a firm's actual performance, including operational, market and environmental and emissions reduction performance.

In light of this research gap, this study makes three contributions. First, the authors explore how firms differ in climate-entrepreneurial proactivity, characterized as sensing and interpreting climate change issues and integrating them into a managerial decision-making process. Second, this study investigates differences in corporate attitude toward the Korean ETS regulation and carbon management practices. Third, the authors examine how climate-entrepreneurial proactivity leads to operational performance and market and emission reductions in the context of South Korea.

2. Theoretical and practical backgrounds

2.1 South Korean policies fighting climate change

This section provides an overview of the South Korean government's climate change policies. South Korea adopted the National Strategy for Green Growth in 2009, aiming to promote eco-friendly growth and contribute to international efforts to fight global warming.

In light of this strategy, South Korea announced its goal to reduce national GHG emissions to 30 per cent below its "business-as-usual" projection by 2020. A few years later, South Korea reset this target to 37 per cent below business-as-usual levels in 2030. In 2010, the Framework Act on Low Carbon, Green Growth was enacted, which created the legislative framework for mid- and long-term emissions reduction targets, cap-and-trade, carbon labeling, carbon information disclosure, and other related policies. The Act included a system of mandatory carbon emissions reporting by all carbon- and energy-intensive industries, and provided a basis for the enforcement of a carbon-trading scheme (ETS). As a precursor to the ETS, the Target Management Scheme (TMS), a GHG management program with 490 entities and 1570 sites, was introduced in 2010 and officially implemented in 2012. As of 2011, the TMS covered almost 68 per cent of the total GHG emissions in South Korea. The TMS imposed GHG reduction on large-scale facilities emitting a substantial quantity of GHGs, consuming a high level of energy, while energy conservation targets obligated them to meet their goals. The legislation on the ETS, the Greenhouse Gas Emission Permit Allocation and Trade Act, was adopted in 2012. The ETS was originally scheduled to come into force in 2012, but the South Korean government delayed it in order to give companies more time to prepare for this regulation.

South Korea officially launched its ETS in January 2015 amid strong resistance from the business and industry. The idea was to tighten regulations on companies' emissions gradually through a cap-and-trade system. The Korean ETS is split into three phases: 2015-2017, 2018-2020 and 2021-2025. In the first phase, 525 of the country's largest emitters of GHGs, consisting of private and government-owned organizations, have been subject to the ETS. In Phase 1, total carbon allowances were cut by 20 million tons annually from 570 million tons to 550 million tons. Most sectors received free allowances based on the average GHG emissions of the base period (2011-2013). In Phase 2, free allocation and auctioning will jointly apply as 97 per cent free allowances and 3 per cent for auction. In the third and final five-year period (2021-2025), less than 90 per cent will come under free allocation and the rest will be auctioned. However, particular businesses involved in energy-intensive and trade-exposed sectors will receive 100 per cent of their allowances in all phases, at no cost to them; this initiative aims to reduce their concerns about losing competitiveness in the global market.

2.2 Climate-entrepreneurship

Firms subject to the same set of external environmental pressures may adopt different practices and policies (Delmas and Toffel, 2008). Managerial perceptions of external stakeholders and their demands about environmental issues have served as a vital determinant of subsequent action (Sharma, 2000; Henriques and Sadorsky, 1999). Taking a proactive stance on climate change issues is a starting point to examine how the external competitive environment is translated into corporate action. This study employs "entrepreneurialism" to conceptualize such managerial perceptions of climate change-related environmental risks, opportunities, and organizational capabilities, which are believed to influence management's decision-making (Lee and Klassen, 2016) and in turn determine the range and level of corporate carbon strategies. In general, entrepreneurialism is understood as the activation of opportunities to combine limited resources to create value and secure returns in new ways, through problem-solving practices under resource constraints and decision-making flexibility. By selectively combining concepts of entrepreneurship, environmental proactivity and organizational capabilities, this study characterizes "climate-entrepreneurship" consisting of the following three elements: sensing, seeking and integrating climate change issues in business.

First, climate change "sensing" is an aspect of recognizing potential impacts of climate change on a business. Sensing provides the basis for being keenly aware of climate change issues and then responding to them. It does not entail careful planning by considering various alternatives. Instead, managers are involved in automatic and relatively effortless processing and learning of climate change-related information. Sensing relies on intuition, which is particularly critical in the context of surging climate change issues as it enables a firm to integrate wide-ranging stimuli into usable categories of information (Dane and Pratt, 2007). Second, climate change "seeking" is a tendency to explore potential business opportunities when encountering unprecedented climate change challenges. Managers vigilantly awaiting an opportunity from climate change and sensing tangible business value propositions connect rather abstract climate change outputs. They create solutions to challenges related to climate change by using creative perspectives to develop new products, services and businesses (Sanders and Wood, 2015). With respect to business performance, the focus should be on managerial perception regarding the benefits rather than costs or risks from a proactive response to climate change. Firms may differ in the implementation of carbon management practices owing to the differences in how managers assess the consequences of their responses to climate change. Managers focusing on the bright side of responding to climate change (i.e. positive expected benefits) take a proactive stance toward climate change issues. Third, "integrating" is an aspect of organizational capabilities that incorporates climate change issues into a firm's strategic planning process. It is one of the ways to give high priority to climate change, which supports organizational initiatives for climate change. "Integrating" can offer firms an opportunity to develop valuable, potentially rare, and not easily imitable capabilities, which in turn leads to new competitive advantages (Barney, 1991).

