IGES Research Report No.2014-01

Market-based Instruments for Improving Company Carbon Performance in Northeast Asia

May 2014

Kansai Research Centre
Institute for Global Environmental Strategies

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Please cite this publication as: Liu, X.B., Suk, S.H., et al., 2014. Market-based Instruments for Improving Company Carbon Performance in Northeast Asia. Research Report, Institute for Global Environmental Strategies.

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ISBN: 978-4-88788-173-0

Printed in Japan
Printed on recycled paper

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Foreword

The three major economies in Northeast Asia – Japan, China and the Republic of Korea – all qualify for inclusion in the world's top-10 GHG emitters. However, in contrast with their significant shares of global GHG emissions and relatively ambitious mitigation targets over the medium term, the progress of policy related to carbon pricing is laggard in this region. The largest barrier facing the introduction and implementation of carbon pricing tools is industry itself. By adopting a difference approach that comprehends the issue from the perspective of the target industries themselves, the Institute for Global Environmental Strategies - Kansai Research Centre (KRC/IGES) embarked on a research project entitled 'Market-based Instruments (MBIs) for Improving Company Carbon Performance in Northeast Asia', from April 2010 to March 2013, with the aim of providing more traction to carbon pricing policy in the region.

In collaboration with local research partners in China and the Republic of Korea, and with support from the Government of Hyogo Prefecture of Japan, the MBIs project was undertaken via comprehensive policy overviews at the country level, numerous consultations with policy experts and governmental officials, company interviews and questionnaire surveys, and modeling exercises for policy analysis. This report provides a summary of the key outcomes of this three-year MBIs project, and consists of six parts. Part I presents a synthesis of the project activities and key findings, Part II outlines the progress in carbon pricing policies in this region, particularly carbon tax and GHG emissions trading schemes (GHG ETS), Part III measures the involvement of companies in energy saving practices in the three countries and identifies the corresponding determinant factors, Part IV discusses, in the context of MBIs, the awareness and subjective acceptability of companies on climate policies, Part V estimates the actual carbon prices affordable for the companies under study – the core component of the MBIs project, and Part VI discusses the preference of companies to policy design alternatives of carbon tax and GHG ETS.

I would like to take this opportunity to express my deep appreciation to all the researchers at KRC/IGES involved in this meaningful project, as well as to the local research partners, for their extensive contributions. I would also like to acknowledge the assistance provided by the project peer reviewers in offering their constructive comments. This research report was intended to provide insight into carbon pricing tools from the perspective of the actual businesses concerned, and thus bridge the gap in the development of effective climate policies in this region.

May 2014

Prof. Yutaka Suzuki
Director, Kansai Research Centre
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Acknowledgements

This project was carried out jointly with local research partners and with the support of related organisations from the target research countries. The authors deeply appreciate the cooperation extended by the following persons, whom together enabled this project to proceed smoothly to its successful conclusion: Prof. Can Wang at Tsinghua University School of Environment and Prof. Cunkuan Bao at Tongji University College of Environmental Science and Engineering, who participated in the research activities in China, Dr. Kwang-kyu Kang and Dr. Sang-youp Lee from Korea Environmental Institute (KEI), who coordinated the joint studies in the Republic of Korea, and Mr. Eiji Endo at the Government of Hyogo and Mr. Toshio Manabe at Hyogo Environmental Protection Management Association, both of whom provided support for the survey in Hyogo Prefecture, Japan.

The authors would also like to thank the top management of IGES, particularly Prof. Hironori Hamanaka, Mr. Hideyuki Mori and Prof. Yutaka Suzuki, for their kind support in project planning and implementation, and the Government of Hyogo Prefecture for financing this project. Colleagues at IGES headquarters and KRC provided assistance through all stages of this research and in preparing this report. Special thanks are also extended to Mr. Yoshio Shizukuishi and Ms. Akiko Mizumoto for their logistical and various other forms of support.

PART I:

SYNTHESIS SUMMARY OF THE MBIs PROJECT

Chapter 1:

Synthesis summary of the MBIs project

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Chapter Highlights:

- This chapter synthesises the project, namely 'Market-based Instruments for Improving Carbon Performance at the Company Level in NE Asia', implemented at IGES's Kansai Research Centre during the 5th phase (FY2010–2012).
- The project objectives, framework, components, research methodologies, major findings and their policy implications are outlined in this chapter.
- A review and comparative analysis of policy reveals laggard progress in the pricing of carbon emissions in this region and confirms resistance from industry as the largest barrier.
- Good practices of companies in energy saving are mainly determined by their business strategies and internal capacities. The role of governments is still weak.
- Companies have low awareness of carbon pricing policies; carbon prices affordable for them are generally low and some different for companies in different sectors or countries.
- The policy choice experiments in China and Korea identified company preferences in terms of carbon pricing policies.
- Findings from project provide meaningful implications for the development of carbon pricing policies in Northeast Asia. Impacts have been rapidly generated through publications and information dissemination. Further efforts are needed to transform the project outputs into actual policy processes.

1. Introduction

The term "market-based instruments" (MBIs) broadly refers to the instruments or regulations that encourage behavior through market signals rather than explicit directives. Environmental economists favor MBIs, such as subsidies on the abatement, emission taxes and tradable permits, for internalising the environmental externalities due to their theoretical advantage in cost efficiency. MBIs allow companies to make modifications to their unique business structure and take advantage of opportunities. The incentives to discover cheaper ways to achieve outcomes provide dynamic ways to reduce the costs for achieving specific targets.

There are three potential levers MBIs can employ. The relative impact of price-based instruments, e.g., providing subsidies or levying taxes, is reflected by altering the prices of goods and services. Such price-based policies provide certainty for industry as to the compliance cost but lead to uncertainty as to the environmental outcome from the community at large. Rights-based instruments, e.g., cap and trade schemes, are designed to maintain the quality of environmental goods at appropriate levels. This type of tool provides certainty as to the environmental outcome but not the cost for achieving that outcome. As the third category, the approaches to reduce market friction are less common. They stimulate the market to produce a desired environmental outcome by reducing the transaction cost or improving information flows, with eco-labeling of products and information disclosure as examples.

Many Asian countries have declared their national targets in the mitigation of greenhouse gases (GHG) emissions over the medium and even long term, including Japan, China and the Republic of Korea as the three major economies in Northeast Asia. As a medium-term target, Japan once pledged to reduce its GHG emissions by 25% from 1990 levels by 2020, which was premised on aggressive reduction targets also being achieved by all the major emitting countries. The long-term climate target of Japan is to reduce GHG emissions by 80% from 1990 levels by 2050. While China has traditionally avoided policies that explicitly target CO_2 emissions, its government committed in November 2009 to cut the country's CO_2 emissions per unit of GDP (Gross Domestic Product) by 40 to 45% by 2020 compared with 2005 levels. On 17 November 2009, Korea announced a decision to adopt a 30% reduction target of GHG emissions by 2020, compared with 'business as usual' (BAU) levels.

Accordingly, these countries are gearing their national policy frameworks to embrace countermeasures for climate change. However, despite the relatively bold targets these three countries have set to reduce GHG emissions, and bearing in mind these countries are the major GHG emitters in the region, progress in respective policies has on the whole been lacking. The crux of the problem for each country is in how to adopt MBIs that set appropriate prices for GHG emissions.

In a practical sense, the success of any industrial energy efficiency or climate policy is largely dependent on how individual companies, in all their shapes and forms, react to the policy. This is why policy analysis at the company level is so crucial. Apart from the body of literature dealing with this subject in Europe, there is scant research identifying the success conditions for the practices of MBIs from the company perspective in Asia.

Aiming to close this research gap and support ongoing discussions and development of economic climate policies in Asia, particularly the carbon pricing tools, IGES's Kansai Research Centre (KRC/IGES) launched a project in the fifth phase (April 2010 to March 2013) under a research field on Business and the Environment (BE). The project is entitled

‘Market-based Instruments for Improving Carbon Performance at the Company Level in Northeast Asia’, abbreviated to ‘the MBIs project’. It received financial support from the Government of Hyogo Prefecture, where KRC is based. This chapter presents a synthesis of research activities and major outcomes of this project.

2. Project objectives and target countries

The overall goal of this research is to support the design and possible implementation of carbon pricing tools, with carbon taxes and GHG emissions trading schemes (GHG ETS) as the focus, to improve carbon performance of industry in Northeast Asia. The specific objectives include: a) To overview and follow up on the progress of policies with relevance to company efforts in energy saving and carbon mitigation in this region; b) To examine current levels of energy saving and identify the corresponding determinant factors; c) To measure company awareness of MBIs and subjective acceptability to industrial energy saving and climate policies; d) To estimate levels of carbon emission pricing affordable for companies in the current context; e) To measure company preferences to the alternatives of carbon tax policy and GHG ETS; f) To identify behavioral changes of companies in response to the introduction of carbon pricing policies; and, g) Based on the findings from various survey analyses, to propose a practical approach to introduction and implementation of carbon pricing policies to enhance the carbon performance of industries in this region.

This project is a cross-country research under common policy topics, allowing some leeway in drawing up specific survey questions and study areas to account for local conditions and feasibility issues. China, Japan and Korea were selected as the target countries because they are economically significant both in Asia and the rest of the world. Their economic structures and carbon intensities are broadly representative for this region – for instance, around half of China’s GDP is generated from manufacturing, while in Japan the value added by the service sector accounts for nearly 70% of GDP. Per-capita carbon emissions of Japan were 9.6t-CO_2 in 2005 and were respectively 9.4t-CO_2 and 4.3t-CO_2 for Korea and China in the same year. The policy practices utilised to date and the way forward for the three countries thus warrant study. Another reason is that these countries have more experience in translating economic policies into environmental actions. For example, a sulfur emissions charge was levied in Japan to collect revenues used for compensation for pollution damage, a longstanding pollutant levy system exists in China based on ‘the polluter pays’ principle and other economic approaches such green credits are being piloted in China, and in Korea, a tax differentiation policy offers tax deductions for companies involved in environmental efforts. In short, higher levels of familiarity with economic environmental policies make it easier to analyse climate policies at the company level in these three countries.

3. Project framework and the research components

As indicated in Figure 1.1, this project consists of six research components.

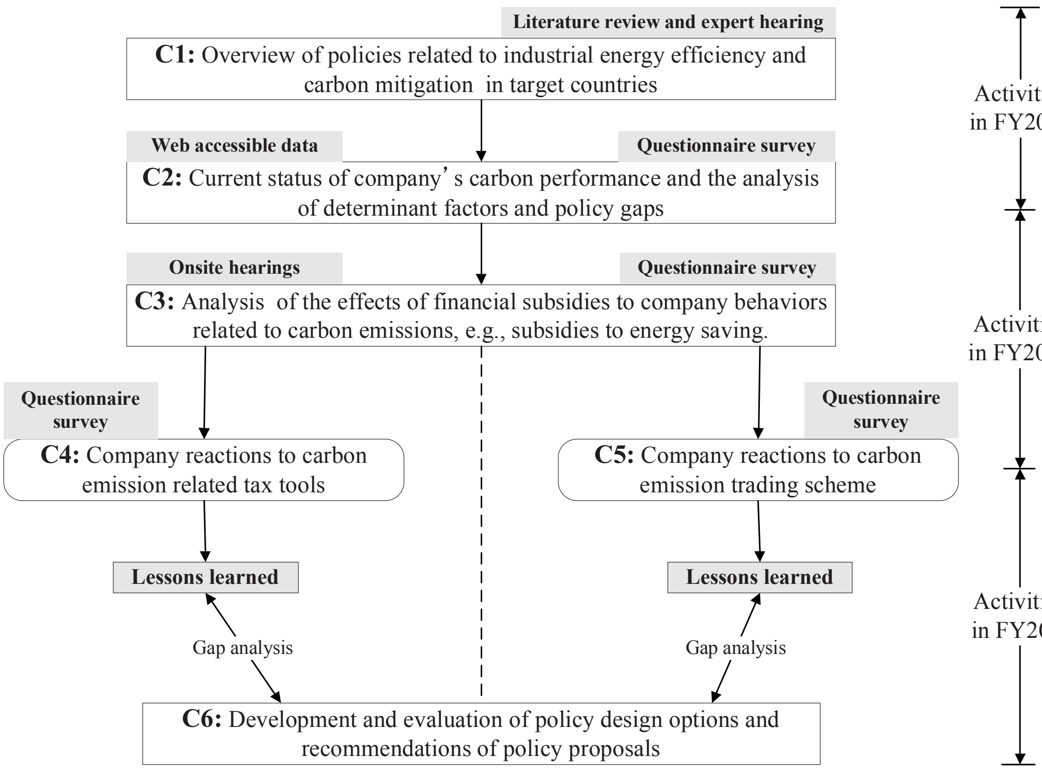

Figure 1.1 Project framework and research components

Component 1 (C1) is an overview of policies with relevance to industrial energy efficiency and carbon mitigation in the three countries. This component emphasizes the policy approaches applying economic incentives or disincentives, such as financial subsidies, voluntary standards based labeling, tax differentiation, tradable emissions permits and carbon taxes. The latest policy progress and policy deficiencies for carbon reductions in the industrial sector are identified. This preliminary overview aids in comprehending climate policy in the region and clarifies the MBIs to be explored in further empirical analyses.

Component 2 (C2) is to measure the current status of company carbon performance and analyse the related determinant factors. Information forming the basis for this part is gathered online from available literature and raw datasets collected by questionnaire surveys in target countries. Determinant factors for companies to reduce their carbon emissions are identified by econometric regressions.

Component 3 (C3) is the analysis of impacts of financial subsidies on company behaviors concerning carbon emissions. As mentioned earlier, the overall implementation of MBIs for carbon reductions is lax in this region. Financial subsidies are major economic tools under implementation. This part aims to analyse the impacts of ongoing subsidies, such as subsidies for energy saving investments on company efforts in carbon reductions. This may be viewed as a retrospective policy assessment and is conducted by interviews conducted at company sites.

Components 4 and 5 (C4 & C5) identify how companies react to carbon taxes and GHG ETS. The analyses of these two representative carbon pricing tools are carried out in parallel. The surveys measure a company's awareness and subjective acceptability of representative MBIs. Considering these two policies were at the discussion stage in this region when this project was launched, the research efforts provide estimations of carbon prices affordable for the companies and their preferences for alternatives to individual policies. The results provide meaningful referendums for discussion and development of policies that can be modified to actual socio-political contexts of the target countries.

Component 6 (C6) applies the research findings from earlier components to recommend practical solutions for developing carbon pricing policies in target countries from the business perspective.

4. Human resource structure for project implementation

Figure 1.2 depicts the human resource structure used to implement the MBIs project.

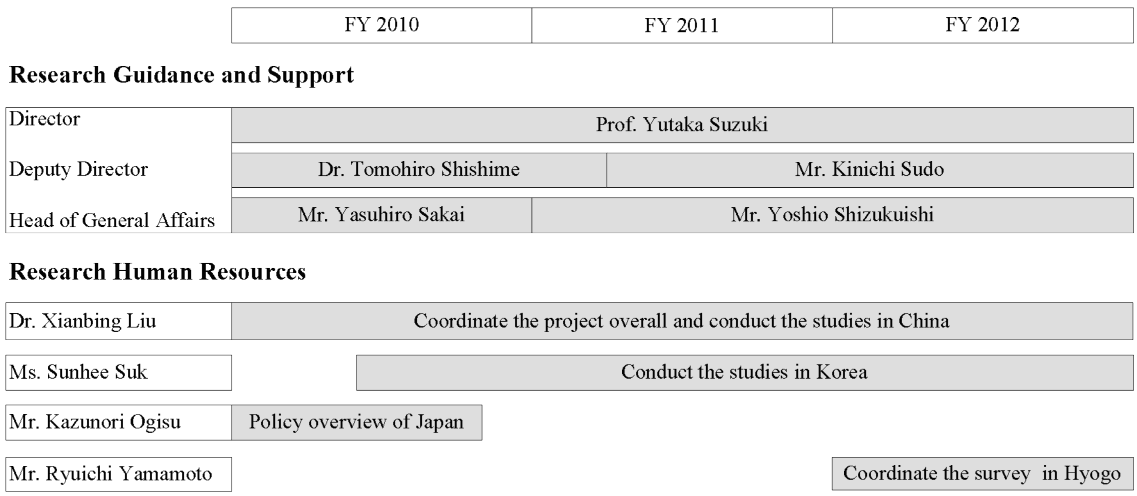

Figure 1.2 Human resource structure for the MBIs project.

Under the guidance of directors and support of administrative staffs at KRC, two regular researchers were fully involved in the survey studies in two of the three target countries (China and Korea) for the bulk of the three years. For the research in Japan, one visiting researcher conducted an overview of industrial energy saving policies of Japan over six months at the start. The research activity in Japan was halted in the second year due to the lack of a supervisory researcher. During the third year, a questionnaire survey involving large energy-consuming companies in Hyogo Prefecture was arranged under the coordination of staff disseminated from the Government of Hyogo. The content of the Hyogo survey is similar to that used in the company surveys for China and Korea in the first two years and allows in-depth comparisons of the three countries to be made.

5. Research methodologies

The methodologies applied for the MBIs project include: a) Comprehensive overview of available literature and consultations with local experts to comprehend the status quo and future trends of policies related to industrial energy saving and carbon mitigation in the target countries; b) Development of analytical frameworks to identify determinant factors of company energy saving practices, policy awareness and subjective policy acceptability; c) Adaptation of willingness-to-pay models for the estimations of company's affordability of energy cost increases due to the introduction of carbon pricing policies; d) Selection of models used to analyse discrete choice datasets on company policy preferences; e) Preparation of survey documents for the companies to answer specific research questions; f) Field work, including onsite interviews with and questionnaire surveys sent to environmental and energy managers of companies for data collection; g) Database construction, model estimations and econometric regression analysis; h) Participation and presentations in domestic and international conferences to disseminate research outcomes.

6. Major findings from the MBIs project

6.1 Progress of carbon tax policy in Northeast Asia

The MBIs project provides an overview and comparison of recent progress in carbon tax policy in the three target countries, as summarised below.

Energy-related taxes have been levied in Japan for many years, including automobile fuel-related taxes, aviation fuel tax, petroleum and coal tax and a development tax on the promotion of power resources. These tax rates vary considerably if the fuel is converted into carbon content – the highest being 24,052 JPY/t-CO_2 for gasoline and the lowest only 291 JPY/t-CO_2 for coal. Energy taxes were estimated to generate a 0.9% CO_2 emissions reduction for Japan. Carbon taxing, a subject under discussion since the early 1990s in Japan's Ministry of the Environment (MOEJ), involves two main strands: one is a high tax rate, and the other is a low tax rate with subsidies for climate change mitigation activities. From 2004 to 2006, MOEJ presented carbon tax proposals on three occasions, each based on introducing a low-rate tax earmarked for global-warming countermeasures designed to be most palatable to the public and private sectors.

The FY2011 Tax Revision Package (concluded by the Japanese cabinet on 16 December 2010) details a roadmap for specific taxes aimed at climate change mitigation in Japan. The updated tax rates are 760 JPY per kl of petroleum and oil products, 780 JPY per tonne of gaseous hydrocarbon and 670 JPY per tonne of coal. These rates are equivalent to 289 JPY/t-CO_2 and are much lower than the earlier MOEJ proposals. A three-stage phase-in approach was used for these taxes: from 1 October 2012 taxes at one-third the above were introduced, another third was added on 1 April 2013, and the full rate was to be fully implemented by 1 April 2015. Besides maintaining relief measures for existing energy-related taxes, the FY2011 tax revision package also includes exemptions and refunds of this special anti-climate change tax.

A carbon tax has also been developed in China over recent years, based on expert discussions at research institutes under the Ministry of Environmental Protection (MOEP), the Ministry of Finance (MOF) and the State Administration of Taxation (SAT). Considering the long-term cost of CO_2 emissions reductions and the resulting impacts on the economy, it was agreed that taxes should be gradually introduced, and differentiated. The proposed carbon tax rate is initially 10 Yuan/t-CO_2, increasing to 40 Yuan/t-CO_2 several years thereafter.

Korea has adopted transportation-energy-environmental taxes. The prices of refinery gasoline and diesel were 0.21 and 0.20 USD/l respectively in 1999. Post-tax prices were 0.94 and 0.40 USD/l, making energy taxes for gasoline and diesel 0.73 and 0.20 USD/l respectively at that time. Korea had a higher energy tax rate (74.8%) for gasoline than Japan (56.2%) and the U.S. (31.0%), but a lower tax rate (39.9%) for diesel than Japan (52.4%) and the UK (72.1%). This implies that Korea's government has generally given preference to industrial rather than household fuel use.

The Korea Institute of Public Finance (KIPF) initially proposed carbon tax rates in its details for fossil fuels in 2008. These rates were calculated according to the carbon price of EU-ETS (25 EURO/t-CO_2, equivalent to 31,328 KRW/t-CO_2), and were expected to procure an annual revenue of 8.5 to 9.1 trillion KRW (7.38 to 7.91 billion USD) based on Korea's emissions in 2007. However, a later report from KIPF stated that the carbon tax should be introduced separately at much lower rates (1/8 of those proposed earlier) without cutting the existing taxes at the early stages. In the medium and long term, it is preferable to increase the rates of carbon tax and energy tax simultaneously with the mitigation of the existing income taxes to keep the national tax reform revenue-neutral. The revenue procured from the carbon tax should be recycled into renewable energy investments and R&D for clean technologies, as well as a range of incentives for the export sectors to help cushion the impact of carbon taxes. Tax exemptions and direct support for those on low incomes were proposed in parallel in the latest KIPF report.