3. Research framework

3.1 Climate-entrepreneurship and corporate response to climate change

Previous studies have attempted to classify different corporate responses to climate change by characterizing the real carbon management activities that firms adopt and implement. They have proposed a wide range of models as a typology to understand carbon activities of companies (Table I). For example, Kolk and Pinkse (2005) highlighted this type of research by clustering *Financial Times*' (FT) 500 firms with carbon measures and identified six distinct climate strategy configurations. Similarly, Weinhofer and Hoffmann (2010) and Sprengel and Busch (2010) examined corporate responses to climate change and derived six and four different strategies, respectively. Recently, Lee (2012) presented six types of corporate carbon strategies in South Korea based on their varying levels of adoption and implementation of actual carbon practices.

Unlike such previous studies that have focused more on actual carbon practices employed by a firm, the present study characterizes corporate responses to climate change based on climate-entrepreneurship (sensing, seeking and integrating aspects). Climate-entrepreneurship is a novelty proposed in this study by combining relevant models, such as eco-entrepreneurialism (Sanders and Wood, 2015) and environmental championing (Anderson and Bateman, 2000). Eco-entrepreneurialism is characterized by innovation-enhancing resource efficiency, reducing environmental impacts, meeting unmet needs of the society and transforming waste into a valuable asset (Sanders and Wood, 2015; p. 70). It emphasizes on opportunity-seeking attitude toward environmental and social challenges by using creative perspectives regardless of owning enough resources. Environmental championing can be understood as an enthusiastic effort and activity to improve the environmental performance of an organization by observing environmental issues on a local, national and international scale, raising environmental

Research	Carbon strategy types	Remark
Lee (2012)	All-round explorer, emergent explorer, all-round enhancer, product enhancer, cautious reducer and wait-and-see observer	A cluster analysis of 241 Korean companies based on content analysis
Weinhofer and Hoffmann (2010)	All-rounder, compensator, substituting compensator, reducer, substituting reducer and preserver	A cluster analysis with a sample in the electricity industry
Sprengel and Busch (2010)	Minimalists, regulation shapers, pressure managers and emission avoiders	A cluster analysis with a sample of the Down Jones global index companies
Jeswani *et al.* (2008)	Indifferent, beginner, emerging and active	A cluster analysis based on a continuum model with a sample from Pakistan and the UK
Kolk and Pinkse (2005)	Cautious planner, emerging planner, internal explorer, vertical explorer, horizontal explorer and emissions trader	A cluster analysis with a broad sample of FT500 companies
Levy and Kolk (2002)	Avoidant, resistant, compliant and proactive	Case studies of the petroleum industry

Source: Adopted and modified from Lee (2012)

Table I. Corporate response to climate change identified in the literature

awareness within an organization, advocating for-good environmental practices and promoting environmental initiatives. It can convince and enable an organization to turn environmental issues into successful corporate programs and innovations (Anderson and Bateman, 2000), which provide our model with a theoretical background for sensing and integrating dimensions.

This approach implies that corporate carbon strategies differ depending on the proactive perception of climate change and capability of integrating climate change issues into a firm's strategic and managerial decision-making processes. This framework distinguishes between relatively shallow and more profound approaches for each of the climate-entrepreneurship dimensions. As a result, a combination of different levels of a firm's climate-entrepreneurship indicates its particular strategy.

These arguments present the following proposition:

P1. Differences in climate-entrepreneurial proactivity of South Korean firms translate into distinct types of corporate responses to climate change.

3.2 Climate-entrepreneurship, carbon management practices and performance

Previous studies have provided consistent evidence about the relationship between management's forward-looking perception of environmental issues and the adoption of new practices. A proactive response to an emerging environmental issue potentially requires significant firm-level resource investment, which is likely to be made only with the consent of the top management (Klassen, 2001). Environmental championing behavior by individuals in C-executive positions influences others in the upper echelons to take pro-environment actions (Branzei *et al.*, 2004; Anderson and Bateman, 2000). A risk-taking propensity is one of the unique characteristics of entrepreneurs. Although there is a long-standing debate, an argument that the risk propensity of entrepreneurs is greater than that of administrative managers has been widely supported (Stewart and Roth, 2001). For uncertain environmental issues such as climate change, managers may attempt preventive actions instead of merely responding to events that have already occurred (Aragon-Correa and Sharma, 2003). Being

proactive can also help shape the nature of future discourse with stakeholders and competitors. Management's entrepreneurial risk-taking regarding climate change issues that view climate change as central to competitiveness will favor a "proactive" approach (Forlani *et al.*, 2002).