Considering the difficulty of collecting taxes, all the carbon tax proposals in the three target countries opt to levy taxes on fuels containing carbon. In this scheme, the importers, producers, wholesalers and retailers of fossil fuels at the furthest point upstream or across the upstream spectrum are all targeted for the carbon tax. In light of the negative impacts on the economy and industrial competitiveness, especially for energy and carbon-intensive sectors, the proposed carbon tax rates are low: Japan's actual carbon tax rate is 289 JPY/t-CO_2 (around 3.0 USD/t-CO_2) for the fuels under consideration; China's carbon tax (as proposed by experts) is even lower at about 1.5 USD/t-CO_2; that for Korea is also set at quite a low rate. All carbon tax proposals in the three countries consider relief measures: Japan excludes fuels for specific purposes; in China, tax exemptions and a return mechanism are suggested for the energy-intensive industries; and experts in Korea suggest applying measures for industries with large cost changes resulting from introduction of the carbon tax.

6.2 Progress of GHG ETS in Northeast Asia

The importance and advantages of GHG ETS have been acknowledged, and headway has been made in introducing this cost-effective instrument in the three countries.

Japan initiated the Voluntary Emissions Trading Scheme (J-VETS) and has developed an integrated domestic market on trial. The experimental market is small, voluntary and composed of a number of programmes not targeted at actually reducing overall emissions but to instead give participants a taste of GHG ETS. China has been largely involved in the international carbon market through the project-based clean development mechanism (CDM), and many exchange institutes have been established at the local level in China due to the high expectations surrounding the carbon market. These institutes have experimented with voluntary GHG emissions trading and urged the government to develop rules for the trading of VERs. Korea has been active in the phase-in of GHG ETS, and its government launched a voluntary GHG reduction programme a few years ago and recently started pilot projects to test the country's GHG ETS bill.

As regards domestic GHG ETS in Japan, several intermediate propositions have been considered, and in Korea a mandatory GHG ETS has been determined by incorporating the opinions of industry. Similarities exist in the stances of the two countries and both support the targeting of energy-related CO_2 emissions of large emitters. The discussions focus on a specific method for GHG allowance allocation. Determining the base-year emissions requires consideration of historical emissions, the potential for the introduction of technology, and the potential for actual reductions of the concerned entities, with all allowances allocated for free initially. The banking and borrowing of allowances would be permitted. Based on the lessons learnt from EU-ETS, offering concessions and offering flexibility in allocating allowances may circumvent resistance from industry but should not be practiced overzealously as this would reduce the policy efficacy.

In practice, Japan's GHG ETS proposal has stalled due to serious concern over its negative impacts, which has prompted a rethink by the cabinet of its impact on industry and employment.

In other words, GHG ETS has been postponed in Japan. In view of Korea's strength as an export economy and a heavy industry chemicals producer, concern has been voiced from industry over the possible loss of competitiveness due to increased production costs. Korea's industrial sector has requested more synchrony between the mandatory target management system (TMS) and GHG ETS to avoid duplicitous regulations. Based on industrial sentiment, therefore, Korea's GHG ETS has been postponed until the beginning of 2015.

As for China, GHG ETS should be developed on the basis of setting emission caps. Since China's economy is still accelerating in terms of industrialisation and urbanisation, its GHG emissions will inevitably increase, which places its government in an awkward position as regards setting specific ceilings for GHG emissions in the near future, as doing so could lead to job losses in energy-intensive sectors. Increased unemployment and related social problems would be unacceptable for local governments. Overall, carbon trading in China is presently conducted on a voluntary basis by a small number of companies and corporate awareness of GHG ETS is limited. As well as the emitting companies, financial organisations and even individuals are necessary in order to attach a price to VERs. The recent progress of China's government in a pilot domestic carbon market scheme is a positive step forward.

6.3 Energy saving practices of companies and the determinant factors

A series of survey analyses were carried out to measure the level of energy saving practices of companies in the three countries and identify the determinant factors.

The questionnaire survey in China was conducted in Taicang, a county-level city of Jiangsu Province near Shanghai, from July to September 2010. A total of 141 companies responded and 125 were confirmed to be valid for the analysis. More than 80% of the samples were from chemical, textile & dyeing and machinery manufacturing sectors. Overall, the sampled companies actively practiced the pre-listed energy saving activities (ESAs) and tended to adopt the softer ESAs at the beginning. Compared with ESAs via technological and engineering measures, institutional and managerial ESAs achieved higher participation ratios. Econometric regressions indicate that there is no significant relationship between a company's energy saving practice level and coercive pressure from the government and normative pressure from industrial associations. Nevertheless, the sampled Chinese companies are sensitive to energy management of their business competitors and are concerned about losing comparative advantage by being outperformed by competitors. Regarding the internal factors, positive attitudes alone do not lead to actual energy saving practices due to the limitation of various barriers. In-house training of employees focused on energy saving would greatly enhance a company's ability to practice ESAs. Upper management support is useful for a company's practices in ESAs, especially for ESAs requiring the coordination of internal divisions or incurring high costs to introduce new equipment or facilities in small and medium-sized enterprises (SMEs), as in Taicang, China.

The data for the analysis of company ESAs in Korea was collected by a survey in January and February 2011. Questionnaires were sent to a total of 362 business sites of 244 companies and the valid responses were 66. More than 60% of the samples are from power generation, petro-chemical and paper sectors and most samples are SMEs. As in the survey in China, the surveyed Korean companies prefer to practice ESAs by institutional and managerial measures with less resource. The involvement of ESAs of the sampled SMEs in Korea, such as in the research and development of energy efficient products and strategic cooperation with external business partners, is still not merged into their business cycles. Regarding the determinant factors, the strongly regulative pressure perceived by Korean companies does not start to function significantly for their practical ESAs. In spite of the importance of industrial associations for the companies in Korea, their role is limited in influencing the SMEs to improve their energy efficiencies. Korean company ESAs are partly attributed to company strategy; support from top managers is needed to instigate actual energy saving practices. Training of employees specific for energy saving indicates a significant and positive influence on a company's energy saving practices. The large and medium-sized companies have better energy saving practices than the smaller ones. Providing financial subsidies and technical assistance for the SMEs in capacity building was confirmed as effective in saving energy in Korea companies.

The survey in Japan was carried out from July to October 2012 and targeted 465 industrial companies with annual energy usages exceeding 1,500 kl oil equivalent in Hyogo Prefecture. Of the 230 valid responses, around half of them are from food processing, chemical, iron & steel and electronic industries. Small companies number only four and there are 62 large ones. The remaining 164 are medium-sized. Consistent with the surveys in China and Korea, the sampled Hyogo companies actively practiced the pre-classified ESAs and have adopted a common-sense approach in opting for the low-cost institutional and managerial ESAs at the outset. They also have good practices in technological and engineering ESAs, such as in investing in new production facilities for energy saving and installing monitoring devices to gather statistics for internal energy use. Hyogo companies indicate low participation in energy-saving R&D and joint activities with external stakeholders, which implies they prefer to practice ESAs at their own discretion. Econometric regressions confirmed that there is no significant relationship between company energy saving practice level and the three external pressures. The efforts of Hyogo companies in ESAs are mainly attributed to internal factors, including the awareness of internal energy management problems, willingness for energy saving, top management support and training of employees. The organisation size is significantly associated with ESAs in the Hyogo survey. SMEs demonstrated less involvement in energy saving practices in comparison with large companies.

6.4 Company awareness and acceptability of MBIs

6.4.1 Company awareness and acceptability of MBIs in China

The survey in FY2011 in China focused on three energy-intensive sectors: iron & steel, cement and chemical industries. CO_2 emissions from these three sectors accounted for nearly 30% of the national total in 2009. The data for measuring company awareness and acceptability of MBIs was collected by a questionnaire survey in Shandong Province (east coast) and Shanxi Province (in the west) over August and December 2011. Of the total 170 respondents, more than 70% are from the three target sectors and around 85% are SMEs.

The surveyed Chinese companies reveal moderate awareness of MBIs overall. Comparatively, the respondents had high awareness of the MBIs under implementation, such as financial subsidies and rewards for energy saving and the differential electricity pricing policy. Carbon taxes and GHG ETS, which are still under discussion in China, received lower policy recognition. Econometric regressions were performed to identify the determinants of a company's awareness of MBIs and the result suggests that market competition acts as a driver for the companies to collect strategic information, including that on energy saving and climate policies. The larger companies indicate a deeper understanding of MBIs, confirming the usefulness of resources for taking proactive environmental strategies. Another interesting result from MBIs awareness analysis is that the companies are concerned more about the policies with higher relevance, and would selectively collect information related thereto.

The sampled Chinese companies indicate high receptivity to energy saving policies in general. Economic incentives such as financial subsidies and tax credits are preferable. The subjective acceptability of carbon taxes would largely increase if tax relief measures and revenue recycling could be taken into account to minimise the policy's negative impacts on company profitability, which implies companies worry about the distributional effects of carbon pricing policies. The Chinese companies opt to maximize the freedom in dealing with governmental requirements in energy saving and appreciate voluntary approaches. Whilst they agreed that certain mandatory regulations are necessary, econometric analysis has confirmed that they would be reluctant to accept an additional burden due to carbon tax policy if energy prices were already deemed to be high. Overall, the companies are more receptive to policies that would engender higher comparative advantages.

The survey in China in FY2011 qualitatively measured company behavioral changes under the precondition of unilateral introduction of either or both of a carbon tax and GHG ETS. The companies would avoid knee-jerk reactions and instead would make internal efforts in energy saving to relieve the policy's negative impacts. A meaningful finding is that the companies would not simply offload the policy burden onto their customers, which confirms the effectiveness of carbon pricing tools in enhancing company efforts in carbon mitigation.

The barriers hindering a company to invest in energy efficient technologies were clarified. The existence of other promising investment opportunities and reticence to replace existing facilities are the major obstacles. Further, uncertainty surrounding the quality of new technologies hinders company investment decisions to certain degree. The companies do not believe that waiting for government subsidies is a good option, but would, on the other hand, be willing to invest if an energy saving project was profitable and of assured quality.

The Chinese companies were requested to show their acceptable payback period for energy saving projects. Of the 127 respondents to this question, 80% of them would accept a payback time of less than three years and nearly 20% even expected to recoup their investment within one year. Therefore, the high profitability expectation of the surveyed Chinese companies acts as a hindrance to making investments in energy saving projects.

6.4.2 Company awareness and acceptability of MBIs in Korea

The Korea survey of FY2011 also targeted three energy-intensive sectors: iron & steel, cement and chemical industries. The data for measuring company awareness and acceptability of MBIs was collected via questionnaire over January and February 2012. Of the 62 respondents, nearly half were SMEs and half were large-medium and large companies.

The Korean companies demonstrated moderate awareness of the pre-listed nine MBI items. The respondents are comparatively more aware of MBIs with implementation success, such as soft loans for energy saving companies (ESCO) projects and grants for high energy efficiency equipment and products. In spite of the strong resistance from industry, recent discussions on GHG ETS in Korea have attracted the attention of energy-intensive companies and GHG ETS achieved relatively high awareness in this survey. Unlike Chinese companies, econometric regressions found no significant relationships between a company's awareness of MBIs and the external pressures in the Korea survey. However, company size is significantly associated with company awareness of four MBIs with statistically significant regressions. Medium-sized companies show higher policy awareness than large companies, which implies Korean companies pay more attention to the policies with relevance and gather policy information related thereto.

As with Chinese companies, the sampled companies in Korea prefer economic incentives. Conversely, however, carbon pricing policies, including carbon tax and GHG ETS, achieved the lowest means. Korean companies expect to cope with the government requirements in energy saving in a flexible manner and indicate high receptivity to certain voluntary approaches, such as the voluntary agreement for energy saving. Further, the respondents agree that certain government regulations must be mandatory. The acceptability of MBIs is significantly associated with company characteristics; compared with the iron & steel industry, chemical companies indicate a higher acceptability to carbon pricing policies and the TMS target companies are more likely to resist carbon tax policy and GHG ETS than the non-TMS ones.

Similarly to the survey in China, the sampled Korean companies would avoid knee-jerk reactions and instead make efforts internally in energy saving to relieve the negative impacts of carbon pricing policies. The respondents are unlikely to offload the policy burden to their customers, which confirms the effectiveness of carbon pricing tools in enhancing a company's efforts in energy saving and carbon mitigation in Korea.

The lack of support from the national level government was identified as the most important impediment for energy saving investment of Korean companies and the respondents expressed concerned over production disruptions and losses caused by equipment and facility replacements. The internal budgetary constraint is another obstacle of relatively high importance. At the early stage of TMS and GHG ETS the sampled Korean companies would likely opt to pay the mild fines rather than invest huge sums of money in energy efficiency. This confirms the necessity of increasing TMS and GHG ETS penalties to a reasonable level – sufficient to urge the Korean companies to make energy saving investments.

All 62 respondents answered the question regarding payback time for energy saving projects – nearly 65% of them would accept a payback time of within two years and 13% of them even expect to recoup the initial costs with one year. This result mirrors the survey of Chinese companies, and confirms the high profitability expectation linked with energy saving investments.

6.4.3 Company awareness and acceptability of MBIs in Japan

The data analysing MBIs awareness and acceptability in Japan was collected from 230 respondents in Hyogo, in which company representatives voluntarily answered a series of survey questions.

Those in Hyogo companies are not well versed in pre-listed MBIs – nearly all the MBIs achieved low to moderate levels of policy awareness. The only exception was the subsidies for energy-efficient products, such as eco-car tax reductions and eco points for electronic appliances, which have been implemented widely in Japan. There was some disparity between company awareness of various MBIs; the policy with the lowest recognition is soft loans for energy saving facilities. Another two policies with relatively low awareness are MOEJ subsidies for achieving mitigation targets of participating J-VETS companies and an interest subsidy provided by METI for investments in large energy saving equipment.

The pressure of energy prices functions as a driver for Hyogo companies to collect information on climate policies. Similarly to the analysis of Chinese companies, the organisation size is significantly and positively associated with company awareness of MBIs, in that large companies have a better understanding of MBIs than small and medium-sized ones, which conforms to the resource-based logic that large companies have greater access to the resources required for proactive environmental practices. There is no obvious gap across the sectors as regards policy awareness in Hyogo.

In comparison with the survey in China, Hyogo companies indicate moderate acceptability to the pre-listed energy saving policies. Economic incentives are more preferable, such as tax credits for energy saving products and technologies, direct subsidies for investments in energy saving projects and subsidies for energy-efficient products. In contrast, companies are reluctant to accept policies that would incur economic burden for them. Carbon pricing tools achieved a similarly low level of acceptability. The voluntary approaches achieved moderate acceptability. Hyogo companies agree that certain administrative requirements are acceptable for them.

Similarly with the survey in China, Hyogo companies would avoid kneejerk reactions, such in reducing levels of production or moving production bases to the areas with looser policies in response to implementation of a carbon tax and/or GHG ETS. Practicing managerial energy-saving activities is the most feasible action they would take, and investing in energy efficient technologies was given a moderate possibility. Further, the respondents would not simply offload the costs onto their customers, probably because doing so would put them at a competitive disadvantage.

Hyogo companies presented low to moderate evaluations to the barriers for energy saving investments. Comparatively, the highest barrier is the internal budgetary constraint. The existence of other more promising investment opportunities is another obstacle with relatively high importance. Differing from the survey in China, uncertainty over the quality of energy saving technologies is a minor issue for the companies in Hyogo. Providing financial subsidies is supportive in leading a company’s investments toward increased energy efficiency. The companies in Hyogo do not view waiting for subsidies from governments as a choice.

Of the total 220 respondents on the question of acceptable payback time for energy saving investments, around 30% expect a payback time of less than three years and 41.4% expect to recoup their investments between 3 to 5 years. Less than 2% of the samples could accept a payback period over 10 years. This result is similar to that of UK companies, indicating an average payback time of 3–5 years, which is longer than that of Chinese and Korean companies.

6.5 Affordability of carbon prices

Policy acceptance at the company level is crucial to the survival of any new climate policy. From a conventional economic viewpoint, company acceptance of a policy is chiefly affected by the cost attributed to implementing it. With this in mind as regards a carbon tax and GHG ETS, the MBIs project estimates the affordability for companies of energy cost increases based on a phase-in of such policies. Three energy-intensive sectors – iron & steel, cement and chemical industries – were targeted in China and Korea. The survey in Japan targeted companies in Hyogo Prefecture.

6.5.1 Affordability of carbon prices for Chinese companies

Using a multi-bounded discrete choice (MBDC) format, data was collected from 170 respondents mainly from the three target energy-intensive industries in China. The MBDC format allows companies to vote on a wide range of subjects and also express a level of certainty for each, which underpins the quantity and quality of information used in the analysis. Companies were presented an ordered and ascending sequence of 15 energy cost increase thresholds (from 0.1 to 100.0%) and were given five acceptance levels, 'easily acceptable', 'acceptable', 'barely acceptable', 'rejection' and 'strong rejection'.

Applying the model of willingness-to-pay (WTP) of individuals, the mean and standard variance of affordability of companies for energy cost increases was estimated. The simulations indicate that a mean of 8.8% in energy cost increase would be acceptable for all the samples in China. Chemical companies reveal a slightly higher affordability at 9.9%, while that of cement companies was lower, with a mean of 7.7%. The figure for Iron & steel industries was the same as the mean of the surveyed companies as a whole. Econometric analysis confirms that market competition has a significant but negative relationship with affordability, while company size is significantly and positively associated with affordability.

Using the estimated affordability energy cost increase ratios, energy use structures, current energy prices and emissions factors for various types of energies of the surveyed companies, carbon prices affordable for the companies were calculated. The results indicate that the mean affordable energy cost increase roughly equates to a carbon price of 83.7 Yuan/t-CO_2 (about 12 USD/t-CO_2) for chemical companies and around 40 Yuan/t-CO_2 (about 6 USD/t-CO_2) for iron & steel and cement sectors.

Based on the discussions of carbon tax policy outlined in the available literature, as well as this estimation result, a price of 10 to 40 Yuan/t-CO_2 for carbon emissions would be possible and appropriate in China at present. Considering the disparity in affordable carbon prices among different sectors, relief measures or subsidies should be considered for certain energy-intensive sectors to alleviate the policy's negative impacts.

6.5.2 Affordability of carbon prices for Korean companies

The data for estimation of carbon price affordability for Korean companies was collected from 62 respondents from the three target industries, 90% of which are under control of the TMS in

Korea. In the MBDC format applied for the survey in Korea, the companies were presented with an ascending sequence of 12 energy cost increase thresholds, from 0.1 to 50.0%.

The mean energy cost increase affordable for all the sampled Korean companies was 2.6%. For chemical, iron & steel and cement companies, the figures were individually 2.6%, 2.5% and 2.8%, much lower than the figures for China. This may be due to the perception, from the standpoint of Korean companies, that there is limited potential for saving energy, especially for energy-intensive industries. Business ownership is significantly associated with affordability for Korean companies; compared with domestic private companies, foreign-funded ones indicate relatively higher affordability for energy cost increases.

Further calculations reveal that a carbon price of 2,500 to 4,000 KRW/t-CO_2 (about 2.3 to 3.5 USD/t-CO_2) would be affordable for the surveyed companies in Korea, and is similar to the tax rate proposed by KIPF. This confirms that KIPF's latest carbon tax proposal would be acceptable for Korean companies in terms of tax rate.

6.5.3 Affordability of carbon prices for Japanese companies

The data used to analyse carbon price affordability for Japanese companies was gathered by the same survey in Hyogo from July to October 2012. A total of 230 companies responded with around half from the representative sectors in Hyogo. As with the survey in Korea, an ascending sequence of 12 energy cost increase thresholds (from 0.1 to 50.0%) was presented for the sampled Hyogo companies.

The mean energy cost increase affordable for all the surveyed Hyogo companies was 2.3%; that for the chemical industry was 3.1%, slightly higher, and for iron & steel companies, 1.5%, lower than that of the samples as a whole. The food processing and electronics industries have means similar to the samples as a whole. Econometric analysis confirms that market competition and energy price pressure significantly but negatively influence affordability, while company energy saving potential is significantly and positively associated with affordability.

Calculations indicate that the mean affordable energy cost increase equates to a carbon price of 1,062 JPY/t-CO_2 (about 13.1 USD/t-CO_2) for chemical companies and 426 JPY/t-CO_2 (about 5.3 USD/t-CO_2) for the iron & steel sector. For food processing and electronics companies the figures are 683 JPY/t-CO_2 (about 8.4 USD/t-CO_2) and 801 JPY/t-CO_2 (about 9.9 USD/t-CO_2), respectively. Therefore, the carbon prices affordable for the companies in Hyogo (5–13 USD/t-CO_2) are in a similar range to those of Chinese companies (6–12 USD/t-CO_2).

The actual policy practices in the pricing of carbon emissions in Japan have been carried out within the range affordability of companies in this survey. However, macro-economic analysis points to the fact that attaching a much higher price tag to carbon emissions is necessary in order for Japan to realise its mitigation targets over the medium and long term. Japan's commitment of a 25% reduction in GHG emissions would require a price of at least 30 USD/t-CO_2 in most analyses under the Asia Modeling Exercises (AME). Further efforts are needed in Japan to gradually increase carbon prices to appropriate levels in order to mitigate its GHG emissions cost efficiently.

6.6 Company choice preference regarding carbon tax policy and GHG ETS

The design of a specific instrument is considered to be of higher importance than the choice of policy type. Stringency and predictability are the two key aspects in formulating a carbon pricing policy. Under the MBIs project, the preference of companies to the alternatives of carbon tax and GHG ETS was measured in FY2012 by policy choice experiments in China and Korea.

6.6.1 Choice preference to carbon tax policy of Chinese companies

An analysis of choice preference of Chinese companies to the options of carbon tax policy was conducted. Data was collected by a choice experiment from August 2012 to January 2013. A total of 201 companies answered the survey questions, with around half the samples present in the western Shanxi Province and the other half in the eastern Jiangsu Province. Four aspects – tax rate, tax relief measure, utilisation of tax revenues and starting time – were defined as the policy attributes in this experiment.

The use of D-optimal design by Design-Expert 8.0 created 12 choice sets for carbon tax policy, which were then randomly separated into two versions of questionnaires, each consisting of six sets. NLOGIT5.0 was applied for the analysis of discrete choice datasets. Various modeling practices, including multinomial logit (MNL), random parameter logit (RPL) and latent class (LC) models, confirmed the statistically significant relationships between company choices with the policy attributes of tax rate, tax relief measure and tax revenue utilisation.

The above revealed that a lower tax rate is more preferable for the companies. According to earlier estimations, which were based on the WTP approach, a carbon price of 40 Yuan/t-CO_2 would be currently affordable for Chinese companies, even in the most energy-intensive sectors. Macro-economic modeling reveals a very slight fall in GDP and employment if levying a carbon tax of around 30 Yuan/t-CO_2 in China. Therefore, to impose a carbon tax of 10–30 Yuan/t-CO_2 in the initial phase would be realistic in China. Further, as regards company preference in the design of carbon tax policy in China, providing tax relief to energy-intensive industries and using the tax revenues therefrom to combat climate change was seen as preferable for the companies. This research revealed no statistically significant influence on the starting time; however, to launch a carbon tax during the 13th five-year plan period (2016–2020) has been recommended as doing so would coincide with the completion of ongoing resource tax reform in China.

6.6.2 Choice preference to carbon tax policy and GHG ETS of Korean companies

Korean company preferences for alternatives to carbon tax and GHG ETS were analysed by a choice experiment conducted in FY2012 in Korea. A total of 150 samples were collected from five sectors: iron & steel, cement, chemicals, paper-making and electronics. As for the survey in China, tax rate, tax relief measure, utilisation of tax revenues and starting time were defined as policy attributes for the carbon tax. To analyse GHG ETS, cap setting, allocation of emissions allowances, penalties and criteria for carbon leakage were selected as the attributes. Analysis of the dataset for Korea similarly applied the MNL, RPL, and LC models.

The results identified the chief policy attributes influencing choice of carbon tax and GHG ETS for Korean companies. For the carbon tax, a higher tax rate would incur a heavier burden for the companies and increase their resistance to this policy. Reducing the taxes either for energy-intensive or energy-efficient industries would increase choice as regards a carbon tax for companies. Differing from the result in China, for Korean companies the starting time is significant in determining choice preference to carbon tax. For GHG ETS, Korea's government has decided to apply grandfathering in the first phase; however, the LC modeling result shows that companies with different class memberships have different preferences as regards the cap-setting approach. The class characterised as comprising large and large medium-sized companies the from paper industry, with a class possibility of nearly 30%, prefers the grandfathering method, whereas nearly half of the sampled companies favour the benchmarking method; the remaining samples, with a class possibility of around 20%, indicate a preference to cap setting via a hybrid approach. The increase in auction ratio for the allocation of allowances and a penalty as high as three times the market price of carbon credits for emissions that exceed allowances would significantly reduce company preference for GHG ETS. For the classification of sectors with carbon leakage risk, energy intensity is more preferable as the criteria than trade intensity.

The WTP of respondents for various policy attributes was estimated using the tax rate and auction ratio for allowances allocation as the price attributes respectively for carbon tax and GHG ETS. For carbon tax policy, setting tax relief measures for energy-intensive companies equals to a decrease of 1,804 KRW/t-CO_2 of tax rate in influencing the company's preference to this policy. The surveyed companies demonstrated an equal preference for either a carbon tax introduced in 2015 or one phased-in from 2021 but at a tax rate increased by 1,665 KRW/t-CO_2. For GHG ETS, adoption of the benchmarking approach rather than grandfathering is similar as an increase of auction ratio by 16.2% in influencing the company's choices of GHG ETS. The findings of this experiment reflect the business perspective to alternatives of a carbon tax and GHG ETS and could be referred to for policy development in Korea.

7. Policy implications and impact generation of the MBIs project

7.1 Policy implications of the MBIs project

The findings of the MBIs project provide meaningful implications for policies that could enhance industrial carbon performance in Northeast Asia, especially for the design and development of carbon pricing tools from the business perspective.

The beginning of this section gave a comprehensive policy overview with reference to industrial energy saving and carbon mitigation in the three target countries, an approach that enables comparative analyses to be made to elicit common characteristics and differences of policy practices in different countries. As an example, industrial energy saving policy in this region commonly addresses large energy-consuming companies. In contrast, however, the energy saving efforts of industries in Japan largely stem from voluntary action plans of business associations. In China and Korea it is the government that clarifies the responsibilities of large energy-consuming companies to improve energy efficiency.

The review and comparisons of the most recent advances in carbon tax policy and GHG ETS in the three countries revealed a laggard rate of progress in the pricing of carbon emissions in this region. Japan has started to levy a carbon tax recently, but the actual rate is quite low and the expected mitigation effects very marginal. Concerning the negative impact on economic growth and international competitiveness of industry, the carbon tax proposals of China and Korea involve very low tax rates. Korea is slated to launch domestic GHG ETS at the start of 2015. China is actively promoting a pilot GHG ETS in five big cities and two provinces. Japan has attempted to establish an integrative carbon market for many years; however, GHG ETS has been blocked. Considering the strong resistance from industry, the ongoing practices of GHG ETS in this region cannot exert a real burden on the emitters since the emissions allowances would be allocated fully for free in the early phase of formal GHG ETS under construction. Therefore, the pricing of carbon emissions in this region is still at a preliminary stage, a state of affairs that all decision makers should be made aware of.

The sampled companies in the three countries all demonstrate good ESA practices. Analysis of the determinant factors confirmed that company energy saving efforts are mainly attributed to internal factors and limited by practical capacity, which reveals that the government and business associations must focus on company energy saving practices and provide companies, especially SMEs, with more information on policies and technological solutions. The limited knowledge of companies in energy saving technologies was confirmed to hinder investments in energy efficiency projects for SMEs. Although economic incentives, such as financial subsidies and preferential taxes, are preferable for the companies, waiting for financial support from the government was not a desired option. Conversely, if an energy saving project was proven to be profitable, the companies would be likely to invest in such. A common and interesting finding from the surveys in the three countries is that the companies would make in-house efforts to save energy to offset the negative impacts of carbon pricing policies rather than simply offloading the policy cost onto their clients. This confirms the effectiveness of carbon pricing policies for enhancing the carbon performance of companies in Northeast Asia.

This innovative application of the WTP approach to estimate affordable carbon prices for companies provides a meaningful referendum for the development of carbon pricing policies. Japanese and Korean companies indicate similar levels of sensitivity to energy cost increases, which is much lower than that of Chinese companies. On the other hand, due to differences in energy use structure and energy prices, the carbon prices affordable for companies in Japan and China are in the same range. Korean companies indicate a much lower affordability for carbon prices. These results can be used for the setting tax rates for carbon tax policy and carbon market prices under GHG ETS. It also reveals a large gap between a company's affordable price level at present and the carbon prices required to realise GHG mitigation targets in the medium term. The policy choice experiments in China and Korea provide useful implications for the design of a carbon tax and GHG ETS in the two countries and the results clearly show the preference of companies in response to major policy attributes and thus clarify the direction and principles policy design needs to adopt. Relationships between different attributes in influencing company choices show the policy options preferable for such companies. In short, arriving at a fair and equitable solution to this problem is the key challenge for policymakers in this region.

7.2 Impact generation of the MBIs project

Impacts from the MBIs project have been generated in various ways. The policy overview and questionnaire surveys in China and Korea were carried out together with leading national research institutes and university scholars; the survey in Japan was enabled with support from local government and the environmental association in Hyogo Prefecture, and joint research activities and communications with companies connected with the surveys enhanced the level of understanding of related stakeholders in policy progress and policy gaps of this region, as well as the usefulness of outcomes from the project. Another outcome is in the ongoing dissemination of research outputs via timely publication in reputed journals together with presentations at domestic and international conferences. Publications generated from the MBIs project have attracted much attention from academia and promoted further research and discussion in similar topics, and the research findings contained in the publications may have a knock-on effect in related policies. A third impact outcome was in establishing and extending research networks in China and Korea by approaching experts at research institutes under related ministries at the national level. The project outputs were shared with these experts in a timely manner since some of them are actually responsible for input into policy drafting. This kind of outreach provides them additional evidences from the business viewpoint, which are key to developing related policies in the target countries. The MBIs project initially set out to target existing policy platforms at the regional level, such as the Tripartite Environment Ministers Meeting (TEMM) between the three target countries, to directly add policy messages. This plan, however, turned out to be slightly overambitious, as a single research could not be expected to come up with proposals within a such a short timeframe and cover all the topics needed in order to address actual policy formulation, thus the idea of realising a direct policy 'plug-in' approach for this region requires further efforts in research impact generation.

8. Conclusions

The MBIs project was carried out in the most efficient way possible, especially the survey studies in China and Korea. All the pre-designed research tasks were accomplished and the primary objectives were fully achieved within a short period of time. Much effort was extolled in making use of local networks wherever possible to gather the data needed from the companies to enable statistical analyses to be made. Many interesting findings were generated, which provide meaningful implications for discussions in carbon pricing policies in this region. Further, an innovative extension of the cognition-valuation method of environmental good, from individuals to businesses, has received recognition from academia, which confirms the knowledge contribution of this project.

There remain two important topics for research following the MBIs project. First, from a theoretical standpoint, discussion needs to adopt a broader-scoped policy mix perspective, as the current project focused on carbon pricing tools and analysed carbon tax and GHG ETS individually, which leads to the need to design an integrative and effective policy framework with regulative measures, economic incentives, carbon pricing tools and voluntary approaches. The second topic should involve evaluating the effects of carbon pricing policies aimed at introducing innovative, low carbon technologies for the companies concerned. This kind of research could be linked with a country's policy and technological roadmap to realise its GHG mitigation targets in a cost-effective manner.

Appendix:

List of publications of the MBIs project

A1: Peer-review journal articles

❒ Liu, X.B., Yamamoto, R., Suk, S.H., Company's awareness and approval of market-based instruments for energy saving: A survey in Hyogo, Japan, article in press, Journal of Cleaner Production.

❒ Liu, X.B., Yamamoto, R., Suk, S.H., A survey analysis of energy saving activities of industrial companies in Hyogo, Japan. Journal of Cleaner Production 66(2014): 288-300.

❒ Suk, S.H., Liu, X.B., Lee, S.Y., Go, S.J., Sudo, K., Affordability of energy cost increases for Korean companies due to market-based climate policies: A survey study by sectors. Journal of Cleaner Production 67(2014): 208-219.

❒ Liu, X.B., Niu, D.J., Bao, C.K., Suk, S.H., Sudo, K., 2013. Affordability of energy cost increases for companies due to market-based climate policies: A survey in Taicang, China. Applied Energy 102(2013): 1464-1476.

❒ Suk, S.H., Liu, X.B., Sudo, K., 2013. A survey study of energy saving activities of industrial companies in the Republic of Korea. Journal of Cleaner Production 41(2013): 301-311.

❒ Liu, X.B., Niu, D.J., Bao, C.K., Suk, S.H., Sudo, K., 2013. Awareness and acceptability of companies on market-based instruments for energy saving: A survey study in Taicang, China. Journal of Cleaner Production 39(2013): 231-241.

❒ Liu, X.B., Wang, C., Zhang, W.S., Suk, S.H., Sudo, K., 2013. Company's affordability of increased energy costs due to climate policies: A survey by sector in China. Energy Economics 36(2013): 419-430.

❒ Liu, X.B., Wang, C., Zhang, W.S., Suk, S.H., Sudo, K., 2013. Awareness and acceptability of Chinese companies on market-based instruments for energy saving: A survey analysis by sectors. Energy for Sustainable Development 17(2013): 228-239.

❒ Liu, X.B., Niu, D.J., Bao, C.K., Suk, S.H., Shishime, T., 2012. A survey study of energy saving activities of industrial companies in Taicang, China. Journal of Cleaner Production 26(2012): 79-89.

A2: Book chapters

❒ Liu, X.B., Suk, S.H., Sudo, K., 2012. GHG emissions trading schemes in Northeast Asia: An overview and analysis of current scenarios, in: Kreiser, L., Sterling, A.Y., Herrera, P., Milne, J.E., Ashiabor, H. (Eds.), Critical Issues in Environmental Taxation, Vol. XI, pp.149-166.

❒ Liu, X.B., Ogisu, K., Suk, S.H., Shishime, T., 2011. Carbon tax policy progress in north-east Asia, in: Kreiser, L., Sirisom, J., Ashiabor, H., Milne, J.E. (Eds.), Critical Issues in Environmental Taxation, Vol. IX, pp.103-118.

❏ Liu, X.B., Yamamoto, R., Suk, S.H., Company's affordability of energy cost increases due to climate policies: A survey in Hyogo, Japan, under review, Critical Issues in Environmental Taxation.

A3: Conference papers and presentations

❒ Liu, X.B., Suk, S.H., 2013. An analysis of company's choice preference to carbon tax policy in China, 14th Global Conference of Environmental Taxation (GCET), 17-19 October, 2013, Kyoto, Japan.

❒ Suk, S.H., Liu, X.B., Sudo, K., 2013. A choice experiment analysis of company's preferences to GHG emissions trading schemes in Korea, 14th Global Conference of Environmental Taxation (GCET), 17-19 October, 2013, Kyoto, Japan.

❒ Liu, X.B., Suk, S.H., 2013. The pricing of carbon emissions from the business perspective in Northeast Asia, Shanghai Forum 2013, 25-27 May, 2013, Shanghai, China.

❒ Suk, S.H., Liu, X.B., Sudo, K., 2012. Carbon prices affordable for the companies in Northeast Asia – with the Republic of Korea and China as the cases, Annual Conference of Korea Association of Public Finance (KAPF), 7-8 September, 2012, Yosu, Korea.

❒ Suk, S.H., Liu, X.B., Sudo, K., 2012. Company's perspective to GHG emissions trading scheme: A survey in the Republic of Korea, 2012 Annual Conference of Japan Society for Environmental Economics and Policy Studies (JSEEPS), 15-16 September, 2012, Sendai, Japan.

❒ Suk, S.H., Liu, X.B., Shishime, T., 2011. A survey study of energy saving and greenhouse gases mitigation activities of industrial companies in Republic of Korea, 2011 Annual Conference of Japan Society for Environmental Economics and Policy Studies (JSEEPS), 23-24 September, 2011, Nagasaki, Japan.

❒ Liu, X.B., Niu, D.J., Bao, C.K., Suk, S.H., Shishime, T., 2011. Firm's energy saving activities and the determinant factors: A survey study in China, the 18th Annual Conference of European Association of Environmental and Resource Economists (EAERE), 29 June - 2 July, 2011, Rome, Italy.

❒ Liu X.B., 2010. Policy progress of carbon taxation to mitigate climate change in Northeast Asia, an invited presentation in Special Session on Climate Change & Taxation at GSSD Expo, UNDP, 23 November, 2010, Geneva, Switzerland.

❒ Liu, X.B., Ogisu, K., Shishime, T., 2010. Opportunities and barriers of implementing carbon tax policy in Northeast Asia: A comparative analysis, the 11th Global Conference on Environmental Taxation (GCET), 3-5 November, 2010, Bangkok, Thailand.

PART II:

PROGRESS IN CARBON TAX POLICY AND GHG ETS IN NORTHEAST ASIA

Chapter 2:

Carbon tax policy progress in Northeast Asia*

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Chapter Highlights:

- This chapter gives an overview of the latest progress in carbon tax policy in the three project target countries, Japan, China and Korea, in Northeast Asia.
- After many years of discussions, a carbon tax was finally introduced in Japan in October 2012 with a tax rate considered to be low. The carbon tax proposals of China and Korea are similarly characterised by low tax rates.
- Resistance from industry hinders actual introduction of carbon taxes, thus this policy requires public support for smooth implementation.
- Design of the carbon tax policy is crucial, and must be adaptable to the actual situations of different countries in this region.

1. Introduction

Both carbon tax policy and cap and trade schemes aim to discourage the use of fossil fuels by making carbon emissions more costly. Many economists endorse a carbon tax due to its several advantages over an emissions trading scheme (ETS). For example, carbon taxes can be levied on carbon emissions from all sectors, while ETS requires accurate monitoring of emissions and thus is only applicable to large emitters. Further, fair allocation of carbon credits is almost impossible in an ETS. Uncertain carbon prices in an ETS cause companies to become short-sighted, which discourages reduction efforts; conversely, a fixed carbon tax rate is more straightforward for companies and allows them to make decisions for the medium and long term. Additionally, it is easier to minimise the number of losers using tax revenues, either by reducing other taxes or lowering the burden on energy-intensive sectors. Recently, several noted economists have even argued that an international carbon tax is systematically advantageous and could be agreed upon more easily as a post-Kyoto scheme than a global cap and trade scheme (Mankiw, 2007).

Carbon taxing was first introduced in Finland in 1990 and then levied in several other European countries, such as Sweden, Norway, the Netherlands and Denmark. Although obvious

* The main content of this chapter was published as: Liu, X.B., Ogisu, K., Suk, S.H., Shishime, T., 2011. Carbon tax policy progress in north-east Asia, in: Kreiser, L., Sirisom, J., Ashiabor, H., Milne, J.E. (Eds.), Critical Issues in Environmental Taxation, Vol. □, pp.103–118.

differences were found between the carbon tax policies implemented in Europe (Cansier and Krumm, 1997), they have shown broadly positive effects in reducing the use of fossil fuels and CO_2 emissions and in increasing employment, while bringing about only very slight negative impacts on economic growth (Anderson and Ekins, 2009).

The progress of policy on appropriate pricing of carbon emissions in Asian countries, either by taxation or ETS, has been much slower. The three largest economies of Northeast Asia – Japan, China and the Republic of Korea – all make the list of the top ten CO_2 emitters in the world; however, their policy countermeasures on climate change remain sparse, particularly as regards the adoption of market-based instruments (MBIs). This chapter provides an overview of emerging discussions on carbon tax policy in this region, and is arranged as follows: Section 2 provides a glimpse of the latest climate policies in the three target countries, section 3 summarises related analyses of carbon tax at the country macro-level, section 4 reviews actual progress in carbon tax policy using available information, section 5 identifies opportunities for and barriers to introduction of carbon tax policy from multiple viewpoints and section 6 concludes the findings and suggests a way forward for development of this policy.

2. Current climate policies in the three target countries

2.1 State of carbon emissions in the three target countries

China has surpassed the U.S. to become the largest carbon emitter in the world. CO_2 emissions increased by 152.8% in 2006 compared with 1990 figures, with an annual growth rate of 5.1% during the period. The CO_2 emissions of the Republic of Korea also increased rapidly with a total increase of 96.7% and an annual average growth of 4.2% from 1990 to 2006. The CO_2 emissions of Japan were stable over the same period but showed a slight increasing trend, with an average growth rate of 0.6%. From the viewpoint of averages, per capita CO_2 emissions in China were much lower in 2006, around half that of Japan and Korea and one quarter that of the U.S. Nevertheless, CO_2 emission intensity by GDP (Gross Domestic Product) in China was over three times that of Japan and twice that of the U.S. (sourced from World Development Indicators, World Bank).

According to International Energy Agency (IEA) estimates, about 68% of China’s 2005 GHG emissions arose from fuel combustion; 5% evaporated as methane from energy related systems; 10% arose from industrial processes; 14% was from agriculture; and waste and miscellaneous sources shared the remaining 4%. The energy use of the industrial sector is the largest source of CO_2 emissions in Japan, despite a decreasing share from 42.2% in 1990 to 34.5% in 2008. CO_2 emissions from the transport sector, as well as commercial and residential sources, increased during this period. In 2008, the residential sector accounted for 14.1% of the total, and the transport and commercial sectors each had equal shares of 18.9% (sourced from Ministry of the

Environment, Japan). Likewise, industry contributed to 66% of CO_2 emissions in Korea in 2007. The residential sector accounted for 10%, a decrease of 16% compared to 1990 levels, due to energy substitution from coal to clean energies like natural gas and electricity in the 1990s (sourced from the website of Green Growth Committee, Korea).

2.2 The latest climate policies in the three target countries

Under the Kyoto protocol, Japan committed to reduce its 1990 GHG emissions by 6% from 2008 to 2012. As a mid-term target, Japan has pledged to reduce GHG emissions by 25% from 1990 levels by 2020, a commitment premised upon an agreement on aggressive reduction targets being achieved with the participation of all major emitting countries. Japan also announced its long-term target to reduce GHG emissions by 80% from 1990 levels by 2050. The main climate countermeasures of Japanese industry include energy efficiency-related policies, a shift to low carbon energy, and carbon capture and storage (CCS) for large sources of GHG emissions to be introduced after 2020 (MOE, 2010). Keidanren's (nationwide business association of Japan) Voluntary Action Plan, trial domestic ETS, a carbon offset scheme and carbon financing have all been implemented. A calculation, reporting and disclosure system for GHG emissions has been implemented since 2006. Regarding legal measures, 'The Basic Act on Global Warming Countermeasures' is under discussion, which lists various measures in the draft toward achieving mid- and long-term reduction targets.