Regulations have continued to be unpredictable in many countries, vacillating between stringent public policy favoring lower carbon emissions and limited or no regulatory action. For instance, several firms have vigorously lobbied regulators to delay or avoid climate change-related legislations by emphasizing their inability to forecast the costs and competitive impacts of such measures (Delmas *et al.*, 2016; Jones and Levy, 2007). Thus, the authors expect that a significant number of managers may display resistance or hesitation toward precautionary actions in response to climate change, and if they have to take such actions, they may implement small token adjustments. However, others who are climate-entrepreneurial risk-takers may have a different stance and actively encourage their organization and policymakers to respond creatively and proactively to climate change-related challenges. This reasoning leads to the following proposition:

P2. Climate-entrepreneurial proactivity relates to the positive attitude toward climate change regulations and substantive adoption and implementation of carbon management practices. Corporate attitude toward climate change policy (the Korean ETS) and carbon management practices differ depending on climate change entrepreneurship.

Although there has been a long-standing argument about the relationship between proactive environmental strategy and performance, a large number of studies support a win–win possibility. A firm's proactive stance toward climate change, which is envisaged with climate-entrepreneurship and actualized with the implementation of particular carbon management practices, can have positive effects on firm performance, including improvement in environmental, operational and market performance, as well as carbon emission reduction. The literature has provided evidence of and explained the positive link between a firm's climate change response and its performance as follows.

First, proactive and preventive environmental management may lower manufacturing costs, prevent environmental liabilities (Karpoff *et al.*, 2005) and enhance productivity. In production operations, carbon management practices emphasize waste reductions, efficient and effective input use and control of internal processes, which in turn lead to improvements in cost, quality and delivery, and quick response to customer demand (Sroufe, 2003; Rothenberg *et al.*, 2001). Second, firms may achieve revenue growth by accessing new markets generated by climate change and enhance their environmental reputation with greener products in existing markets (Lee, 2012; Kolk and Pinkse, 2005; Seifert *et al.*, 2003). Tesla in the electric vehicle market and Toyota with its hybrid vehicles are exemplary cases of "market gains," that include market share gains, experienced-based scale economies, certifications and higher margins. Third, climate-entrepreneurial proactivity may facilitate organizational and technological learning and innovation (Lee and Klassen, 2016), which are dubbed "innovation offsets" (Porter and van der Linde, 1995). Low-carbon and carbon-free products and processes may require a high level and multidisciplinary range of technical expertise, know-how and technological capabilities. Such challenging efforts toward a low-carbon economy can foster organizational learning and absorptive capacity, which in turn leads to higher technological and innovation outcomes.

The primary purpose of the present paper is not to test a hypothesis about the relationship between climate-entrepreneurship and firm performance. Instead, this study examines the differences in operational, market and emission reduction environmental

performance between particular types of climate-entrepreneurship. This reasoning presents the following proposition:

P3. Climate-entrepreneurial proactivity relates to operational, market and emission reduction performance.

4. Research methodology

4.1 The sample

The present research used a survey method. Consistent with the purpose of this study to explore business responses to climate change and related regulations, the authors selected and surveyed the general industry and power utility sectors that were subject to the Korean ETS regulation. A total of 428 entities (389 sites from general industry and 39 sites from power utilities) were complied. A single respondent with knowledge of their firm's carbon management, including response to the Korean ETS, was surveyed. A total of 257 responses were collected, which represented 60.0 per cent of the original group. From this original dataset, the authors narrowed the sample to companies that were or would be expected to be exposed to a benchmark emissions allocation policy for a particular reason. This study examines the difference in emissions reduction performance depending on the levels of climate-entrepreneurial proactivity. Only the companies subject to the benchmark allocation policy were available to acquire data on their actual GHG emissions. Benchmarks are reference values for the GHG emissions, in tons of CO_2, relative to a production activity, used to determine the level of free allocation that each entity within each sector would receive. In 2015, a total of 139 companies within the sample of 389 companies were subject to the benchmark policy. The authors acquired the actual GHG emissions and carbon productivity data from public sources, evaluated as unit emission per outputs or inputs. A total of 94 of the 257 responses were used for the analysis, representing a response rate of 63.5 per cent in terms of benchmark policy. Table II provides a demographic summary of the respondents.

4.2 The survey

4.2.1 Three dimensions of climate-entrepreneurship. This study identifies climate-entrepreneurship considering the following three dimensions: sensing, seeking, and integrating. The concept is newly introduced in this study; as such, the authors developed measures based on relevant literature (Sanders and Wood, 2015; Anderson and Bateman, 2000). This study measured each dimension using a single item. Climate-entrepreneurship "sensing" is defined as "an ability of a firm to recognize and be aware of the potential impacts of climate change issues on their current and future business." Climate-entrepreneurial "seeking" is measured as "an attitude of a firm to see an opportunity from climate change challenges at being fully alert," while "integrating" is depicted as "an ability of a company to incorporate climate change issues into its strategic planning and managerial decision-making processes."

4.2.2 Carbon management practices. This study investigated five carbon management practices, including low-carbon production, low-carbon processes, employee engagement, supply chain cooperation and external initiative participation. This study measured these practices using a seven-point Likert scale, reflecting the levels of adoption and implementation of these practices. The authors used the measurement items used in previous studies (Lee and Klassen, 2016; Lee, 2012; Jeswani *et al.*, 2008; Kolk and Pinkse, 2005).

4.2.3 Operational and market performance. This study measured operational performance considering four items based on a list of manufacturing competitive priorities

Sector	Number	No. of data collected	Response rate (%)	Benchmark*	No. of respondents used in this study	Response rate for the benchmark policy (%)
General industries	389	228	58.6	139	88	63.3
Machinery	19	14	73.7	2	1	50.0
Display	5	4	80.0	n/a	excluded	
Lumber	7	2	28.6	7	1	14.3
Semiconductor	20	10	50.0	8	4	50.0
Non-ferrous metal	24	18	75.0	n/a	excluded	
Petrochemical	85	45	52.9	19	13	68.4
Textile	15	6	40.0	10	5	50.0
Cement	23	17	73.9	14	21	150.0
Glass and ceramics	24	10	41.7	13	6	46.2
Food and beverage	23	9	31.9	n/a	excluded	
Automobile	19	15	78.9	n/a	excluded	
Electronics	21	12	57.1	n/a	excluded	
Petroleum	4	2	50.0	4	0	0.0
Pulp and paper	44	27	61.4	39	25	64.1
Shipbuilding	8	7	87.5	n/a	excluded	
Steel	37	28	75.7	11	11	100.0
Telecommunication	6	1	16.7	5	1	20.0
Aviation	5	1	20.0	7	0	0.0
Utility	39	29	74.4	9	6	66.7
Total	428	257	60.0	148	94	63.5

Notes: *No. of entities scheduled to be subjected to the benchmark allocation policy

Table II.
Demographics of the respondents

that could serve as primary performance goals for manufacturers, including quality, cost, delivery and flexibility (Ward *et al.*, 1998). This study uses increases in profits, and sales and market shares as a proxy for market performance. All items were perceptual measures.

4.2.4 Emissions reduction performance. This study used two different measures for emission reduction performance. The first is a perceptual measure, consisting of three items relating to improvements in general environmental performance, energy efficiency and GHG emissions reduction. The second is objective measures based on actual data on emissions and production inputs or outputs, including carbon productivity (defined as "GHG emissions divided by unit production input or output"), changes in actual GHG emission volumes and changes in carbon productivity. The authors used the following two types of carbon productivity: three-year average and the year 2015.

4.2.5 Attitude toward the Korean emissions trading scheme. This study also surveyed how firms perceive the Korean ETS regulation. The items include a company's perception of the appropriateness of the Korean ETS enforcement and its timing, extent of the desire to postpone the Korean ETS, readiness (preparation) for this regulation and extent to which it is challenging to cope with the Korean ETS.

The survey questions are provided in Appendix 1.

4.3 Data analysis

This study used a cluster analysis to categorize corporate carbon strategies from a climate-entrepreneurial perspective. First, Wardian cluster analysis with a randomly selected sample of 45 observations out of 94 responses yielded an explanatory power and pseudo *F*-value

supporting the four accurately categorized clusters. Second, the FASTCLUS procedure of the SAS program run on the 94 responses presented four distinct groups. Third, analysis of variance (ANOVA) was used to examine *P2* and *P3*.

5. Results and discussion

5.1 Climate-entrepreneurship and corporate response to climate change

Cluster analysis presented four different types of corporate responses to climate change. Table III shows the mean scores for each dimension of climate-entrepreneurship and the number of cases belonging to each cluster.

The first cluster shows the highest scores in all aspects of climate-entrepreneurship. Companies in this group are aware of the potential impacts of climate change on their business, are fully alert and likely to identify an opportunity when they face new challenging competitive environments. They incorporate climate change issues into the strategic decision-making process, implying that they may have a formal and systematic procedure to consider these issues in their management processes. The authors labeled this cluster "climate change explorer," in short, the "explorer."

The second group represents companies that showed a moderate level of climate-entrepreneurship. The firms in this cluster are informed about climate change issues and potential impacts on their business and have only started discussing climate change as part of their strategic decision-making processes. In general, this cluster is recognizing and concerned with the consequences of climate change, but firms do not take preventative action. This group is labeled the "wait-and-see hesitator," in short, the "hesitator."

The third cluster scores highly in climate-entrepreneurial sensing and integrating, while ranks low in the seeking dimension. This type takes some action to cope with climate change by considering their related business issues in their strategic management processes. They appear to recognize the potential business impact of climate change well; however, they are likely to perceive climate change as risks or threats rather than business opportunities. The authors labeled this cluster the "cautious attempter," in short, the "attempter."

The last cluster scores relatively low in all three dimensions of climate-entrepreneurship, indicating that the companies in this group do not seriously consider climate change issues. This type shows limited concern for climate change, almost ignores it and shows limited interest in taking measures to address the issue. The authors labeled this group the "climate change laggard," in short, the "laggard." This cluster represents the largest number of respondents, accounting for 33 per cent.

Collectively, this result supports *P1*, indicating that South Korean firms' response to climate change differs depending on their climate-entrepreneurship.