China's climate policy was outlined in its National Climate Change Programme of 2007 and Climate Change White Paper of 2008. While China has traditionally avoided policies that explicitly target CO_2 emissions, its energy and forestry programmes have provided the basic framework for its National Climate Change Programme. The central government set two key policy targets in 2006: One was to reduce national energy intensity by 20% by the end of 2010 and the other was to increase renewable energy in the energy mix to 15% by 2020, both of which are ambitious for China as a developing country. The Chinese government further pledged in November 2009 to cut CO_2 emissions per unit of GDP by 40–45% by 2020 compared with 2005 levels. These targets represent voluntary actions to tackle climate change problems based on China's domestic conditions. China's climate policy is diverse and includes targets and quotas, industrial processes and equipment standards, as well as financial incentives and penalties. The country has gained some experience in the carbon market through CDM (Clean Development Mechanism) projects. On the energy supply side, improving the energy efficiency of the power sector has been a major task. IEA (2009) estimated that by 2011, 80% of China's coal-fired power plants would be modernised to provide capacities above 300 MW, and projected this number to rise to 90% by 2020. On the energy demand side, the Top 1,000 Enterprises Programme was part of key efforts to reduce industrial energy intensity. Since 2006, this programme has accounted for a large portion of the 20% energy intensity reduction target by directly targeting around 1,000 of the largest state-owned enterprises, the majority of which are heavy industries. The programme goal was achieved in its first year (Price et al., 2008).

On 15 August 2008, the Republic of Korea proclaimed 'Low Carbon, Green Growth' as its new national vision to shift the current quantity-oriented and fossil fuel-dependent economy to quality-oriented growth. On 17 November 2009, the Green Growth Committee announced a decision to achieve a 30% GHG emissions reduction target by 2020, compared with BAU (Business as Usual) levels. Along with the mid-term mitigation goal, countermeasures include adoption of a legal and regulatory framework, carbon emissions trading, and the creation of a national GHG inventory reporting system by 2010, in addition to raising public awareness. Other measures include adoption of new auto emissions standards, a waste-to-energy programme, promotion of low-carbon transportation, introduction of light-emitting diodes (LEDs), stricter heat insulation standards for buildings and development of CCS technologies.

3. Academic discussions on carbon tax policy related to the three target countries

Several analyses of carbon tax policy related to Japan, China and the Republic of Korea at the national level are available.

Nakata and Lamont (2001) examined the impacts of using carbon and energy taxes to reduce CO_2 emissions in Japan. A partial equilibrium model of the energy sector was constructed to evaluate energy system changes up to 2040. Their results confirm that a carbon tax would suppress CO_2 emissions – at a tax rate of 160 USD/t-C (43.6 USD/t-CO_2), total emissions would be 391 Mt-C, corresponding to a reduction of 100 Mt-C. Using a multi-sector dynamic CGE model allowing for 27 sectors over 100 years, Takeda (2007) examined the double dividend of a carbon tax in Japan. His model assumes that government revenues remain constant and that carbon taxes are utilised to alleviate distorted taxes. A strong double dividend does not arise when labour and consumption taxes are reduced, but arises when capital tax is reduced. Although Japan's industry strongly opposes carbon tax policies, introduction of such might be feasible if it could be combined with reductions in capital tax (Takeda, 2007).

Liang et al. (2007) established a CGE model simulating carbon tax policy in China. By referring to existing policy schemes in Europe the authors define different tax scenarios based on whether adoption of tax relief is assumed or not for the production sectors. Their results confirm that the negative impacts of carbon taxes could be alleviated if relief or subsidies were provided to the production sectors. A carbon tax rate for different reduction targets was estimated under a preferable scheme that completely exempts iron & steel, building materials, chemicals, non-ferrous metals and the paper industries from taxes, while being identical for all other sectors. The tax rate is 163 Yuan/t-C (5.4 USD/t-CO_2; 2002 constant price) for a reduction target of 5% compared to the baseline and 348 Yuan/t-C (about 11.5 USD/t-CO_2) for a 10% reduction target.

Kwon and Heo (2010) first revealed the impacts of carbon taxes on commodity prices in the Republic of Korea using an input-output model and a simple CGE model. Their results suggest that an upstream carbon tax equivalent to 36,545 KRW/t-CO_2 (about 31.0 USD/t-CO_2) must be imposed to achieve the government's mid-term target. A carbon tax system with revenue recycling enhances income redistribution, and a lump-sum transfer of the revenue would make this policy progressive. Their findings emphasise the advantages of a tax system over ETS in that the latter is less likely to procure sufficient revenue.

4. Actual progress of carbon tax policy in the three target countries

4.1 Progress of carbon tax policy in Japan

4.1.1 Existing energy-related taxes in Japan

Table 2.1 summarises the tax rates and revenues of energy-related taxes in Japan.

Table 2.1 Existing energy-related tax rates and revenues in Japan

Fuel	Unit	Energy Tax							Total: JPY	
		Gasoline Tax	Regional Gasoline Tax	Petroleum and Coal Tax	Diesel Tax	Promotion of Power-Resources Development Tax	Liquefied Petroleum Gas Tax	Aviation Fuel Tax	Per unit	Per t-CO_2
Tax collector		National	National	National	Prefectural & Municipal	National	National	National		
Taxation position		Upstream[2]	Upstream	Mainly Upstream[1]	Downstream[3]	Downstream	Downstream	Downstream		
Gasoline	JPY/l	48.6	5.2	2.04					55.8	24,052
Diesel	JPY/l			2.04	32.1				34.1	13,034
Heavy oil	JPY/l			2.04					2.0	753
Jet fuel	JPY/l			2.04				26	28.0	11,386
Coal	JPY/kg			0.7					0.7	291
LNG	JPY/kg			1.08					1.1	400
LPG	JPY/kg			1.08			17.5		18.6	6,193
Electricity	JPY/kWh					0.375			0.4	675
Tax revenue (2010)	100 million JPY	25,760	2,756	4,800	8,432	3,300	240	910		

Notes: [1] Mainly upstream: taxation at import or extraction stage

[2] Upstream: taxation at shipment stage out of manufacturing site

[3] Downstream: taxation at supply stage to the consumer

The existing energy-related taxes in Japan include: automobile fuel-related taxes (gasoline tax, regional gasoline tax, diesel tax and liquefied petroleum gas tax), aviation fuel tax, petroleum and coal tax, and promotion of power resources development tax. Energy taxes in Japan may help mitigate energy use and corresponding CO_2 emissions, and the rates vary considerably if converted into carbon content of the fuels. The highest rate is 24,052 JPY/t-CO_2 for gasoline and the lowest is 291 JPY/t-CO_2 for coal. Energy-related taxes are estimated to contribute to 0.9% of CO_2 emissions reductions (Kawase et al., 2003).

4.1.2 Carbon tax proposals of the MOE of Japan

Carbon tax policy has been discussed since the early 1990s within the Ministry of the Environment, Japan (MOEJ). Options have been narrowed down into two streams: a high tax rate or a low tax rate in combination with subsidies for climate change mitigation activities. CEC (2003) suggests that CO_2 reductions through levying of a carbon tax with a low rate (e.g., 3,400 JPY/t-C) – in which all revenue (approximately 950 billion JPY) is directed to a specific budget for climate change mitigation efforts – might have the same effect as a CO_2 reduction via levying a high rate carbon tax (e.g., 45,000 JPY/t-C). From 2004 to 2006, the MOEJ presented carbon tax proposals on three occasions, as listed in table 2.2. Considering a lack of public support, strong resistance from business lobbyists and an indifferent Ministry of Finance (MOF), these proposals outlined a low-rate tax earmarked for global-warming countermeasures.

Table 2.2 Carbon tax proposals of the MOEJ from 2004–2006

	2004 Proposal	2005 Proposal	2006 Proposal
Tax rate	2,400 JPY/t-C (655 JPY/t-CO_2, 5.45 USD/t-CO_2)		
Revenue (Ind.: Ser.: Hou.)	490 billion JPY (150:200:140)	370 billion JPY (160:110:100)	360 billion JPY
Use of revenues	Subsidy for climate change and forestry (340); reduction of social security (150)	General budget; subsidy for climate change and forestry	General budget; subsidy for climate change and forestry
Special treatment	Exemption for steel, agriculture, forestry and fishery; Reduction for heavy industry, diesel, small firms and households	Exemption for steel; 50% reduction for large emitters that perform reduction activities; 50% reduction for kerosene; Put-off motor fuel	Exemption for steel and fishery; 80% reduction for large emitters that perform reduction activities; 50% reduction for kerosene; Put-off motor fuel

The MOEJ's FY2010 proposal considered imposing a tax on importers and companies that exploit fossil fuels. A carbon tax on gasoline levied on refineries has been considered, but a tax on diesel is pending. As shown in table 2.3, the sum of this newly added carbon tax and existing energy taxes of Japan is much lower than the average of European countries. The MOEJ estimates that a total of 2.0 trillion JPY in revenues could be raised through the introduction of this proposed carbon tax. The FY2010 carbon tax proposal also considers tax exemptions for the following items: a) fossil fuels such as raw materials like naphtha; b) coal and cokes for iron and steel manufacturing; c) coal for cement manufacturing; and, d) bunker A fuel oil for agriculture, forestry and fisheries. The companies subject to a domestic ETS would receive relief once the domestic ETS was introduced. Also suggested in the proposal is that carbon tax revenues be assigned to a general budget in preference to using such to counter global warming.

The FY2011 Tax Revision Package, concluded by the Japanese cabinet on 16 December 2010, outlines a roadmap for specific taxes aimed at climate change mitigation. The updated rates for these taxes are 760 JPY per kl of petroleum and oil products; 780 JPY per tonne of gaseous hydrocarbon; and 670 JPY per tonne of coal. These rates equate to 289 JPY/t-CO_2 and are much lower than the earlier proposals of the MOEJ. Taxes are scheduled to be phased in three stages: From 1 October 2012, taxes at rates one third of those listed above will be introduced, a further third will be added from 1 April 2013, and full implementation of the taxes will take effect from 1 April 2015. Besides maintaining relief measures for existing energy-related taxes, the tax revision package of FY2011 also adds exemptions and refunds of the special anti-climate change tax.

Table 2.3 FY2010 carbon tax proposal of Japan and existing taxes of EU countries (Unit: JPY/t-CO_2)

Country		Gasoline	Diesel	Heavy oil	Coal	Natural Gas
Japan	Energy tax	24,052 (12,831*)	13,034	753	291	400
	Carbon tax	8,531 *	1,064 **	1,064	1,174	1,064
	Total	21,362 *	14,098	1,817	1,465	1,464
UK		45,543	40,368	7,200	1,083	1,820
Germany		45,388	28,915	1,458	587	1,930
France		42,087	26,333	989	588	1,044
Netherlands		47,780	25,632	24,777	865	12,002
Finland		43,481	22,374	3,583	3,375	1,622
Denmark		38,651	25,506	17,429	15,256	23,692
EU-Average		43,822	28,188	9,239	3,626	7,018

Source: Ministry of the Environment website, as of 6 September 2010.

Note: * The carbon tax rate for gasoline is set with a precondition that the existing temporary energy tax on gasoline will be changed to the number in parentheses. ** Additional tax on diesel is under consideration.

4.2 Progress of carbon tax policy in China

4.2.1 Existing energy-related taxes in China

In China, taxes related to the environment and resources include resource taxes, consumption taxes, vehicle and vessel usage taxes and a vehicle purchase tax. Some are related to energy use, and are summarised in table 2.4.

Table 2.4 Taxes related to energy use and carbon emissions in China

Name	Item	Tax rate	Note
Resource tax	Crude oil	8-30 Yuan/t	Except oil refined from bituminous shale
	Natural gas	2-15 Yuan/1,000 m^3	Except natural gas from coal mines
	Coal	0.3-5 Yuan/t	Refers to raw coal, excludes washed and separated coal
Consumption tax	Gasoline	0.2 Yuan/l	
	Diesel	0.1 Yuan/t	
	Motorcycle	10%	
	Automobile	3–8%	
Vehicle and vessel usage tax	Vessel	1.2–5.0 Yuan/t.a	Classified by the tonnage
	Vehicle	16–320 Yuan/a	Differs according to purpose of use and type
Vehicle purchase tax	Vehicle	10%	

4.2.2 Carbon tax policy proposals in China

In recent years, experts at research institutes under MOEP (Ministry of Environmental Protection), MOF (Ministry of Finance) and SAT (State Administration of Taxation) have actively discussed how to develop carbon tax policy in China.

They conclude that carbon taxes in China should be limited to fossil fuels, i.e., coal, oil and natural gas. Li (2010) suggests that a carbon tax should not be levied on electricity because coal-fired power plants are major electricity suppliers in China and thus might be taxed twice if both coal and electricity are taxed. Li (2010), Wang et al. (2009) and Su et al. (2009) further suggest that two options exist for carbon taxation: One is to impose a carbon tax on the producers of fossil fuels and the other is to target the wholesalers, retailers and users of fossil fuels. Under the first option, the producers would pass costs downstream to customers. In this case, the price pressure from the carbon tax would decrease along the supply chain of fossil fuels and lead to a relatively weak effect on CO_2 emissions reduction (Li, 2010). Nevertheless, considering the cost of tax collection, Cao (2009) suggests that a carbon tax should be imposed at the source of energy exploitation or the energy distribution hub. Particularly for coal, petroleum and natural gas, taxes should be paid by the exploitation companies; for refined oils like gasoline and diesel, taxes should be paid by the refinery companies. Li (2010) proposed another option: to impose taxes on secondary energy products, such as oil, kerosene and gas, on the wholesalers and retailers in the middle.

Considering the cost of CO_2 emission reductions in the long run, as well as resulting impacts on the economy, tax rate setting should be a gradual process and differential tax rates should be adopted. Rates should be low at the early stages and then rise gradually. Su et al. (2009) conducted a simulation study of carbon taxes using a CGE model. Suggested tax rates are shown in table 2.5.

Table 2.5 Proposal for carbon tax rates in China

Item	Tax rate	
	From 2012	From 2020
Carbon tax (Yuan/t-CO_2)	10	40
Carbon tax on coal (Yuan/ton)	19.4	77.6
Carbon tax on oil (Yuan/ton)	30.3	121.2
Carbon tax on gasoline (Yuan/ton)	29.5	118
Carbon tax on kerosene (Yuan/ton)	31.3	125.2
Carbon tax on natural gas (Yuan/1,000 m^3)	2.2	8.8

Li (2010) suggests several carbon tax relief measures applied from international contexts to China's actual conditions. First, energy-intensive industries should enjoy preferential measures only under certain conditions, such as with signed agreements with the government to reduce CO_2 emissions and engage in efforts toward energy saving. Second, tax refunds could be provided as incentives to companies with significant reductions, increased investment in energy saving or improved energy efficiency via use of advanced technologies. For low-income groups, tax returns should be offered to guarantee a basic standard of living and to maintain social stability.

Any imposition of a carbon tax must overcome obstacles from taxpayers and consider both domestic and international conditions. Su et al. (2009) point out that according to the Bali Roadmap, not only are developed countries required to commit to extensive emissions reductions, but developing countries as well must take action to reduce GHG emissions. China will face increasing pressure to control its GHG emissions after 2012, and implementation of a carbon tax around 2012 would be consistent with the country's strategy of adding policies to control CO_2 emissions.

4.3 Progress in carbon tax policy in the Republic of Korea

4.3.1 Energy-related taxes in the Republic of Korea

Transportation, energy and environmental taxes are in place in the Republic of Korea. According to Lee (2005), refinery prices of gasoline and diesel were 0.21 and 0.20 USD/l respectively in 1999. After-tax prices were 0.94 and 0.40 USD/l, making energy taxes for gasoline and diesel 0.73 and 0.20 USD/l respectively at that time. Korea had a higher energy tax rate (74.8%) for gasoline than Japan (56.2%) and the U.S. (31.0%), but a lower tax rate (39.9%) for diesel than Japan (52.4%) and the UK (72.1%). This implies that the Korean government has generally supported industrial rather than household fuel use. The Korean government has taken steps towards reforming its energy taxes (Kim et al., 2001) – one of its key targets is to narrow the price differences between transportation fuels by increasing the price of diesel and LPG up to 80% and 65% of gasoline respectively. For industrial fuels, one proposal was to increase the price of bunker C fuel oil by 28% and keep the price of LNG unchanged.

4.3.2 Discussions on carbon tax proposals in the Republic of Korea

Debate is ongoing in the Republic of Korea regarding the introduction of carbon tax policy. A simple method would be to levy a tax on fuels containing carbon, which would satisfy the Polluter Pays Principle (PPP) (Kim, 2008). Kim (1997) argues for an indirect tax rather than a direct one. As the production structure of Korea has a lower substitutability for other energy inputs, carbon taxing would stimulate the substitution effect, which could transform the economic structure through energy-saving technologies (Park, 2003). Choi et al. (2000) assert that large fluctuations in prices by industry would occur with a high carbon tax rate and suggest application of relief measures for industries with large price changes. Cho (2005) explains potential positive and negative aspects of carbon tax in the Republic of Korea – a negative aspect is the possibility of transference of the carbon tax burden from producers to consumers. A further negative is a drop in demand due to price increases, leading to shrinking production, and by extension lower wages and unemployment. A positive aspect is the possibility of enhanced industrial competitiveness due to investment in research and development. In the long run, the initial impacts on energy price increases due to carbon tax can turn into economic benefits. Kim and Shin (2007) argue that Korea depends on petroleum and coal products more than China, Japan and the U.S. If a carbon tax is introduced, the Republic of Korea will suffer the most compared with its main trading partners. Nevertheless, the general attitude toward a carbon tax is rather positive among scholars on the environment.

The Korea Institute of Public Finance (KIPF) initially proposed detailed carbon tax rates for fossil fuels in 2008, as listed in table 2.6 (Kim et al., 2008). These rates were calculated according to the carbon price of the EU-ETS (25 EUR/t-CO_2, equivalent to 31,328 KRW/t-CO_2). The total expected annual revenue from the proposed carbon tax was to be 8.5 to 9.1 trillion KRW (7.38 to 7.91 billion USD) based on 2007 emissions in Korea. KIPF suggests that a carbon tax could be implemented from 2010, replacing the existing transportation tax originally scheduled to end in 2009. A later option for introducing a carbon tax would be 2012, as the maximum rates of income tax and corporate tax are planned to be abated by then. According to a later report of Kim et al. (2009), considering that income tax and corporation tax has been reduced after the launch of a new government in 2008, carbon taxes should be introduced separately at much lower rates than those listed in table 2.6 without cutting the existing taxes at an early stage.

Table 2.6 Initial proposal for carbon tax rates of the Republic of Korea

Items	Tax rate
Carbon tax on gasoline (KRW/l)	67.5
Carbon tax on diesel (KRW/l)	82.4
Carbon tax on kerosene (Jet fuel) (KRW/l)	77.7
Carbon tax on B-C oil (KRW/l)	95.5
Carbon tax on butane (KRW/l)	53.2
Carbon tax on propane (KRW/kg)	92.0
Carbon tax on LNG (KRW/m^3)	71.0
Carbon tax on coal (Anthracitic) (KRW/kg)	58.9
Carbon tax on coal (Bituminous) (KRW/kg)	33.7

In the medium and long term, it is preferable to increase the carbon tax or energy tax rates simultaneously with mitigation of the existing income taxes (such as personal income tax, corporation tax and social security contributions) to maintain the national tax reform revenue-neutral. The revenue from carbon taxes should be recycled into renewable energy and R&D for cleaner technologies, as well as incentives for the export sectors to help cushion the blow caused by introduction of the carbon tax. In addition, tax exemptions and direct support for low-income persons was proposed in parallel with introduction of this new tax.

5. Carbon tax proposals of the three target countries – a comparative analysis

Considering the cost and difficulty of tax collection, each of the carbon tax proposals in the three target countries involve levying taxes on fuels containing carbon. The importers, producers, wholesalers and retailers of fossil fuels at the furthest point upstream or along the way would be targeted by the carbon tax. Concerning the negative impacts on economies and industrial competency, especially for energy and carbon-intensive sectors, proposed carbon tax rates are low: the latest carbon tax proposal of Japan's MOE suggests a rate of 289 JPY/t-CO_2 (around 3.40 USD/t-CO_2) for the fuels under consideration, which is much lower than the rate recommended by Nakata and Lamont (2001) (43.6 USD/t-CO_2). Similarly, the carbon tax proposed by experts in China is even lower (about 1.5 USD/t-CO_2 from 2012), differing by up to a decimal point from that suggested by Liang et al. (2007) (5.4 to 11.5 USD/t-CO_2). The proposed carbon tax in the Republic of Korea is also set at quite a low rate (Kim et al., 2009). As described earlier, all discussions on carbon tax policy in the three target countries consider relief measures; the proposed carbon tax policy in Japan excludes fuels for certain specific purposes and appropriate tax exemption and return mechanisms are suggested for the energy-intensive industries in China (Li, 2010). Principally, a carbon tax refund is the preferred incentive in exchange for the energy-saving efforts of companies. Experts in the Republic of

Korea also suggest applying measures for industries that would undergo large cost changes due to introduction of carbon taxes (Choi et al., 2000).