Climate-entrepreneurship dimension	Cluster 1 (Explorer)	Cluster 2 (Wait-and-see hesitator)	Cluster 3 (Cautious attempter)	Cluster 4 (Laggard)
Sensing	5.91	4.42	5.88	2.97
Integrating	5.73	4.00	5.35	2.00
Seeking	5.41	3.79	2.18	1.97
No. of cases	22 (23.4%)	24 (25.5%)	17 (18.1%)	31 (33.0%)

Table III. Results of cluster analysis

5.2 Climate-entrepreneurship and attitude toward the Korean emissions trade scheme regulation

The ANOVA provides very consistent results on the responses of different types of climate-entrepreneurship to the newly enforced carbon regulation, the Korean ETS. First, Table IV shows that the "explorer" cluster is likely to have a forward-looking attitude toward the enforcement of the ETS policy. In contrast, the "laggard" shows an anti-regulatory stance. The companies in this group have clear opposition to the implementation of ETS. They argue that it is early days for the ETS in South Korea as no other country has formally implemented the ETS on a nationwide scale, which in turn would undermine global competitiveness of South Korean firms. This stance of the "laggard" is significantly different from those of the other clusters. Second, Duncan's test presents evidence that there is a tendency that the "laggard" demands the ETS be suspended or at least delayed, while the "explorer" apparently welcomes ETS enforcement. Third, all the clusters show similar and moderate levels of readiness for the regulation. However, the "explorer," significantly differs from other types in coping with the ETS, implying that the companies in this cluster have fewer challenges in complying with the new regulation. These results provide partial support for *P2*, stating that climate-entrepreneurship relates to a forward-looking attitude toward the Korean ETS.

5.3 Climate-entrepreneurship and carbon management practices implementation

Table V summarizes the results of the ANOVA, showing how, depending on climate-entrepreneurship, South Korean firms differ in implementing carbon management practices. First, in general, the "explorer" adopts and implements carbon management at the highest level in all areas of production, process, personnel, initiative participation and supply chain, followed by the "cautious attempt" and "hesitator." The "laggard" ranks the lowest. "Explorer" companies are aware of and better prepared for the potential impact of climate change on their business, and identify opportunities regarding climate change issues. They tend to invest significantly in developing low-carbon products and improving process efficiency, as well as more actively participating in global initiatives, such as the carbon disclosure project (CDP) and engage customers and suppliers in collaborative measures, including carbon footprint reduction. Although statistical significance was not sufficiently high, the "cautious attempter" ranks marginally higher than the "wait-and-see hesitator" and "laggard" clusters. The companies in the "attempter" cluster better recognize and

Table IV.
Results of ANOVA on attitude toward the Korean ETS regulation

Attitude toward the ETS	Climate explorer (A)	Wait-and-see hesitator (B)	Cautious attempter (C)	Climate laggard (D)	Duncan's test	*F*-value
a) Willingly accepting the ETS	5.0	4.2	4.5	2.7	A=C=B>D	14.65**
b) ETS timing	4.8	3.4	3.8	2.1	A>C=B>D	25.41**
c) Putting the ETS on hold	3.9	4.7	5.4	5.9	D=C>C=B>B=A	9.53**
d) Readiness to the ETS	4.1	3.1	3.1	3.9	A=D=B>D=B=C	2.60***
f) Difficulty in complying with the ETS	3.9	5.0	5.6	5.4	A<B=D=C	6.79**
No. of cases	22 (23.4%)	24 (25.5%)	17 (18.1%)	31 (33.0%)		

Notes: $^{+}p < 0.1$; $^{*}p < 0.5$; $^{**}p < 0.01$

consider the potential impact of climate change issues in their managerial decision-making processes, such that they implement carbon management practices at a higher level.

Second, in the practice of employee engagement, the "explorer" cluster shows a significantly higher level than the other groups. The companies in this cluster endeavor to integrate carbon management issues into daily business routines by encouraging their workforce to increase awareness and providing employees with climate change-related training and education. They may incorporate climate change issues into employee and organizational performance evaluation processes through reward or compensation systems.

Third, it is noteworthy that low-carbon process development practices are more widely implemented than other carbon practices when addressing climate change issues. The reason behind this may be twofold. First, the companies subject to the Korean ETS regulation are energy-intensive and large GHG emitters. They have leaned toward responsive strategies of expressing serious concerns about GHG emissions, taking action to set clear reduction targets and applying such targets in their production processes (Lee, 2012). For instance, firms in the steel and petrochemical industries in South Korea have prioritized energy-saving measures to achieve GHG reduction goals for a very long time (Lee, 2013). Second, energy consumption in manufacturing processes is very closely related to production costs and profits, and thus such energy-intensive firms have focused more on process-related technology options. However, paradoxically, South Korean companies may lack knowledge and information on how to take action in other areas of carbon management practices, such as product and supply chain dimensions.

Collectively, these results provide evidence that partly support the second proposition, indicating that climate-entrepreneurship is associated with the actual adoption and implementation of carbon management practices.

5.4 Climate-entrepreneurship and performance

This study examined whether differences exist between operational- and market performance-related clusters. The results reveal a tendency that the "explorer" and "laggard" show relatively higher levels of performance than the "hesitator" and "attempter." Regarding operational performance, as a composite measure of quality, delivery, cost and flexibility, the "explorer" ranks first and the "laggard" ranks second followed by the "attempter" and the "hesitator." However, the statistical significance was not sufficiently high. In particular, in delivery performance, the "explorer" and "laggard" outperform the "hesitator" and "attempter." The "explorer" shows a significantly higher level than other clusters in customer

Carbon management practice	Climate explorer (A)	Wait-and-see hesitator (B)	Cautious attempter (C)	Climate laggard (D)	Duncan's test	*F*-value
Low-carbon product development	4.7	3.4	4.2	2.7	A=C>C=B>B=D	8.71**
Low-carbon process improvement	5.2	4.6	5.0	4.3	A=C=B>B=D	2.93*
Employee engagement	4.9	3.9	3.9	3.6	A>B=C=D	4.17*
Initiative participation	5.1	4.2	5.0	3.9	A=C=B>B=D	4.17**
Supply chain cooperation	4.7	3.4	3.9	2.9	A=C>C=B>B=D	7.53**
No. of cases	22 (23.4%)	24 (25.5%)	17 (18.1%)	31 (33.0%)		

Notes: ***$p < 0.1$; *$p < 0.5$; **$p < 0.01$

Table V. Results of ANOVA on carbon management practices

related aspects, including customer satisfaction and flexibility dimensions, an ability to respond quickly to customers' order changes. Considering market performance, a composite measure of increase in profits, revenue and market share, the "explorer" is likely to outperform other clusters marginally; however, statistical significance is weak (Table VI).

It is worth noting that the "explorer" and "laggard," which are opposites of climate-entrepreneurial proactivity, appear to show relatively higher performance than the "hesitator" and "attempter." This implies that there may be a U-shaped relationship between environmental proactivity and firm performance, showing that a negative and positive effect of climate-entrepreneurship depends on its level. This result is in line with those of previous studies corroborating evidence that corporate environmental or social responsibility has a non-linear and U-shaped relationship with firm performance (Trumpp and Guenther, 2017; Barnett and Salomon, 2012). For instance, Trumpp and Guenther (2017) suggest a theoretical framework of the "too-little-of-a-good-thing" by integrating the tradeoffs and win-win hypotheses between corporate environmental performance (CEP) and firm performance. They argue that companies can benefit from CEP only when it is above a particular minimum level as a threshold. If the authors interpret the four clusters positioning on a continuum of climate-entrepreneurship, the "laggard" and "explorer" are at opposites and the "hesitator" and "attempter" are between them. In addition, they appear to follow the U-shaped relationship between climate-entrepreneurial proactivity and performance. However, this conjecture should be further tested.

5.5 Climate-entrepreneurship and environmental and emissions reduction performance

The ANOVA result (Table VII) provides weak evidence that there is a difference in emissions reduction performance in an objective measure between climate-entrepreneurship. Considering perceptual measures, the result finds a tendency that the "explorer" and "cautious attempter" show higher levels than the "hesitator" and "laggard" in improving environmental performance and curtailing GHG emissions reduction.

Collectively, the results in Sections 5.4 and 5.5 provide partial support for *P3*. This study found differences in operational performance between climate-entrepreneurship types, while the authors did not confirm any significant difference in environmental and emissions reduction performance. In addition, the "explorer" is likely to show higher levels of operational and environmental performance in perceptual measures; however,

Performance	Climate explorer (A)	Wait-and-see hesitator (B)	Cautious attempter (C)	Climate laggard (D)	Duncan's test	*F*-value
Operational performance	5.7	4.7	4.8	5.3	A=D>D=C>C=B	5.60**
Quality	5.4	4.7	4.8	5.3	–	1.62
Delivery	5.8	5.0	4.9	5.9	D=A>B=C	5.69**
Cost	5.0	4.2	4.7	5.0	A=D>D=C=B	4.11**
Flexibility	5.9	4.9	4.8	5.3	A>D=B=C	5.56**
Customer satisfaction	5.6	4.9	4.8	4.9	A>B=D=C	3.57**
Market performance	5.1	4.2	4.4	4.5	A=D>D=C=B	3.22*
Profit	5.1	4.3	4.8	4.7	A=C=D>C=D=B	1.77
Revenue	4.8	3.8	4.0	4.4	A=D=C>D=C=B	2.31***
Market share	4.8	3.8	3.8	4.3	A=D>D=B=C	3.24*
No. of cases	22 (23.4%)	24 (25.5%)	17 (18.1%)	31 (33.0%)		

Notes: ***$p < 0.1$; *$p < 0.5$; **$p < 0.01$

Table VI.
Results of ANOVA on operational and market performance

Performance	Climate explorer (A)	Wait-and-see hesitator (B)	Cautious attempter (C)	Climate laggard (D)	Duncan's test	*F*-value
Perceptual measure						
General environmental performance	4.9	4.0	4.7	4.3	1=3>3=4>4=2	5.06**
Energy consumption reduction	4.7	4.1	4.8	4.2	–	2.47***
GHG emission reduction	4.9	3.9	4.3	3.7	1=3>3=2=4	5.33**
Objective measure						
Carbon productivity	0.375	0.379	0.443	0.388	–	0.21
Change in GHG emissions	0.016	0.057	0.020	0.020	–	0.49
Change in carbon productivity	0.022	−0.001	0.030	−0.021	–	1.10
No. of cases	22 (23.4%)	24 (25.5%)	17 (18.1%)	31 (33.0%)		

Notes: ***$p < 0.1$; *$p < 0.5$; **$p < 0.01$

Table VII. Results of ANOVA on environmental and emission reduction performance

no significant differences were found between the other clusters of the "cautious," "hesitator" and "laggard."