Various barriers exist and hinder the actual introduction of policy in this region. In Japan, strong resistance from industrial lobby groups, like Keidanren, has been the chief factor blocking introduction in the past. Multifaceted political issues such as environmental tax reform require cooperation between competent ministries such as MOF, METI (Ministry of Economy, Trade and Industry, competent for energy policy), MLIT (Ministry of Land, Infrastructure and Transportation, competent for spending of gasoline tax revenue), MAFF (Ministry of Agriculture, Forestry and Fisheries) and the MOEJ. Although a roadmap for introducing a climate change mitigation tax has been determined by the cabinet, the interests of related ministries remain uncoordinated and lack cohesion. However, one encouraging sign has emerged here in the form of growing public support for this policy – proponents of carbon taxes increased from only 24.8% in 2005 to 40.1% in 2007, while the proportion of those against the tax was 32.4% and 32.0% for the respective years. More than 70% of the proponents would prefer tax revenue to be channeled into climate change countermeasures (Cabinet Office of Japan, 2007). Chinese experts are optimistic about the introduction of a carbon tax in China; the 2009 research report of the ERI (Energy Research Institute) on a carbon tax scheme points out that the loss of GDP would be less than 0.5% by 2025 due to introduction of such policy (Jiang, 2010). Further, the attitudes of related ministries, such as MOEP, NDRC (National Development and Reform Commission), MOF and STA, are positive regarding environmental tax reform. However, as a tax on carbon is still a relatively new concept in China, companies may exhibit some reticence at the beginning and the public may require some time before fully comprehending this tax. On the other hand, Korean policy-makers must overcome various obstacles before a carbon tax can be realised (The Korea Times, 2010). In this respect it is vital to advance structural reform of the nation’s economy so that companies may adjust to the low-carbon strategy. It is necessary to push ahead with overall tax reform, and the government needs to adopt a proactive approach to build a public consensus on carbon tax in particular.

6. Conclusion

This chapter provides a preliminary overview of emerging discussions on carbon tax policy in the three target countries in Northeast Asia. A comparative analysis identified opportunities for and barriers to introduction of carbon taxes in this region and further points to the paramount importance attached to the design of carbon tax schemes, which must embrace the scope, tax rate and methods of collection and utilisation of the tax adapted to the actual context of each country. Further discussion is required to convince decision-makers. A short comparison identified problems in target countries in implementing carbon tax policy. As carbon taxation may cause a shift from coal to other low-carbon energies, existing energy taxes with a supplementary carbon tax would be a stable and acceptable option for Japan and the Republic of Korea, which rely heavily on energy imports. As a way forward, discussions on levels of acceptability from the perspective of individual companies are crucial in order to overcome the resistance of industry to this policy, thus reactions to optional tax schedules and corresponding behavioral changes, especially technological innovations and the choice of low carbon technologies, require in-depth observation.

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Chapter 3:
An overview of GHG emissions trading schemes in Northeast Asia*

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Chapter Highlights:

- This chapter provides an overview of the establishment of GGH emissions trading schemes in the three project target countries in Northeast Asia.
- Japan's government attempted to establish a trial integrated domestic market for GHG emissions. Japan's GHG ETS has been blocked due to resistance from industry.
- Korean business groups strongly oppose this policy. By reflecting the opinions from industry, the GHG ETS bill was approved and will be launched in the beginning of 2015.
- China has been deeply involved in the international carbon market through project-based CDM. In spite of the difficulty for China to set emissions caps at the country level in the near future, recent pilot projects at local levels are encouraging for the establishment of a domestic carbon market.
- Aiming to overcome the barrier for GHG ETS, the acceptability of individual companies, especially those in highly influenced sectors, is a research priority.

1. Introduction

In contrast with the large shares of global greenhouse gas (GHG) emissions and relatively ambitious medium-term mitigation targets of Japan, China and the Republic of Korea, progress in their respective climate policies has been lagging. The core to policy lag in these three major economies in Northeast Asia is a lack of experience in adopting market-based instruments (MBIs) and setting appropriate prices for carbon emissions (Liu et al., 2011a). With the aim of bridging this policy gap, this chapter gives an overview and analysis of progress in GHG emissions trading schemes (GHG ETS) in the three countries. The content is structured as follows: Sections 2 to 4 individually describe the efforts of Japan, China and the Republic of Korea in introducing GHG ETS, section 5 compares the current scenarios of GHG ETS in this

* The main content of this chapter was published as: Liu, X.B., Suk, S.H., Sudo, K., 2012. GHG emissions trading schemes in Northeast Asia: An overview and analysis of current scenarios, in: Kreiser, L., Sterling, A.Y., Herrera, P., Milne, J.E., Ashiabor, H. (Eds.), Critical Issues in Environmental Taxation, Vol. XI, pp.149–166.

region and identifies major barriers for the formal introduction of this policy and section 6 proposes topics for future study.

2. Progress of GHG ETS in Japan

2.1 Experimental practices of GHG ETS in Japan

The Japanese government has attempted to establish a trial integrated domestic market for GHG emissions, the framework of which is depicted in fig.3.1.

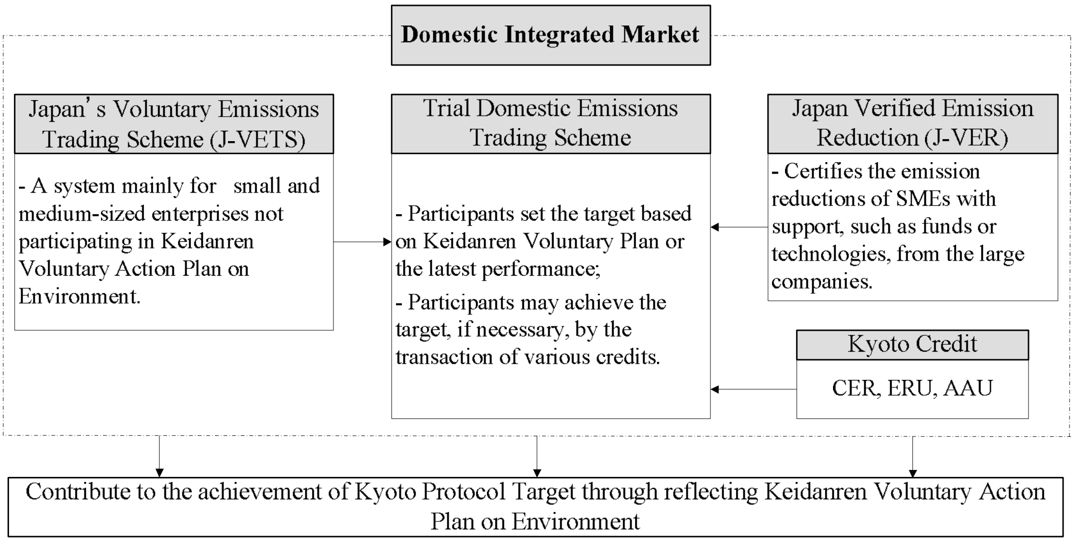

Figure 3.1 Japan’s domestic integrated GHG emissions market on trial

In October 2008, a management secretariat, consisting of members from the Cabinet Secretariat, Ministry of Economy, Trade and Industry (METI) and Ministry of Environment, Japan (MOEJ), was set up to coordinate this market, which was set up in order to identify potential problems before formal introduction of mandatory GHG ETS nationwide. Collecting information on GHG emissions of the participants was another goal. The integrated market admits GHG credits from various mechanisms, including Japan’s Voluntary Emissions Trading Scheme (J-VETS), trial domestic ETS, J-VER and the Kyoto mechanisms.

2.1.1 Japan’s Voluntary Emissions Trading Scheme

MOEJ launched J-VETS in April 2005 by targeting small and medium-sized enterprises (SMEs) not involved in Keidanren’s Voluntary Action Plan. Companies join this scheme voluntarily and commit to concrete reduction targets. Under the scheme, up to one third a company’s expenditure for reduction measures can be subsidised by the government, with a cap of 200 million JPY per project. Participants can trade credit surpluses or debits to achieve their pledged targets. The received subsidy has to be returned to the government if a company fails to achieve its reduction commitments. The implementation results of J-VETS are listed in table 3.1.

A total of 357 companies participated in this scheme and the 2009 data shows that the participants successfully reduced 947,670t-CO_2, an equivalent of 28% of the base year emissions. The traded amount was 57,930t-CO_2 and the average price was 750 JPY/t-CO_2 (MOEJ, 2011). The budget for J-VETS was 1.2 billion JPY for FY2011 and 57 projects were set to receive the subsidies. Expected reductions of these projects are 87,113t-CO_2 for FY2011, with the reductions during the statutory life predicted to be 1,087,949t-CO_2. The subsidy cost-efficiency is 1,128 JPY/t-CO_2 on average.

Table 3.1 J-VETS implementation results (as of May 2011)

Item		2006	2007	2008	2009	2010	2011
Number of companies with targets	Type A	31	58	55	69	62	55
	Type B			3	12	6	Not decided
	Type C		3	3			
Number of companies with trading		7	12	24	No designation	No designation	No designation
Number of verification organisations		12	18	20	20	21	Not decided
Total base-year emissions (t-CO_2)		1,300,361	1,122,593	1,661,251	3,366,288	608,886	473,290
Emissions in implementation year (t-CO_2)		923,305	842,401	1,278,626	2,418,618	To be fixed in June, 2011	To be fixed in June, 2012
Reductions from base year (t-CO_2)		377,056 (29%)	280,192 (25%)	382,625 (23%)	947,670 (28%)		
Initially committed reductions (t-CO_2)		273,076 (21%)	217,167 (19%)	136,410 (8.2%)	334,617 (10%)	101,848 (16.7%)	82,827 (17.5%)
Transaction times		24	51	23	24	To be fixed within 2011	To be fixed within 2012
Transaction amount (t-CO_2)		82,624	54,643	34,227	57,930		
Average price (JPY/ t-CO_2)		1,200	1,250	800	750		

Note: The data in the parenthesis is the ratios.

2.1.2 Trial of domestic ETS in Japan

The domestic ETS trial is the fulcrum of the integrated domestic market for Japan. Participating companies voluntarily set their own CO_2 reduction targets, which should be consistent with Keidanren's Voluntary Action Plan or the participant's latest performance for either total amount of emissions or emissions intensity. The credits from various mechanisms may be used for achieving these targets and the participants may choose the whole of 2008 to 2012 or part thereof for the trial. Each company's emissions are verified annually and companies may opt to receive quotas in advance or as ex-post adjustments. For advance allocations, participating companies are prohibited from trading 90% of the allowance before amortisation at the end of implementation to prevent any illicit financial activity. The performance of participants in the domestic ETS trial for 2009 is listed in table 3.2.

Table 3.2 Performance of participants in Japan's domestic ETS trial for 2009

Sector	Category	Number of the participants						Difference of target and actual emissions (10,000 t-CO_2)		
				Amount target		Intensity target				
		OA	IR	OA	IR	OA	IR	In total	Amount target	Intensity target
Industry	Iron & steel	1		1				1,708	1,708	
	Chemicals	6	5	4		2	5	9	14	-4
	Paper	6	2	2		4	2	-3	10	-12
	Cement and glass	4	3	2		2	3	30	34	-4
	Electric & electronics	5	4	2	2	3	2	27	7	20
	Automobiles	1		1				186	186	
	Other	9	1	5		4	1	11	8	3
Energy transformation	Electricity generation		9				9	-6,190		-6,190
	Petroleum refineries	5	1			5	1	40		40
Commercial	Trade firms and banks	19	4	14	2	5	2	3	2	1
Transportation	Aviation and cargo	4	1	3		1	1	63	44	20
	Total	60	30	34	4	26	26	-4,116	2,011	-6,127

Note: OA: Over attainment; IR: Insufficient self-reduction

Sixty participants successfully attained their targets by self-reductions, the other thirty companies with insufficient self-reductions achieved their targets by borrowing future allowances or buying credits. By target category, 34 participants with total amount targets attained targets by self-reductions. Half of the 52 companies with intensity targets achieved reductions in the same way. For the over-attaining companies, 55 banked their reductions of 21.13 million t-CO_2. The companies with insufficient self-reductions largely relied on Kyoto credits and ten of them bought 52.28 million t-CO_2 from Kyoto mechanisms (MOEJ, 2011).

2.1.3 Japan Verified Emission Reduction (J-VER) Scheme

J-VER, introduced in November 2008, allowed large companies to provide technological or financial supports to SMEs, and thus receive VERs to offset their own emissions. Such companies may use the credits to achieve their own targets in accordance with Keidanren's Voluntary Action Plan or the domestic ETS trial. Agriculture, forestry and residential sectors are also included in this programme. The number of emission reduction and absorption projects registered under J-VER was 106 as of May 2011, of which 63 projects had been verified for a total VER of 111,976t-CO_2 (MOEJ, 2011).

2.2 Intermediate proposal for GHG ETS in Japan

The 'Basic Act on Global Warming Countermeasures', approved by the Japanese cabinet on 12 March 2010, states that a final domestic GHG ETS draft shall be prepared within one year after enactment of the Act, and to this end, a small ETS-designated committee was created under the

Global Environment Working Group of the Central Environmental Council, which initiated discussions on 23 April 2010. After several rounds of meetings a draft intermediate proposal was drawn up in December 2010, the major considerations of which are listed in table 3.3.

Table 3.3 Outline of Japan's intermediate GHG ETS proposal

Item	Description
Period	An initial 3-year phase assuming a 2013 start, with 5-year phases thereafter
Scope	Energy-related CO_2 emissions with discussion on non energy-related emissions considering management accuracy
Opinions of the target	- Entities with business sites emitting large amounts of CO_2, with annual emissions of 10,000 t-CO_2 via referendum; - Discussion on the compliance of various entities considering their competitiveness.
Allowance allocation	- Estimating the total cap assuming possible countermeasures and technologies, and using the cap to determine whether additional policies are needed for realising long- and medium-term targets; - Consideration of the entity's prior reduction efforts, possible technology applications and reduction potentials; - Treating CO_2 emissions of electricity generation as indirect emissions of electricity consumers; - Making power plants responsible for improvements to unit CO_2 emissions; - Setting a cap based on an entity's historical emissions and allocating allowances by grandfathering; - Discussion of possible combinations with other methods.
Compliance	The emissions of target entities will be verified annually to confirm allocated allowances are not exceeded.
Easing measures	- Banking and borrowing of allowances are allowable; - Application of external credits is allowed under certain conditions; - Consideration of the contribution of product manufacturing to emission reductions during allowance allocation.
Other	Necessity for technical discussions of registration system for emission allowance management and trading rules

Even though domestic ETS is recognised as one of the three main global warming countermeasures in Japan, there is concern that this policy would excessively interfere with businesses, block investment in emerging industries and encourage financial speculation. Regardless, however, GHG ETS would provide new regulatory control for large emitters in addition to the tax and feed-in tariff energy policies. Further discussions are needed to consider the economic burden on industry, impact on employment, ETS trends abroad as well as to assess current countermeasures in Japan. Whether a fair and viable post-Kyoto framework agreement between the major emitting countries can be achieved is another factor for consideration.

3. Progress of GHG ETS in China

3.1 CDM in China

CDM is the only mechanism by which China participates in the international carbon market. The related ministries jointly issued the 'Measures for the Operation and Management of CDM Projects' in October 2005, which clearly regulates the requirements and procedures for the development and approval of CDM projects. According to the Measures, GHG credits from

CDM projects are owned by the Chinese government, and revenues from certified emission reductions (CERs) are shared by the government and project owners, with allocations differing according to project type. The government takes 65% of the benefit for HFC and PFC projects, 30% for N_2O projects and 2% for forestation projects. A price limit was set for CER transactions, with the minimum being 10 Euro/t-CO_2 for renewable energy projects and 8 Euro/t-CO_2 for others. As of the end of 2010, 1,145 Chinese CDM projects had been successfully registered at the UN, accounting for 42.3% of the global total. These projects are estimated to realise an annual reduction of 260.32 million tonnes of CO_2 and account for 62.04% of the estimated reductions of all the registered projects. Figure 3.2 shows the percentage of registered CDM projects by category in China. New and renewable energy projects have the largest share, at 79.9%. Energy-saving projects account for 8.1% and the remaining account for 12.0% (CDM website, China, 2011).

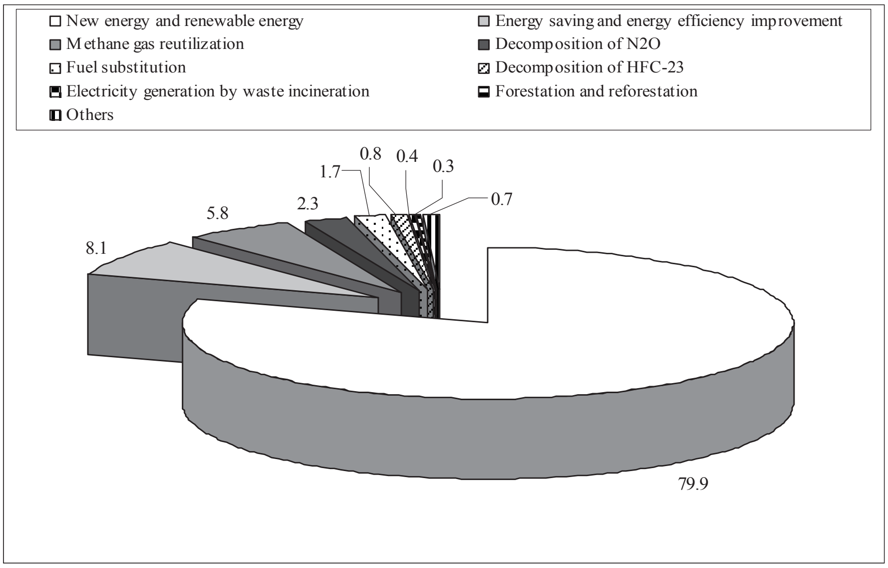

Figure 3.2 Percentages of registered CDM projects in China (as of the end of 2010)

China's CDM fund was developed using the revenues from CDM projects to support climate countermeasures, and is also sourced by donations from organisations and individuals. By August 2010 this fund was reported to exceed 5 billion Yuan (Li and Wan, 2010) and is expected to double by 2012 (Su, 2010). Based on the limited information available from project owners, CER revenues are usually treated as 'operational revenues' or 'government subsidies' by companies, and are used to cover the expenses incurred in implementing CDM projects.

3.2 Environmental exchange institutes and voluntary GHG ETS in China

China has a priority to employ GHG ETS as a market instrument. It has the largest amount of CERs but very limited initiative in determining the price of carbon as there is no domestic carbon market. In preparation for a GHG market, in recent years various environmental exchange institutes have been established; the first two being China Beijing Environmental

Exchange and Shanghai Environment and Energy Exchange, launched in August 2008. In September, 2008, Tianjin Climate Exchange was established as the third. Since then, several more have been formed in the cities of Guangzhou, Shenzhen, Hangzhou and Kunming, and provinces of Hubei, Liaoning and Sichuan, as shown in fig. 3.3.

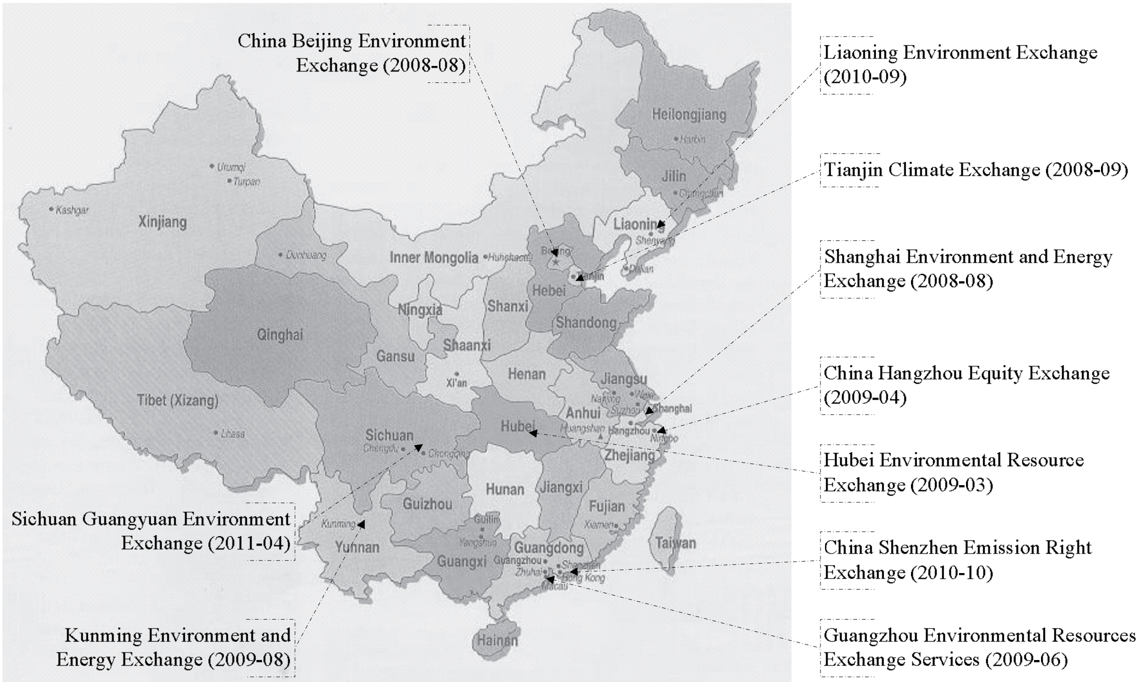

Figure 3.3 Locations of climate exchange institutes in China (as of April 2011)

The exchanges in Beijing and Shanghai mainly deal with the transfer of energy-saving and environmental technologies; the trading of SO_2 and GHG emissions is still under exploration. Tianjin Climate Exchange intends to develop the trading of pollutants emissions and energy efficient products (Zhang and Li, 2010). As the first case of VER trading in China, on 5 August 2009, Tianpin Auto Insurance bought 8,026t-CO_2 from China Beijing Environment Exchange to offset its CO_2 emissions for the period 2004–2008. The VERs were created by Beijing Green Commuting Action during the Olympic Games with a transaction price of 277,600 Yuan and an average price of 35 Yuan/t-CO_2 (CBEEX, 2009).