5.6 Robustness test

As previously mentioned, this study used only 94 responses subject to benchmark allocation policy among a total response of 261 surveys, as only they had actual emissions information available. In this section, the authors tested the robustness of the aforementioned results by comparing the results using all the 261 responses, in terms of climate-entrepreneurship, attitude toward the Korean ETS, carbon management practices and performance but excluding the objective measures of emissions reduction performance.

First, Table VIII presented the result of cluster analysis using 261 samples in the same manner. Four different types of corporate responses to climate change were identified and their characteristics are significantly in line with those indicated by the original cluster analysis. For example, Cluster 1 showed the highest scores in all the three dimensions, referred to as the "climate change explorer," while Cluster 4 scored relatively low in all three dimensions, which is very similar to the "climate change laggard." Cluster 2 showed a moderate level of climate entrepreneurship and Cluster 3 had high scores in sensing and integrating dimensions, while ranking low on the seeking dimension. The latter two clusters are similar to "wait-and-see hesitator" and "cautious attempter," respectively. The frequencies of the clusters in the robustness test results are subtly different from those of the

Climate-entrepreneurship dimension	Cluster 1 (Explorer)	Cluster 2 (Wait-and-see hesitator)	Cluster 3 (Cautious attempter)	Cluster 4 (Laggard)
Sensing	5.47	4.48	5.21	2.22
Integrating	5.28	3.26	4.35	1.76
Seeking	5.43	2.68	3.02	1.83
No. of cases	73 (28.0%)	88 (33.7%)	45 (17.2%)	55 (21.1%)

Table VIII. Result of robustness test: cluster analysis with a total sample ($n = 257$)

original analysis; however, four types of business responses to climate change in terms of climate-entrepreneurship can be identified in both findings.

The ANOVA result (Appendix 2) provides evidence that there is limited difference in climate-entrepreneurship, attitude toward the Korean ETS, carbon management practices and performance between the two groups of samples. At a 5 per cent cutoff level, differences were found only in attitude toward the Korean ETS and the perceptual measure of quality performance. Companies subjected to a benchmark allocation policy tend to experience less challenges in complying with the ETS, but show lower quality performance than general ETS targeted companies. However, in general, such limited differences showed the robustness of the result of this study even though it used a limited number of samples in relation to the actual emissions information.

6. Conclusion

6.1 Managerial implications

In 2015, the Paris Agreement galvanized global consensus on tackling climate change. Pressure and expectations from governments, public opinion, consumers and financial institutions on firms to play a vital role in mitigating the impacts of climate change continue to increase. Companies have reacted differently in addressing climate change issues depending on how they interpret its impacts on their business. This study provides some implications for managers and policymakers who attempt to address climate change issues proactively in firms' strategic and managerial decision-making processes.

First, companies vary in sensing the potential impact of, seeking an opportunity from and integrating climate change issues into their strategic decision-making processes. Firms should recognize that climate change is not an environmental issue, but a market issue for businesses with climate-entrepreneurship, which ultimately transforms existing competitive business contexts. Second, policymakers often encounter significant resistance from business circles when they attempt to take measures to mitigate climate change. Governments ought to realize that such resistance does not reflect real opinions of all businesses, as enterprises have very different attitudes and understandings of climate change. Policymakers should focus more on such firms having a more forward-looking and proactive stance and implement policies to encourage such climate-entrepreneurial companies. Third, companies ought to realize that climate-entrepreneurship may enhance competitiveness in emerging and existing markets without compromising profitability. It is also noteworthy that benefits of climate-entrepreneurship for operational and market performance can be secured only when such proactivity exceeds a certain threshold. However, firms eventually benefit from taking an entrepreneurial approach to climate change issues.

6.2 Limitation and future research

By stating some limitations, this study suggests the directions for future research. First, this study identified four distinct types of climate-entrepreneurship. However, this concept was first introduced in this study. As such, it should have been more elaborate, based on relevant theories and with more valid and reliable measurement items. Second, the results of this study cannot be generalized, as they were rather context/time-specific. Significant research is required to understand the corporate response to climate change in different contexts (e.g. other OECD countries and emerging economies). Furthermore, future research based on longitudinal perspectives is warranted to better understand how climate-entrepreneurship changes over time. Third, further research to explore what factors lead to climate-entrepreneurial proactivity is required. Environmental championing, organizational

resources and stakeholders' pressure can be considered as some of the crucial factors. Fourth, future research requires the extension of the sample, including the service sector and small- and medium-sized enterprises to enhance the generalizability of this study's findings. Finally, objective financial measures, such as return on investments, Tobin-Q and profits, should be included to examine differences in firm performance in future research.