The present demand for VERs in China is therefore obviously only marginal due to the lack of buyers, which represents the biggest barrier to development of the VER market in China. Most Chinese companies see no reason to neutralise their emissions voluntarily, and further, the public has little awareness of VERs. The lack of management of VER trading rules and of regulations covering certification of verification organisations are additional problems (Liberation Daily, 2010).

3.3 Pilot for establishing national GHG ETS in China

GHG ETS is still in its infancy in China and was first mentioned in 2010 in a government document. However, no specific decisions as to whether caps should be voluntary or mandatory have been made and no timetable exists for its formal introduction (Liu, 2010).

There is, however, positive news as regards the pilot GHG ETS project, which is set to be launched during the 12th Five-year Programme period (2011–2015). Much ministerial discussion has surrounded both the timing of the launch and related operations, with three options currently on the table (Zhang, 2010). One is to conduct a pilot in selected regions, which was started in September 2010 with a national pilot project for low-carbon provinces and cities. For this, five provinces (Guangdong, Liaoning, Hubei, Shaanxi and Yunnan) and eight cities (Tianjin, Chongqing, Shenzhen, Xiamen, Hangzhou, Nanchang, Guiyang and Baoding) were selected. These regions, especially the eastern coastal areas with better economies, can join the national ETS pilot. The second option is to carry out the pilot in certain sectors, such as power and petrochemicals, as these energy-intensive sectors have large reduction potentials and better capacities attributed to high industrial concentrations. The third option is to request cooperation from giant state-owned companies under the State-owned Assets Supervision and Administration Commission (SASAC), which represents a broad spectrum of energy-intensive sectors. This last option has the advantage of simpler monitoring and verification of CO_2 reductions.

4. Progress of GHG ETS in Korea

4.1 Korea's voluntary GHG reduction programme and CDM implementation

In July 2005 the Ministry of Knowledge Economy (MOKE) established the Department of GHG Reduction Registry under the Korea Energy Management Corporation (KEMCO) to issue Korea Certified Emission Reductions (KCER) for participants of the Korea Voluntary Emission Reduction Programme (KVER). KVER was designed as a precursor to a national carbon market in Korea. In this programme, if an entity fails to meet its renewable energy requirements in the Renewable Portfolio Standard (RPS), it has the option of purchasing KCERs to satisfy this compulsory standard. KCERs may be sold on the international market after converting them to internationally recognised CERs. Any unsellable KCERs are then purchased by the Korean government, the budget for which was about 6.85 billion won for 2007–2011. In 2007, 103 projects were registered under KVER, worth an anticipated approx. 2.05 million t-CO_2 reductions annually, 940,000t-CO_2 from 37 projects of which were certified as KCERs. The Korean government purchased all KCERs of the 37 projects at an average price of 5,000 won/t-CO_2 (Kim, 2008).

Korea's involvement in CDM started with the registration of the Ulsan Chemical HFC23 Decomposition Project in 2005. As of July 2008, 19 CDM projects had been registered in the UN with expected emission reductions of 14.6 million tonnes of CO_2 per year, 6.6% of the worldwide reductions created by the 1,143 registered CDM projects at that time. This figure puts Korea is fourth place after China, India and Brazil. Currently, 10 new CDM projects are under development.

4.2 Korea's GHG ETS proposal

In order to maximise Korea's efforts in cutting GHG emissions, discussions on introducing a domestic GHG ETS were started under the 'Framework Act on Low Carbon Green Growth'. A preliminary GHG ETS proposal was formulated in November 2010, which suggested GHG ETS be introduced in three phases. The first phase would start in 2013 and end in 2015. Two subsequent phases, each running for five years, were to follow after 2016. In the proposal, 10% of allowances would be allocated by auction and the remaining 90% for free in the first phase, with the auction allowance proportion increased thereafter. The penalty for any non-compliance emissions, those exceeding the allotted amount, was less than five times the average market price of the emissions. However, this proposal received strong opposition from industry, the main points of which are summarised in table 3.4.

Table 3.4 Korean industry's opinion on preliminary GHG ETS proposal

Item	Industry opinion	Government opinion
Double regulations	Double regulations due to overlapped targets of ETS and the ongoing TMS	TMS and ETS targets differ according to GHG emissions amount
Introduction time	2013 is too early. ETS should be phased in after TMS has been stabilised and after consideration of the international negotiation process	Emission allowance borrowing is allowed in the 1st phase. The actual start will be 2015
Global trend	Only EU and New Zealand introduced ETS and only five countries in G20 joined the EU-ETS	U.S. RGGI and Tokyo Cap-and Trade Programme are local-level programmes. The U.S., Japan and Australia attempted to introduce ETS
Concrete plan	Uncertainty in clarifying issues via law, like presidential decrees	Technical issues will be clarified when the ordinance is passed
Burden on industry	- Product price increase and sales decrease result in lower competitiveness; - Covering the cost of allocating a mere 10% of allowances would require about 5.6 trillion won annually; - Estimated 3–12% electricity bill increase	Compared with TMS, the burden on industry under ETS would decrease. Increasing performance beyond reduction goals could be incentivised
Capital outflow	Possibility of buying cheaper credits from abroad and flow of domestic capital to other nations	The inflow of overseas credits to Korea will be regulated
Allocation	Free allocation is preferred	Gradual increase of allowance ratio for auction

The arguments from industry are that it is too early for Korea to introduce a mandatory GHG ETS given that major economies such as the U.S. and Japan have suspended their plans and that industrial competitiveness would be weakened. Businesses worry about the double burden of

ETS and the mandatory Target Management System (TMS). TMS is a mandatory scheme adopted in 2011 for large energy-consuming entities and business sites (mainly power plants and industrial facilities), and targets entities that emit more than 125,000 t-CO_2 or use more than 500 TJ of energy per year and business sites that emit more than 25,000 t-CO_2 or use more than 100 TJ of energy per year, as of December 2011. This regulation was designed to cover a total of 471 business sites whose GHG emissions in 2007 accounted for about 60% of the national total. TMS may act as a precursor to GHG ETS in Korea as TMS prepares the standards for GHG management (relating to monitoring, reporting and verification (MRV)) and paves the way for ETS. However, GHG ETS faces an uphill struggle due to opposition from the Federation of Korean Industries and other business groups, who demand clarification from the government over double regulations, voluntary participation and the responsibilities of departments heading this policy.

In response, the government's revised proposal raised the free allowance ratio and postponed the start date to 1 January 2015. In April 2011, a second version of the GHG ETS proposal, reflecting the above opinions voiced by industry, was submitted to parliament. It also called for an Allocation Committee to be established to operate GHG ETS, which would operate under the Ministry of Strategy and Finance (MOSF). This committee would be tasked with defining how allowances would be allocated for each field and strategising to maintain market stability. GHG emissions reductions and trading are registered and managed in the GHG Inventory & Research Center (GIR), launched on 15 June 2010. The specific entities to be targeted for ETS will be determined in Korea considering international trends, and one likely option is to target the largest energy consumers or GHG emitters at the top of the TMS list. By 2015, ETS will replace TMS for these entities. Allowances may be fully allocated for free in the primary period and transferable between different implementation periods other than the initial period. Any emissions exceeding the allowances are to subject to a penalty of less than three times the average market price.

4.3 Pilot for GHG ETS in Korea

In 2009, Korea's Ministry of Environment (MOEK) introduced a national pilot GHG ETS programme, which has operated under a three-year plan since 2010 and comprises two tracks – one for companies and large buildings and the other for public institutions. The participating industrial sectors are similar to those in EU-ETS and include metals, minerals, iron and oil refineries. Analyses of reduction potentials, targets setting, monitoring and validation of reductions were conducted by the government under agreements between MOEK and related industries. One local government also signed a GHG-reduction-target MOU with MOEK based on the local situation. The baseline used for the GHG reduction target is the average emissions from 2005–2007 for industry and 2007–2008 for local governments. Emissions are expected to be reduced by 2–5% from the baseline in the pilot period (2010 to 2012). MOEK established online registration systems, GEMS (GHG Emission Management System) for industry and commercial buildings and MEETS (MOE Emission Trading System) for public institutes such as regional and local governments. Economic incentives, such as for recognition of early reduction measures by industry and subsidies for local governments, are offered. A total of 32 business sites, 169 large buildings and 550 public institutes from 15 local governments had registered to join the pilot scheme as of April 2010, resulting in 1,543 trades with a total of 7,655t-CO_2 traded for local governments as the pilot participants. The overall transaction price was about 207 million won (Jeong, 2010).

In May 2011, another GHG ETS pilot was launched by MOKE, designed for industry and power plants. This two-phase project is scheduled to start in the second half of 2011. The first stage covers 172 business sites of 67 large energy-consuming companies, 47 business sites of which have been involved in TMS trials. Energy saving targets will be set at the same levels for those business sites under the TMS. The energy saving target is converted to a GHG reduction target and allowances are allocated to the businesses in the initial period. This pilot will be operated with non-cash transactions using virtual money as the trading tool and there are no penalties. However, high-performing business sites and companies receive incentives, such as government awards.

5. Analyses of GHG ETS progress in the three countries

The importance and advantages of GHG ETS have been recognised and much effort expended and progress made in introducing this cost-effective instrument in the three countries. Japan initiated J-VETS and has developed a trial integrated domestic market. Obvious reductions were observed from the pilot participants. This trial market is small, voluntary, and composed of a number of programmes, and is not targeted at reducing overall emissions. Further, coordinating the existing programmes increases the operational complexity and costs. Nevertheless, the efforts in Japan gave the participants a real taste of ETS in practice and have also helped familiarise the government with the operation and management of this policy. China, on the other hand, has been largely involved in the international carbon market through the project-based CDM. Many exchange institutes have been established at the local level due to the high expectations of the huge potential the carbon market has for China. These institutes have explored some voluntary GHG trading, which has prompted the government to develop rules for the trading of VERs. The Republic of Korea has been active in the phase-in of GHG ETS, and its government launched a voluntary GHG reduction programme a few years ago and recently started pilot projects to test the GHG ETS bill.

As regards domestic GHG ETS in Japan, some intermediate propositions have been considered, and in Korea, mandatory ETS has been approved, based on business sentiment, thus similarities exist in the opinions of the two countries – both support the targeting of energy-related CO_2 emissions of large emitters. The next topic on the agenda is to decide on a specific method for GHG allowance allocation. Determining the base-year emissions requires consideration of historical emissions, the potential for introduction of technology and the potential for actual reductions of the concerned entities. Nearly all the allowances would be allocated for free initially, and banking and borrowing of allowances would be permitted. Based on the lessons learnt from EU-ETS, offering concessions and being flexible in the allowance allocation may help avoid resistance from the industries concerned but should not be practiced in excess as this would reduce the policy efficacy (Hepburn, 2007).

In practice, Japan's GHG ETS proposal has been blocked by the cabinet, the reason for which is serious concern over negative impacts of this policy. The cabinet has thus decided to conduct further deliberations into introduction of this policy after testing various hypotheses, including its impact on industry and employment. Thus, the introduction of GHG ETS has actually been postponed in Japan (Reuters, 2010). Korea's GHG ETS proposal received strong resistance from industry. In view of Korea's strength as an export economy and as a heavy industry chemicals producer, it is feared that GHG ETS would lead to a loss in competitiveness due to increased production costs and product prices. Thus, it has been suggested to provide more free allowances for industries with higher trade dependences and energy intensities (Kim, 2010). The industrial sector has also requested more synchrony between mandatory TMS and GHG ETS to avoid duplicitous regulations. Thus, what the target entities require in order to be able to respond appropriately is unambiguous specifications, provided in the shortest possible timeframe, of an approach that combines free allocation and auctionable allowances. Based on industrial sentiment, therefore, Korea's GHG ETS was postponed until 2015.

According to China, GHG ETS should be developed on the basis of setting emission caps. As China's economic development is still accelerating, both in terms of industrialisation and urbanisation, its GHG emissions will inevitably increase in the long run. However, setting specific ceilings for GHG emissions in the near future would put China in an awkward position, since limiting CO_2 emissions could reduce the labor demand in energy-intensive sectors, which presently possess many out-of-date production lines, leading to a rise in unemployment due to the workforce being displaced by the introduction of more advanced production lines (Cai et al., 2009). A rise in unemployment and related social problems would be unacceptable for local governments. Conversely, without mandatory limits, emitters would have no motivation to buy the credits (Yin and Zhou, 2010). Carbon trading in China is presently conducted on a voluntary basis by a small number of companies based on corporate social responsibility (CSR). Corporate awareness of GHG ETS is very limited in China – less than half of the 125 respondents in our previous survey (93.6% of which are SMEs) knew of the CDM and only 40% had heard of GHG ETS (Liu et al., 2011b). As well as the emitting companies, the opinions of financial organisations and even individuals are necessary in order to set the stage for VER pricing (Huang, 2010). The fact that China's government has decided to carry out a pilot scheme for establishing a domestic GHG market is a positive step forward.

6. Conclusions

This chapter gives an overview of the progress and barriers towards introducing GHG ETS in the three major economies of Northeast Asia. In order to overcome these barriers and ensure policy efficacy, further issues need to be addressed. One of these is the need to comprehend to what extent GHG ETS could contribute to the realisation of a national declared target in the medium term and the answer to this question may in turn convince policymakers to decide on the goals of GHG ETS and estimate the total allowances to be allocated. Since resistance from business groups is identified as the biggest hurdle for GHG ETS in Japan and Korea, the acceptability of individual companies to this policy, particularly those from the sectors that would be most affected, is a research priority. The responses from industry to alternative ETS proposals and corresponding behavioral changes also bear analyses.

One disadvantage of GHG ETS is that designing a new market and infrastructure could involve significant administrative and compliance costs (Pope and Owen, 2009), and little study on this topic exists other than that of Betz (2008), who deals with EU-ETS. Similar estimations would be useful for understanding the real costs surrounding the introduction of ETS in Northeast Asia. Revenue issuance is another essential topic – if the revenue from the auction of allowances could be re-routed into offsetting inefficient taxes or compensating highly impacted sectors and weak communities, the policy would be more easily accepted (Pope and Owen, 2009). The dynamic process of GHG ETS needs to be discussed, as this policy theoretically encourages the adoption of low-carbon technologies. The allowance allocation method may influence the dynamism of this policy in that new entities may require high start-up costs if allowances are grandfathered. Early auctioning of allowances is believed to benefit markets with better risk allocation (Fischer et al., 1998). All these questions need to be examined to support the progress of GHG ETS in this region.

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PART III:

ENERGY SAVING ACTIVITIES OF COMPANIES AND THE DETERMINANT FACTORS

Chapter 4:

A survey study of energy saving activities of companies in Taicang, China*

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Chapter Highlights:

- This chapter summarises a survey analysis of energy saving practices of 125 companies (mostly SMEs) based in Taicang, China.
- The sampled companies exhibit good practices in energy saving via managerial and institutional arrangements, but demonstrate the need for technological solutions.
- Econometric regressions confirmed the pressure from competitors and internal capacities as factors significantly determining energy saving practices within companies.
- The government and industrial associations of China need to be more proactive in enhancing energy saving, particularly for SMEs.

1. Introduction

As the largest GHG emitting country in the world, China's role is critical in combating climate change (SEI, 2009). The climate policy of China was outlined in its National Climate Change Programme of 2007 and Climate Change White Paper of 2008. While China has traditionally avoided targeting CO_2 emissions explicitly, its energy and forestry policies have provided a basis for the National Climate Change Programme. The central government set up two ambitious energy policy goals in 2006; one was to reduce national energy intensity by 20% by the end of 2010 from 2005 levels and the other to was to increase the share of renewable energy in the total energy mix to 15% by 2020 (Seligsohn et al., 2009). China further pledged in November 2009 to slash its CO_2 emissions per unit of GDP (Gross Domestic Product) by 40–45% by 2020 compared to 2005 levels, which was a voluntary action to tackle climate change problems based on domestic conditions (China Daily, 2009). China's climate policies are diverse and highly focused on improving industrial energy efficiency. For example, the 11th Five-Year Plan (FYP, 2006–2010) calls for the closure of small, inefficient and outdated

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* The main content of this chapter was published as: Liu, X.B., Niu, D.J., Bao, C.K., Suk, S.H., Shishime, T., 2012. A survey study of energy saving activities of industrial companies in Taicang, China. *Journal of Cleaner Production* 26(2012): 79-89.

production capacities in energy-intensive sectors (Zhou et al., 2010) and the Top 1,000 Energy-Consuming Enterprises Programme was a key effort to improve industrial energy efficiency. Initiated in 2006, this programme imposed a large portion of national 20% reduction target of energy intensity by directly targeting nearly 1,000 of the largest state-owned enterprises – mainly heavy industries (Price et al., 2008). Providing financial incentives such as subsidies and rewards is frequently practiced to encourage industrial energy saving at national and local levels.

There is a huge potential for energy saving in China's industries, especially those in energy-intensive sectors (Hasanbeigi et al., 2010; Li et al., 2010). Nevertheless, studies have mainly been devoted to identifying the determinants and effective policies for energy saving in small and medium-sized enterprises (SMEs) (Thollander et al., 2007). With the aim of closing this research gap, therefore, this chapter identifies the major factors determining a company's energy saving efforts and provides an empirical study in China. Taicang city of Jiangsu Province, based in the Yangtze River Delta, was selected as the survey area because of its more mature economy compared with other regions. This chapter comprises two topics: a) the current status of energy saving activities (ESAs) of the companies in the study area, and b) determinant factors, external and internal, predicting the level of a company's involvement in ESAs.

2. Literature review

The drivers and barriers of industrial energy efficiency have been surveyed in developed countries since the late 1980s. Initially, researchers focused on the reasons behind the failure to apply the best available technologies and practices (e.g., De Canio, 1993; Weber, 1997). Evaluation of the identified barriers has extended from energy-intensive sectors, such as iron & steel, to other manufacturing industries (e.g., Rohdin et al., 2007; Zhang and Wang, 2008). Broader analyses covered the policy proposals enhancing industrial energy efficiency (e.g., Sardianou, 2008; Schleich, 2009). Industrial energy programmes such as energy audits and long-term agreements (LTAs) are common means for promoting energy efficiency in industry (Thollander and Dotzauer, 2010). As an example, Rietbergen et al. (2002) concluded that anywhere between a quarter and a half of the energy savings realised by Dutch manufacturing firms can be attributed to LTAs. De Groot et al. (2001) analysed the determinants of energy saving of Dutch firms by an empirical study using a data set of 135 samples and concluded that cost-saving potential is the key driver behind investment decisions for energy saving. More attractive opportunities and concern over price drops of new technologies are impediments to investing in energy saving. Based upon the results of a telephone survey covering 304 Danish industrial firms, Christoffersen et al. (2006) confirmed low levels of energy management practices of these companies and concluded that electricity utilities emerge as the main source of inspiration for energy management. A questionnaire survey of the Swedish foundry industry confirmed that limited access to capital is the largest barrier to energy efficiency and that barriers within private foundries are more related to informational problems. The key driver, however, was found to be the long term energy strategies of the companies (Rohdin et al., 2007). Social mechanisms comprising regional or local learning networks of companies are used to motivate improvements in energy efficiency in Switzerland and Germany. Substantial progress has been made in implementing organisational measures and investments in energy efficiency in the participating companies (Jochem and Gruber, 2007). Cagno and Trianni (2010) surveyed 104 SMEs in northern Italy and identified access to capital and the lack of information on energy efficiency solutions as the most relevant barriers. Prindle (2010) distributed a questionnaire survey to nearly 100 U.S. companies and found their energy efficiency strategies to be driven by a commitment to reduce CO_2 emissions and the desire to reduce operating costs. Common barriers for the U.S. companies include a lack of funding, a lack of personnel with appropriate skills and insufficient technical information. The ‘split incentives’ of different departments of a company may represent an ongoing impediment to improvements in energy efficiency (Prindle, 2010) and the lack of energy cost allocation by means of sub-metering probably exacerbates this problem (Thollander and Ottosson, 2010). As a representative study in developing countries, Herrero Sola and Xavier (2007) verified the correlation between organisational factors and the energy losses in companies from 10 industrial sectors in Brazil and found that the determinants are linked to the level of employee education and the company’s strategic vision or mission. The lack of access to appropriate financing mechanisms is one of the key barriers preventing realisation of the tremendous potential to increase energy efficiency in developing countries (Painuly et al., 2003). Energy service companies (ESCOs), as a market oriented mechanism, have experienced success in the U.S., Canada and the Republic of Korea. Based on Korea’s experience, therefore, financial and institutional barriers need to be lifted in order to promote energy efficiency investment and ESCO business (Lee, et al., 2003).

Employing a set of panel data from approximately 2,500 of China’s most energy-intensive large and medium-sized companies during 1997–1999, Fisher-Vanden et al. (2004) identified the rising relative price of energy as a principal driver causing lowered energy intensity. Andrews-Speed (2009) examined the context of nearly 30 years of measures to enhance energy efficiency in China and addressed a number of constraints, including the reluctance to use economic and financial instruments, dependency of energy policy on industrial and social policies, and shortage of necessary skills. Hasanbeigi et al. (2010) surveyed 16 cement plants in China and conducted a benchmarking analysis and found that an average primary energy saving of 12% is feasible if the cement plants operated at domestic best-practice levels, rising to 23% if operated at international best-practice levels. Li et al. (2010) conducted a case study of glass works in China and found that energy auditing largely contributed to the reduction of comprehensive energy intensity of a company. CDP (2010) interviewed 11 large companies in

China to identify the drivers behind investments in energy efficiency and found that a company's internal policy is an important driver for such investment.

Even with the relatively broad scope of literature reviewed above, however, current research tends to focus on barriers hindering improvements in industrial energy efficiency; no comprehensive research into the various issues explaining a company's energy saving efforts, particularly for developing countries like China, has been conducted. An integrative approach embracing more factors thus needs to be tested. As a form of proactive environmental management of companies, the actual concept of energy saving is new for many Chinese SMEs, which is where this study may help, by qualitatively measuring the level of ESAs of companies and clarifying the background reasons therefor.

3. Analytical framework of this study

The analytical framework of this study is depicted in fig. 4.1, and is a modification of an earlier study analysing the driving mechanisms of proactive corporate environmental management in China (Liu et al., 2010).

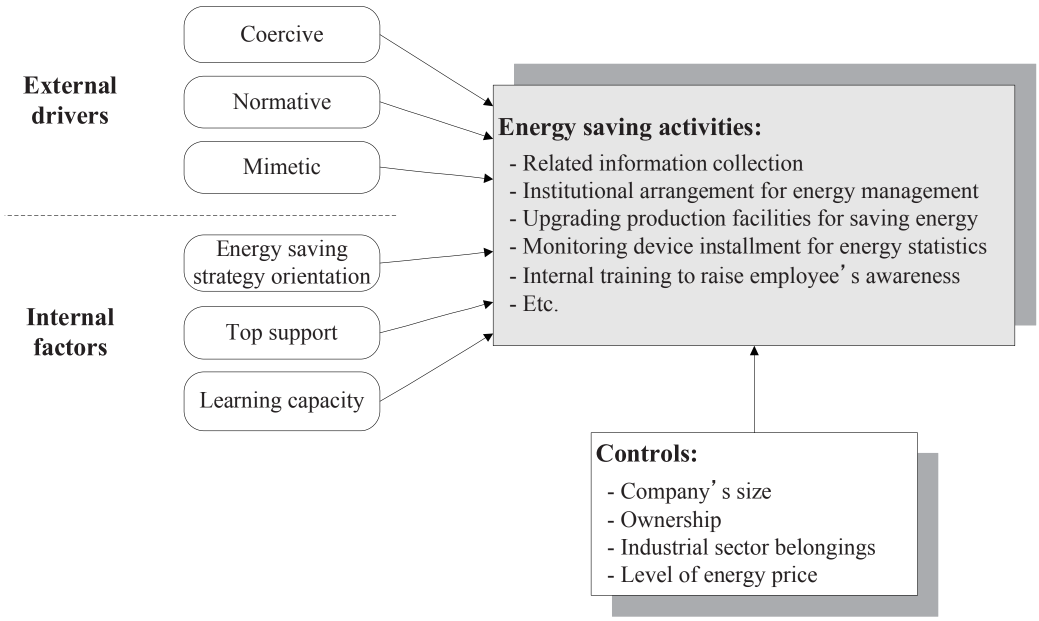

Figure 4.1 Overall analytical framework of this study

This model admits the importance of externally coercive, normative and mimetic pressures, as acknowledged by institutional sociology (DiMaggio and Powell, 1983). Gunningham et al. (2003) argued that institutional theory neglects certain fundamental issues explaining various business behaviors, such as why companies subject to the same level of external pressures perform differently – companies may practice heterogeneous behaviors due to their individual interpretation of the objective external pressures. Our model therefore adds three internal factors, a company's energy saving strategy orientation, top support and learning capacity, to jointly explain a company's ESAs.

External drivers:

We focus on the subset of institutional actors identified by Hoffman (2001), which are most likely to influence a company's ESAs, including coercive pressure from organisations with mandatory power, normative pressure from industrial associations, and mimetic pressure from business competitors. The obvious actors influencing a company's ESAs are related government agencies at different levels. These agencies are authorised to promulgate and enforce regulations related to industrial energy efficiency, and therefore hold coercive power over the related companies. Governments may also enhance company energy saving by announcing mandatory energy efficiency standards in advance, as may coercive pressure from abroad. In this study, the strength of governmental requirements on energy saving and the level of product exports are defined as domestic and international coercive drivers, respectively. Normative pressure originates from norms prepared by institutions such as industrial associations, and behaviors resulting from complying with these norms may help validate a company's mission (Palmer et al., 1993). Although industrial associations are weak in China, their influence on a company's ESAs in the same sector requires analysis and this normative pressure is represented by the 'influence degree of related industrial associations' in our analysis. Furthermore, companies may facilitate mimetic isomorphism (the tendency of one organisation to imitate another organisation's structure based on a belief that the latter's is beneficial). In other words, in order to maintain competitiveness, companies are likely to mimic the practices of leading companies and major business competitors in the same sector. The overall level of energy management of the sector is used to indicate the mimetic pressure felt by the companies.

Internal factors:

A company's orientation of energy strategy, support of top managers and learning capacity are added as internal factors explaining a company's choices of optional energy saving practices. A company's awareness of issues related to internal energy use and willingness to improve energy efficiency are defined as proxies of the company's orientation in terms of energy saving strategy. Since almost all the companies in the survey area are SMEs, the operations of the companies are mainly decided by upper management, thus support from upper management is crucial in environmental initiatives involving high managerial commitments (Ramus and Steger, 2000). 'Top manager' support is thus selected as another internal factor influencing a company's ESAs. In addition, improving a company's energy efficiency is dynamic and closely related to the skills and knowledge of its employees (Hart, 1995), thus a company's learning capacity may represent its ability to practice ESAs. Such skills and abilities of the workforces can be enhanced by further education and job training, thus the education level of employees and the frequency of in-house training on energy saving are adopted as proxies for learning capacity in this analysis.

Controls:

The larger the company, the more likely it is to be supervised by environmental agencies (Hettige et al., 1996). This is so in China, where the policies related to industrial energy efficiency continue to focus on the energy-intensive sectors (Price et al., 2008), as such sectors are highly sensitive to energy prices due to their high rates of energy usage. They also have more experience with energy efficiency programmes (Prindle, 2010), as seen in China's chemical industry, which leads the nation's energy saving efforts and assists in reducing CO_2 emissions in other fields (Jia, 2010). Aiming to analyse the differences in ESAs of the companies with various characteristics, the company's size, ownership, sector belongings and pressure of energy price are selected as control variables in this study.

4. Survey area: Taicang city

A questionnaire survey was conducted in Taicang city of Jiangsu province, located as shown in fig. 4.2.

This city is based on the south bank of the Yangtze River estuary and covers a total land area of 822.9 km^2 and total water area of 285.9 km^2, including 173.9 km^2 of water comprising the Yangtze River. There are seven townships, 100 villages and 3,457 village groups in Taicang and in 2007 the city had a residential population of 813,700, with a registered population of 461,400, the agricultural and non-agricultural populations of which were 261,300 and 200,100 (TSB, 2008).

In 2007, Taicang achieved a total GDP of 44.027 billion Yuan, an increase of about 18.5% over the previous year. The per capita GDP was 70,590 Yuan (about 9,300 USD; 1USD = 7.60 Yuan in 2007, estimated by residential population), around 3.7 times the national average of 18,934 Yuan (NBSC, 2008). The proportional makeup of the three sectors (agriculture, industry and services) in the city's economy was 3.8 / 60.3 / 35.9 (all figures are %) in 2007 (TSB, 2008), whereas that for the whole of China was 11.3 / 48.6 / 4.1 (%) in the same year (NBSC, 2008). As of 2009, Taicang – a city typical of those on China's relatively prosperous eastern seaboard – was at an 'intermediate stage' of industrialisation. The number and scale of industrial companies have increased continuously in the city; in 2008 there were a total of 8,939 industrial companies, nearly all of which are classified as SMEs (according to National Bureau of Statistics of China (NBSC)). Specifically, 90.1% of the companies were small, 8.4% were medium-sized and 0.6% were large. By sector, 25% were chemical manufacturers and 10.06% were dyeing and textiles in terms of numbers. Machinery was another representative sector, with a number share of 5.47%. By ownership, of the total 1,100 companies, 52% were domestically private; foreign-funded companies, including fully foreign-funded and joint-ventures, shared 43.9%.

Figure 4.2 Geographical location of Taicang city

5. Methodology

5.1 Outline of the questionnaire survey and samples

Data for this study was collected by a questionnaire survey in Taicang from July to September 2010. Based on preliminary research covering the study area, a questionnaire was designed with the principal objectives of measuring a company's ESAs and analysing the classified determinants. The questionnaire format mainly consists of three components: background information of the company including the size, ownership and sector belongings; adoption of various ESAs, such as whether the company invested in new production facilities or equipment for energy saving; and, the degrees of external pressures and internal factors of the company, as identified in the analytical framework.

The survey targeted the company's environmental and energy managers and was carried out in three steps over a period of about three months. Local government officials were interviewed at the outset to obtain a clear picture of progress in policy related to industrial energy saving in effect in the city, then a tentative questionnaire format was sent to 24 companies to test the feasibility of the question-answer format. The final questionnaire was then posted to all the companies on a name list provided by the city's environmental protection bureau. A total of 141 responded, of which 125 were confirmed to be valid. The distribution of usable samples by sector is summarised in table 4.1.

Table 4.1 Distribution of valid respondents by industrial sector

Sector	Number of respondents	Percentage
Production and supply of electricity & heat	2	1.6
Electronics	3	2.4
Pharmaceutical industry	2	1.6
Chemical fiber	1	0.8
Machinery manufacturing	19	15.2
Textile and dyeing	33	26.4
Chemicals	51	40.8
Paper making	2	1.6
Food processing	1	0.8
Other	11	8.8
Total	125	100.0

The samples from the sectors of chemicals, textile and dyeing, and machinery manufacturing account for more than 80% of the total, which are representative industries of the city.

5.2 Econometric approach

5.2.1 Identification of econometric model

A company's level of ESAs is hypothesised to be jointly determined by the external drivers and internal factors. The coercive, normative, and mimetic pressures may be indicated by vectors ***C***, ***N*** and ***M***, respectively. In a similar way, a company's energy saving strategy orientation is represented by a vector ***E***, top management support is abbreviated as ***T***, and its learning capacity is represented by a vector ***L***. A company's characteristics, such as size, ownership, sector belongings and the degree of energy price pressure, are indicated by a vector ***Ch***. A company's overall level of ESAs (*TESA*) can be presented in a reduced-form as Eq. (1).

$$TESA = f(C, N, M, E, T, L, Ch) \qquad (1)$$

5.2.2 Valuation of the variables

5.2.2.1 Dependent variable

The *TESA* is the dependent variable in this analysis. The scope of a company's energy saving efforts may be represented by a series of energy saving goals, management procedures and practical activities. As it is difficult to measure a company's energy saving practice level, since it does not necessarily equal the sum of energy saving plans and practices, the most practical approach is to list a series of ESAs that reflect a company's engagement in energy saving. The number of practiced ESAs is therefore used as a proxy for a company's *TESA*. Table 4.2 lists 15 representative ESAs for Chinese companies in the current phase. The corresponding descriptions are used in the questionnaire and the companies were requested to verify whether they had adopted these activities or not in our survey.

Table 4.2 Description of energy saving activities and valuation

Item	Description	Valuation	
		0	1
ESA1	Collect information on energy saving and carbon mitigation policies		
ESA2	Establish internal energy management institution with full-time energy management staffs		
ESA3	Establish internal management regulations on energy saving and carbon mitigation		
ESA4	Conduct energy auditing for understanding internal energy use situation and to identify energy-saving potentials		
ESA5	Adjust the structure of energy consumption by using cleaner energy		
ESA6	Considering to invest in upgrading the production facilities for energy-saving		
ESA7	Have invested in new production facilities to reduce energy use and carbon emissions		
ESA8	Strengthen daily maintenance of production equipment to reduce energy use		
ESA9	Install monitoring devices for major energy-consuming equipment for accurate statistics on internal energy use		
ESA10	Promote eco-design and develop energy efficient products		
ESA11	Optimise the transportation of raw materials and products to reduce energy use of logistics		
ESA12	Arrange internal training of employees to raise their energy-saving awareness		
ESA13	Organise the employees to practice daily energy-saving activities in offices (such as lighting, air-conditioner, etc.)		
ESA14	Participate in energy-saving training and pilot projects arranged by national or local governments		
ESA15	Apply for energy-saving subsidies at national or local level		

Since the relative importance of each activity for a company is difficult to quantify, the 15 activities are assumed to equally contribute to a company's *TESA*. A value of '1' is given to an activity if the company has adopted it and '0' if not. Each ESA therefore obtains a score of '1' or '0' and the sum of the scores of all 15 ESAs is used to represent a company's *TESA*. A higher score means a higher level of energy saving practices.

5.2.2.2 Independent variables

The proxies of independent variables ***C***, ***N***, ***M***, ***E, T*** and ***L*** as determinant factors are listed in panel A of table 4.3, and their descriptions were directly used as the survey items in the questionnaire with a five-level answer format. The companies were requested to choose a value that represented the degree of each factor, with '1' = very low; '2' = relatively low; '3' = moderate; '4' = relatively high; and, '5' = very high. There are two exceptions: one is the export ratio of the product, which used a five-level classification with '5' representing more than half of the products being exported; '4' meaning a 30−50% export ratio; '3' meaning a 20−30% export ratio; '2' being a 10−20% export ratio, and '1' being an export ratio of less than 10%. The other exception is the average education level of employees, with '5' representing more than 40% of employees holding a college and above diploma, '4' being a ratio of 30−40%, '3' being a ratio of 20−30%, ‘2’ meaning a ratio of 10−20%, and ‘1’meaning a ratio of under 10%.

Table 4.3 Description of determinant factors, control variables and valuation

Variable		Description and proxy	Valuation				
			1	2	3	4	5
Panel A: Independent variables							
External pressures	Coercive	Strength of governmental requirements of energy saving (REGULATION)					
		Export rate of the product (EXPORT)					
	Normative	Influence of industrial association on the same sector (ASSOCIATION)					
	Mimetic	Energy management level of competitors (COMPETITOR)					
Internal factors	Strategy orientation	Awareness of internal energy use and problems (AWARENESS)					
		Willingness to improve energy efficiency (WILLINGNESS)					
	Top support	Top manager’s support for energy saving activities (TOPSUPPROT)					
	Learning capacity	Average education level of employees (EDUCATION)					
		Frequency of internal training on energy saving (TRAINING)					
Panel B: Control variables							
Characteristics of the company		Company size (SIZE)					
		Ownership (OWNERSHIP)					
		Industrial sector belongings (SECTOR)					
		Level of current energy price (PRICE)					

5.2.2.3 Control variables

As indicated in panel B of table 4.3, a company’s size, ownership, industrial sector belongings and level of energy price are defined as controls and represented by SIZE, OWNERSHIP, SECTOR and PRICE, respectively. For the valuation, the company’s size is divided into three categories based on number of employees, turnover in 2009 and registered capital scale. The company’s ownership is divided into two types, domestic and foreign-funded. The sector belongings of the companies are categorised into four types: chemicals, textile & dyeing, machinery manufacturing and other. Regarding the variable of PRICE, the companies were requested to give a value to measure the level of current energy price, with ‘1’ = very low; ‘2’ = relatively low; ‘3’ = moderate; ‘4’ = relatively high; and, ‘5’ = very high. The companies with higher energy dependency and those facing higher pressure to reduce energy cost are thus more active in energy saving.

5.2.3 Empirical model for the analysis

The regression capturing the functional relationships between the *TESA* and the classified variables can be constructed and expressed by Eq. (2), where ε represents the error term and β_0 is the constant.

$$
\begin{aligned}
TESA = {} & \beta_0 + \beta_1 REGULATION + \beta_2 EXPORT + \beta_3 ASSOCIATION \\
& + \beta_4 COMPETITOR + \beta_5 AWARENESS + \beta_6 WILLINGNESS \\
& + \beta_7 TOPSUPPORT + \beta_8 EDUCATION + \beta_9 TRAINING + \beta_{10} SIZE \\
& + \beta_{11} OWNERSHIP + \beta_{12} SECTOR + \beta_{13} PRICE + \varepsilon
\end{aligned} \qquad (2)
$$

6. Results and discussions

6.1 Result of company ESAs

Stata10 was used for the statistical analysis and fig. 4.3 provides a summary of ESAs adopted by the surveyed companies. It is encouraging that the sampled companies actively practice the pre-classified ESAs. Except for ESA10 (Promote eco-design and develop energy efficient products) and ESA15 (Apply for energy saving subsidies at national and local levels), all the other 13 ESA items achieved participation ratios of more than 50%. ESA8 (Strengthen daily maintenance of production equipment to reduce energy use) is the most adopted practice, with a ratio of 'YES' answers od 94.4%. The other three ESAs with participation ratios of more than 80% are ESA1 (Collect information of energy saving and carbon mitigation policies), ESA12 (Arrange internal training of employees to raise their energy saving awareness) and ESA13 (Organise the employees to practice daily energy saving activities in office). This result is consistent with intuitive thinking, since the four items of ESAs with higher participation ratios are energy saving practices via institutional and managerial measures. The institutional and managerial ESAs usually involve lower costs compared with the ESAs achieved by technological and engineering methods. The companies show a tendency to adopt relatively simple ESAs at first. Nevertheless, our survey also shows that the respondent companies have good practices in certain technological and engineering ESAs. Examples are ESA7 (Invest in new production facilities to reduce energy use) and ESA9 (Install monitoring devices for major energy-consuming equipment for better statistics of internal energy use), which achieve participation ratios of 68.0% and 53.6%, respectively. Such high ESA performance of the surveyed companies confirms that the national campaign of energy saving and emissions reduction during the 11th FYP period played an active role in enhancing company energy saving efforts.

Fig.4.4 further shows the distribution of a company's TESA. The average TESA is 10.17, indicating a relatively high level of ESAs adopted by the samples. Of the 125 respondents, 10.4% practiced all 15 activities. Companies that have been involved in 6, 8, 9, 10, 12 or 14 items of ESAs account for around 10% of the total samples individually.