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Appendix 1

Construct	Item code	Items
Climate-entrepreneurship		To which extent do you agree or disagree with each of the following statements (*1=not at all, 4=moderately, 7=great extent*)? *Over the past 3 years, your company…*
Sensing	SEN01	has been well aware of the potential impacts of climate change issues on your current and future business
Seeking	SEE01	has been identifying a business opportunity from climate change challenges
Integrating	INT01	has been considering climate change issues in your strategic management decision-making process
Attitude toward the Korean ETS		To which extent do you agree or disagree with each of the following statements (1=*strongly disagree*, 4=*moderately*, 7=*strongly agree*)?
	ETS01	Our firm willingly accepted the Korean ETS implementation
	ETS02	It is time that the Korean government implements the ETS regulation
	ETS03	The enforcement of Korean ETS should be postponed
	ETS04	Our firm has been preparing for the Korean ETS enforcement
	ETS05	Our firm finds it challenging to comply with the Korean ETS
Carbon management practices		To which extent do you agree or disagree with each of the following statements (*1=not at all, 4=moderately, 7=great extent*)? *Over the past 3 years, your company…*
Low-carbon product development	CMP01	has continued to develop energy-efficient or less carbon-intensive products
	CMP02	has invested in research and development (R&D) for less carbon-intensive products/technologies
	CMP03	has continued to undertake projects to increase energy-efficiency in your production processes
Low-carbon process improvement	CMP04	has continued to conduct projects to reduce GHG emissions in your production processes
	CMP05	has introduced innovative process technologies to dramatically reduce GHG emissions in your production
	CMP06	has substituted exiting energy sources with cleaner fuels
Employee engagement	CMP07*	has integrated carbon measures into your firm's performance evaluation and compensation system
	CMP08*	has engaged all employees and departments in reducing GHG emissions by utilizing management systems, such as internal emission trading schemes
	CMP09*	has provided employees with environmental and climate change-related education and training
External initiative participation	CMP10	has actively participated in global initiatives fighting climate change (e.g., Global Compact, UNEP/Financial Initiative)
	CMP11	has transparently disclosed your firm's GHG emissions information (e.g. CDP)
	CMP12	has acquired emissions permits by utilizing carbon markets (e.g., ETS, clean development mechanism (CDM))

(*continued*)

Table AI. Questionnaire items

Construct	Item code	Items
Supply chain cooperation	CMP13	has shared carbon-related information and knowledge with major customers and suppliers
	CMP14	has undertaken collaborative work to develop less carbon-intensive products with major customers and suppliers
	CMP15	has shared carbon-related information and knowledge with major customers
Performance		
		For each of the items listed below, how does your firm compare with its primary competitors? (1=*far worse than competitors*, 4=*about the same as competitors*, and 7=*far better than competitors*)
Operational performance		
	OPER01	Quality
	OPER02	Cost
	OPER03	Delivery
	OPER04	Flexibility
	CUST01	Customer satisfaction
Market performance		
	MPER01	Profit increase
	MPER02	Revenue increase
	MPER03	Market share increase
Environmental performance		
	EPER01	Environmental performance
	EPER02	Energy consumption reduction
	EPER03	GHGs emission reduction

Table AI.

Appendix 2

	Total sample (n = 261)	Sample for this study (n = 94)	F-value
Climate-entrepreneurship			
a) Sensing	4.57	4.55	0.00
b) Integrating	3.86	3.9	0.37
c) Seeking	3.33	3.28	0.08
Attitude toward the ETS			
a) Willingly accepting the ETS	4.24	3.96	2.02
b) ETS timing	3.49	3.35	0.55
c) Putting the ETS on hold	4.66	5.02	2.84**
d) Readiness for the ETS	3.79	3.60	1.08
f) Difficulty in complying with the ETS	3.48	3.02	5.79*
Carbon management practice			
Low-carbon product development	3.67	3.62	0.81
Low-carbon process improvement	4.62	4.71	0.38
Employee engagement	4.01	4.02	0.01
Initiative participation	4.29	4.46	1.02
Supply chain cooperation	3.81	3.68	0.52
Performance			
Operational performance	5.23	5.13	0.84
Quality	5.27	4.98	4.81*
Delivery	5.54	5.43	0.66
Cost	4.91	4.86	0.14
Flexibility	5.21	5.23	0.04
Customer satisfaction	5.15	5.04	0.86
Market performance	4.64	4.55	0.70
Profit	4.65	4.71	0.13
Revenue	4.44	4.27	1.30
Market share	4.35	4.19	1.15
Perceptual measure	4.50	4.56	0.18
General environmental performance	4.42	4.40	0.04
Energy consumption reduction	4.35	4.16	1.67
GHG emission reduction	3.83	3.69	0.73

Notes: **$p < 0.1$; *$p < 0.5$

Table AII.
Comparison of the two sample groups

Corresponding author
Young-Hwan Ahn can be contacted at: ahn@keei.re.kr