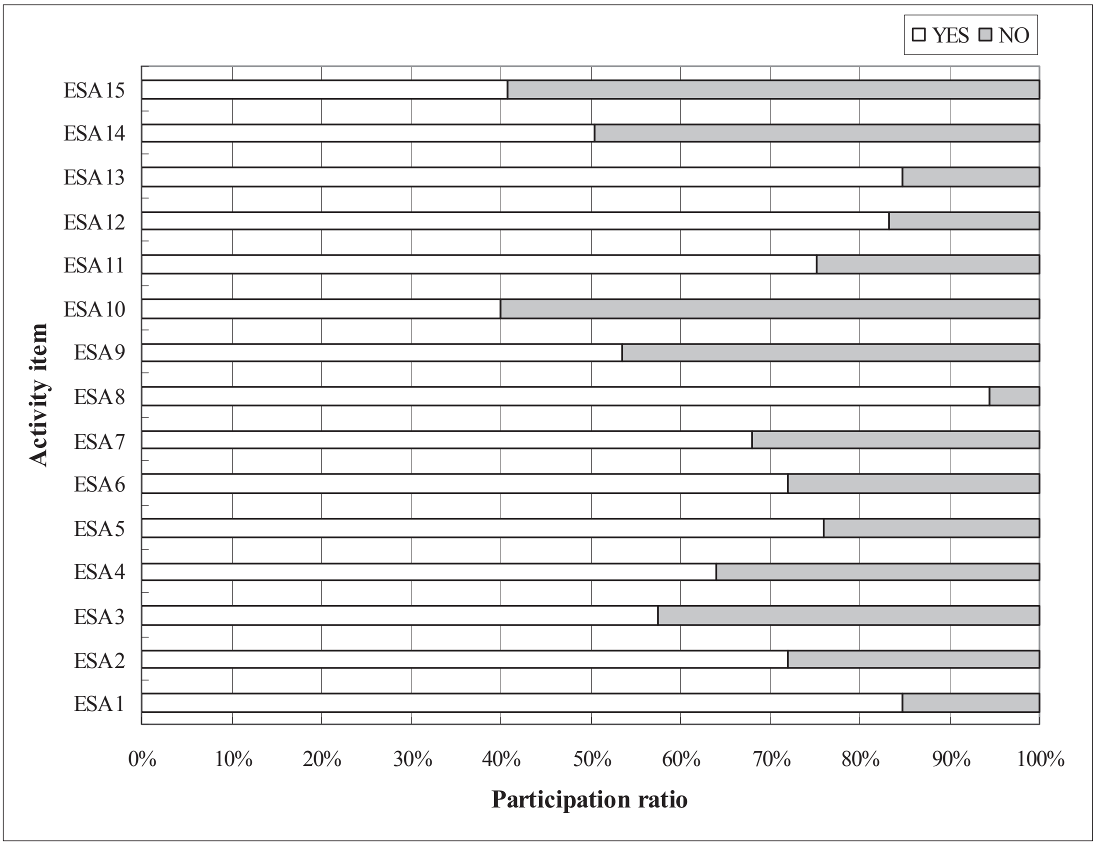

Figure 4.3 Distribution of company energy saving activities (N=125)

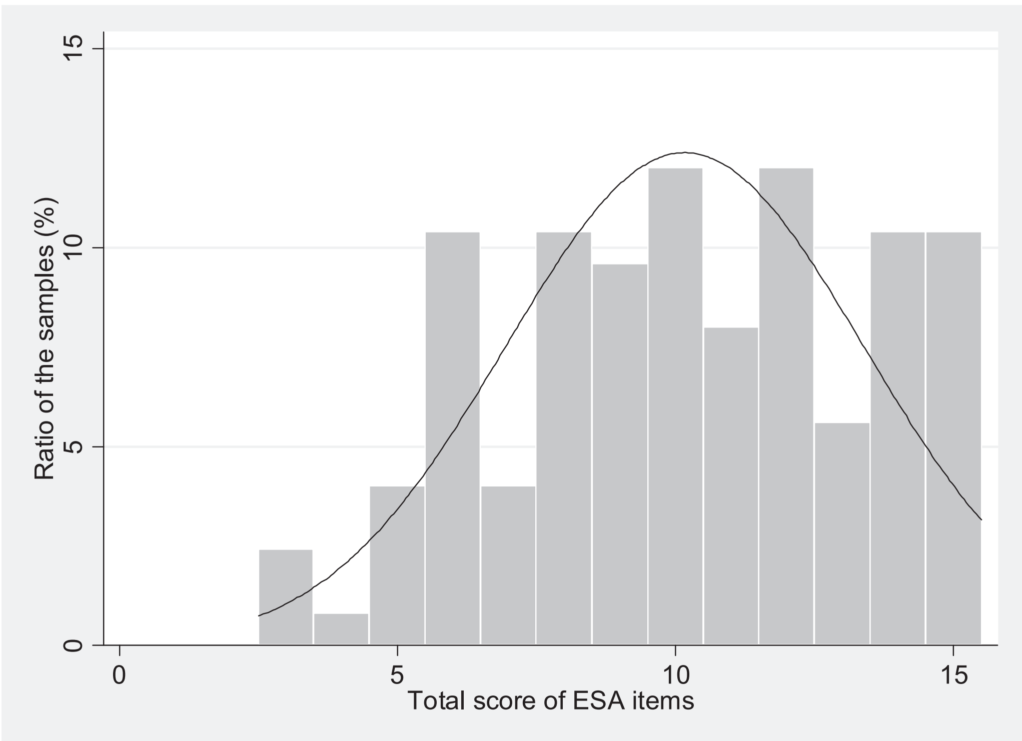

Figure 4.4 Distribution of overall score of energy saving activities (N=125)

6.2 Statistics of the independent and control variables

Table 4.4 summarises the independent and quantitative control variables in Eq. (2).

Table 4.4: Statistical summary of independent variables and quantitative controls

Variable		Obs.	Mean	Std. Dev.	Min.	Max.
Independent	REGULATION	124	3.93	0.68	2	5
	EXPORT	116	2.66	1.68	1	5
	ASSOCIATION	118	3.41	1.15	1	5
	COMPETITOR	121	3.47	0.72	1	5
	AWARENESS	125	3.96	0.73	2	5
	WILLINGNESS	125	4.34	0.69	2	5
	TOPSUPPORT	124	4.28	0.67	3	5
	EDUCATION	124	1.94	1.12	1	5
	TRAINING	123	3.71	0.96	2	5
Control	PRICE	124	3.91	0.58	2	5

It is indicated that most companies have a high awareness of their internal energy use status and problems, with an average score of 3.96 for 'AWARENESS'. The respondents express high willingness of efforts in energy saving, with 'WILLINGNESS' averaged at 4.34. The internal training for energy saving is carried out frequently in the surveyed companies although the average education level of the employees is low. The requirement of energy efficiency improvement from the government is strongly felt by the companies, with the average score of 'REGULATION' being 3.93. This is because energy conservation and pollutant emissions reduction have become critical tasks for environment protection in China, particularly in recent years. Another independent variable having a high score is 'TOPSUPPORT' (averaged at 4.28). The companies felt that the current energy price is relatively high (averaged at 3.91). Nevertheless, the sampled companies evaluate the influence of industrial associations and the overall level of energy management of their business competitors as moderate.

Regarding the control variables indicating a company's characteristics, most of the samples are SMEs as predicted. Large companies, with more than 2,000 employees, an annual turnover of more than 300 million Yuan and a registered capital of over 400 million Yuan, account for 6.4% of the total. Small enterprises, which have less than 300 employees or an annual turnover of below 30 million Yuan or a registered capital of less than 40 million Yuan, share 68% of the total; the remaining 25.6% are medium-sized. By ownership, most samples (70.4%) are domestic companies and the remaining 29.6% are foreign-funded, including fully foreign-funded and joint-ventures. The ratios of respondents from chemical, textile & dyeing, machinery processing sectors and other are 40.8%, 26.4%, 15.2% and 17.6%, respectively.

6.3 Correlation matrix and bi-variable results

Pair-wise correlation was calculated to explore the relationships between *TESA*, the independent and quantitative control variables, the results of which are listed in table 4.5.

Table 4.5 Correlation coefficients of the quantitative variables

	TESA	REG.	EXP.	ASS.	COM.	AWA.	WIL.	TOP.	EDU.	TRA.	PRI.
TESA	1										
REGULATION	0.102	1									
EXPORT	0.029	-0.028	1								
ASSOCIATION	0.229[b]	-0.02	0.117	1							
COMPETITOR	0.204[b]	0.234[a]	0.115	0.125	1						
AWARENESS	0.122	0.010	0.201[b]	0.133	0.254[a]	1					
WILLINGNESS	0.244[a]	0.212[b]	0.070	0.025	0.347[a]	0.541[a]	1				
TOPSUPPORT	0.331[a]	0.387[a]	0.118	0.134	0.344[a]	0.353[a]	0.545[a]	1			
EDUCATION	0.238[a]	-0.061	-0.019	0.125	-0.090	-0.003	-0.067	-0.012	1		
TRAINING	0.457[a]	0.201[b]	-0.169	0.217[b]	0.023	0.205[b]	0.335[a]	0.444[a]	0.205[b]	1	
PRICE	0.055	0.456[a]	-0.063	-0.060	0.043	0.048	0.178[b]	0.168	-0.085	-0.008	1

[a] Significant at 1% level; [b] Significant at 5% level

Unacceptable levels of multi-collinearity do not exist in the above variables, as the highest is 0.545 for 'WILLINGNESS' (Willingness to improve energy efficiency) and 'TOPSUPPORT' (Top manager's support to energy saving activities). Harmful levels of multi-collinearity are expected not to occur until correlation coefficients reach ±0.8 or ±0.9 (Farrar and Glauber, 1967). From the above 'TRAINING' (Frequency of internal training on energy saving) is significantly positively associated with TESA at $P<0.01$. The other three variables showing positive correlations with *TESA* significant at $P<0.01$ are 'TOPSUPPORT', 'WILLINGNESS' and 'EDUCATION' (Average education level of employees).

6.4 Factor analysis of ESA items

An exploratory factor analysis was conducted on the 15 ESA items to check for different dimensions to these activities. The Kaiser-Meyer-Olkin (KMO) test was also carried out to assess the appropriateness of the analysis and the rotated component matrix of the factor analysis and KMO values are listed in table 4.6. All the KMO values are greater than 0.5, indicating a satisfactory factor analysis to proceed. Four principal component factors are extracted, the first of which accounts for 24.6% of the variance in total and the other three accounting for about 10% individually. Together, the four factors account for 53.9% of variability of the 15 items of ESAs. ESA1, ESA2, ESA3, ESA4, ESA7, ESA9, ESA10, ESA12, ESA14 and ESA15 are highly associated with factor 1; ESA5, ESA8 and ESA11 are highly associated with factor 2; ESA13 and ESA6 are related to factor 3 and 4, respectively.

Table 4.6 Rotated component matrix of factor analysis and KMO test values of ESA items

ESA items	Component				KMO value
	1	2	3	4	
ESA1	0.458	-0.111	0.394	-0.171	0.698
ESA2	0.469	0.054	-0.488	-0.298	0.684
ESA3	0.582	-0.335	-0.140	0.221	0.721
ESA4	0.562	-0.027	0.051	-0.407	0.727
ESA5	0.290	0.417	-0.562	0.201	0.569
ESA6	0.280	0.128	-0.261	0.618	0.593
ESA7	0.649	0.232	-0.060	-0.142	0.820
ESA8	0.275	0.642	0.054	0.284	0.616
ESA9	0.598	-0.384	0.110	0.037	0.769
ESA10	0.542	-0.306	0.130	0.470	0.788
ESA11	0.373	0.530	0.286	-0.009	0.659
ESA12	0.593	0.317	0.029	-0.302	0.738
ESA13	0.271	0.376	0.608	0.153	0.659
ESA14	0.637	-0.137	-0.234	-0.217	0.812
ESA15	0.568	-0.445	0.152	0.182	0.779

Based on the factor analysis, four sets of constructs of ESAs may be defined: ESA5, ESA8 and ESA11, associated with factor 2, are ESAs via managerial measures; ESA items highly associated with factor 1 are the energy saving efforts via institutional arrangements and technological upgrades. ESA13 is practiced by changing employee work habits and daily lifestyle. ESA6 is an item specifically measuring a company's intention to invest in new technology and facilities for energy saving. We thus classified these ESAs into four categories, as defined in table 4.7. Besides the overall ESA level, the variables, representing the involvement level of the sub-categories of ESA items, are also used as dependent variables for multivariate regressions to reveal any relationships with the predictive factors.

Table 4.7 Definition and valuation of the sub-category of ESA items

Variable abbreviation	Description of the sub-category	Valuation
$ESA_{I\&T}$	Practice level of institutional and technological ESA	Sum of the scores of ESA1, ESA2, ESA3, ESA4, ESA7, ESA9, ESA10, ESA12, ESA14 and ESA15
ESA_{M}	Practice level of managerial ESA	Sum of the scores of ESA5, ESA8 and ESA11
ESA_{H}	Practice level of habitual ESA	Score of ESA13
ESA_{IN}	Company's intention to invest in new facility for energy saving	Score of ESA6

6.5 Multivariate analysis with TESA as dependent variable

As the dependent variable is an ordinal measurement, an ordered logistic regression was performed and the results are listed in table 4.8. Result robustness was tested by repeating the regression with certain variables omitted, using three models. Model 1 is the case of excluding all the control variables, Model 2 adds the quantitative control variable of companies, 'PRICE' and Model 3 includes all the variables discussed earlier. There are no obvious differences between the three regression results. The number of total observations of econometric analysis is 105 due to missing data of some respondents.

Table 4.8 Ordered logistic regression result with TESA as the dependent variable (N=105)

Variable	Model 1		Model 2		Model 3	
	Coef.	P	Coef.	P	Coef.	P
REGULATION	0.162 (0.292)	0.578	-0.050 (0.317)	0.875	-0.292 (0.331)	0.378
EXPORT	-0.016 (0.113)	0.890	0.011 (0.115)	0.920	-0.040 (0.123)	0.743
ASSOCIATION	0.248 (0.156)	0.113	0.240 (0.155)	0.120	0.167 (0.171)	0.331
COMPETITOR	0.558 (0.267)	0.037	0.592 (0.266)	0.026	0.750 (0.280)	0.007
AWARENESS	-0.452 (0.278)	0.105	-0.473 (0.275)	0.086	-0.411 (0.287)	0.152
WILLINGNESS	0.427 (0.325)	0.189	0.325 (0.336)	0.333	0.118 (0.374)	0.752
TOPSUPPORT	0.573 (0.350)	0.101	0.576 (0.353)	0.102	0.706 (0.374)	0.059
EDUCATION	0.314 (0.172)	0.069	0.306 (0.173)	0.076	0.243 (0.197)	0.219
TRAINING	0.731 (0.232)	0.002	0.830 (0.240)	0.001	0.904 (0.247)	0.000
PRICE			0.544 (0.347)	0.117	0.772 (0.373)	0.039
SIZE-1					-0.856 (0.764)	0.263
SIZE-2					-0.090 (0.753)	0.905
OWNERSHIP-1					-0.283 (0.441)	0.522
SECTOR-1					0.455 (0.525)	0.385
SECTOR-2					0.501 (0.623)	0.421
SECTOR-4					-0.589 (0.636)	0.354
LR chi	44.97^{***}		47.44^{***}		55.48^{***}	
Pseudo R^2	0.089		0.094		0.109	

Note: Data in parentheses is standard error; *** Significant at 1% level

The results in table 4.8 show that there is no significant relationship between *TESA* and the coercive pressures, including 'REGULATION' (The pressure of governmental requirements of energy saving) and 'EXPORT' (The level of product export). This is probably because almost all the target companies of our survey are SMEs using lower amounts of energy. The existing governmental requirements on industrial energy efficiency still do not regulate SMEs in China. There are only two companies in Taicang once listed as key energy-consuming companies by the provincial government and they were required to take various energy saving efforts in a mandatory manner. Meanwhile, the survey did not distinguish the export destinations and the type of exports for which a company's energy efficiency could be used as a screening device for exports. 'ASSOCIATION' (Influence of industrial association of the same sector), as a normative pressure, has no significant influence on *TESA*. As explained earlier, the industrial associations are weak in present-day China and their overall role in providing assistance to the companies in relation to ESA practices is limited. From time to time the associations issue lists of energy efficient technologies for use as reference material and arrange workshops and training courses targeting key energy-consuming companies within their sectors (CDPA, 2010). However, their role of acting as a bridge between government and industry as the sector representative is likely to intensify in the near future. As an example in the field of energy saving, they could help to establish a decomposed index of energy saving by industry sector (NDRC, 2010). Nevertheless, mimetic pressure significantly affects *TESA*, a finding that indicates companies are sensitive to the energy management performance of their business competitors, as one company would be at a comparative disadvantage if its performance was below that of its competitors.

Regarding the internal factors, 'TRAINING' shows significant and positive effects on *TESA*, which confirms that internal training of employees greatly enhances a company's ability to practice ESAs. The company's energy saving orientation (both 'WILLINGNESS' and 'AWARENESS') and 'EDUCATION' do not have significant effects on *TESA* in our analysis. The statistics of variables confirmed that the companies in this survey are clearly aware of their internal energy use status and strong willingness for improved energy efficiency; however, good intentions do not necessary lead to actual energy saving practices due to the presence of various barriers (McKane et al., 2007). Zografakis et al. (2008) confirmed that education can transform human behavior towards more rational use of energy and increase energy literacy. In this survey, the average educational level of a company's employees is not significant probably because energy saving skill is mainly improved by internal training in the current phase. The latest version of China's 'Energy Conservation Law', enacted 1 April 2008, addresses the importance of education and requires the incorporation of energy saving knowledge into the national education system. Until the effects of this are realised, however, the government intends to run training courses for companies to improve their energy saving capacity. 'TOPSUPPORT' shows a slightly positive effect on *TESA*, which confirms the need of support from top managers in the company's energy saving practices. In summary, the internal factors are present and significantly determine a company's ESAs.

As indicated in table 4.8, 'PRICE' is significantly positively related to *TESA*, a result consistent with that of Fisher-Vanden et al. (2004) and Prindle (2010), documenting the rising energy price and energy cost reduction as principal drivers for improving energy efficiency of companies. However, none of the other control variables are significantly associated with *TESA*, a result that differs markedly with other literature that states company size influences the environmental management of companies (e.g., Zhang, et al., 2008). This may be attributed to differences in definition of the dependent variable in this study. Our survey focuses on the ESAs which may be viewed as proactive environmental management efforts of basic forms of compliance in current China, and further, this survey only targeted companies in a small area. The respondents have similar characteristics as represented by the control variables.

6.6 Multivariate analysis with the sub-category of ESAs as dependent variable

Four sets of ESA items are constructed and defined as $ESA_{I\&T}$, ESA_{M}, ESA_{H} and ESA_{IN}. The regressions were repeated by replacing the *TESA* in Eq. (2) with the score of each sub-category of ESA items as the dependent variable. The results for ESA_{H} and ESA_{IN} are not listed here since no significant relationships with the identified factors were found. The results of $ESA_{I\&T}$ and ESA_{M} are listed in tables 4.9 and 4.10, individually.

Table 4.9 Ordered logistic regression result with $ESA_{I\&T}$ as the dependent variable (N=105)

Variable	Model 1		Model 2		Model 3	
	Coef.	P	Coef.	P	Coef.	P
REGULATION	0.212 (0.290)	0.465	-0.007 (0.311)	0.980	-0.268 (0.331)	0.419
EXPORT	0.020 (0.114)	0.861	0.048 (0.115)	0.676	0.015 (0.124)	0.906
ASSOCIATION	0.436 (0.162)	0.007	0.426 (0.160)	0.008	0.427 (0.175)	0.014
COMPETITOR	0.240 (0.268)	0.370	0.260 (0.265)	0.326	0.396 (0.274)	0.149
AWARENESS	-0.392 (0.280)	0.162	-0.398 (0.276)	0.149	-0.331 (0.291)	0.256
WILLINGNESS	0.365 (0.330)	0.269	0.246 (0.344)	0.475	0.045 (0.378)	0.905
TOPSUPPORT	0.588 (0.360)	0.102	0.593 (0.365)	0.104	0.762 (0.380)	0.045
EDUCATION	0.429 (0.176)	0.014	0.429 (0.174)	0.014	0.319 (0.196)	0.100
TRAINING	0.694 (0.235)	0.003	0.801 (0.244)	0.001	0.877 (0.252)	0.000
PRICE			0.595 (0.356)	0.095	0.771 (0.366)	0.035
SIZE-1					-1.181 (0.823)	0.151
SIZE-2					-0.328 (0.798)	0.681
OWNERSHIP-1					-0.680 (0.449)	0.130
SECTOR-1					0.560 (0.531)	0.291
SECTOR-2					0.707 (0.631)	0.263
SECTOR-4					-0.342 (0.638)	0.592
LR chi	48.09^{***}		50.87^{***}		61.14^{***}	
Pseudo R^2	0.102		0.108		0.130	

Note: Data in parenthesis is standard error; *** Significant at 1% level

As with the result of *TESA*, coercive pressures, both ‘REGULATION’ and ‘EXPORT’, have no significant relationships with $ESA_{I\&T}$ and ESA_{M}. The relationships of $ESA_{I\&T}$ and ESA_{M} with the other two external factors, ‘ASSOCIATION’ and ‘COMPETITOR’, appear different. ‘ASSOCIATION’ has a significantly positive effect on $ESA_{I\&T}$ with a significance level at 0.05, while ‘COMPETITOR’ has a significantly positive effect on ESA_{M} with a significance level at 0.01. As with Palm and Thollander (2010), the company’s institutional and technological measures for energy saving are greatly influenced by industrial associations. Usually there are divisions or technical committees in charge of environmental and energy saving issues within or operating under the industrial associations in China. In spite of the weak influence of ‘ASSOCIATION’ on the company’s overall ESAs, the efforts of industrial associations in the selection of energy efficient technologies and dissemination of energy saving knowledge are useful for company energy saving by technological measures (e.g., CDPA, 2010), whereas the managerial activities in energy saving are largely determined by the energy performances of business competitors. This implies that such companies learn from their competitors but would like to practice the managerial ESAs in a simpler manner.

In terms of the internal factors, ‘TRAINING’ indicates obviously positive effects on both $ESA_{I\&T}$ and ESA_M, which confirms the importance of internal training of employees regarding the energy saving practices of these two sub-categories. An interesting finding of this analysis is the different roles of ‘TOPSUPPORT’, as it has a positive effect on $ESA_{I\&T}$ with a significance level at 0.1 but has no significant effect on ESA_M. This indicates that the support of a company’s top managers is particularly necessary for $ESA_{I\&T}$, either in requiring the coordination of split incentives of different internal divisions or in relation to the high costs for introducing new facilities and equipment (Prindle, 2010).

Table 4.10 Ordered logistic regression result with ESA_M as the dependent variable (N=105)

Variable	Model 1		Model 2		Model 3	
	Coef.	P	Coef.	P	Coef.	P
REGULATION	-0.200 (0.348)	0.566	-0.269 (0.391)	0.492	-0.205 (0.413)	0.620
EXPORT	0.137 (0.138)	0.322	0.150 (0.143)	0.293	0.122 (0.150)	0.415
ASSOCIATION	-0.215 (0.195)	0.270	-0.219 (0.196)	0.262	-0.293 (0.219)	0.182
COMPETITOR	1.048 (0.366)	0.004	1.056 (0.365)	0.004	1.151 (0.389)	0.003
AWARENESS	-0.351 (0.343)	0.306	-0.367 (0.346)	0.288	-0.433 (0.370)	0.242
WILLINGNESS	0.160 (0.396)	0.687	0.150 (0.399)	0.707	0.175 (0.442)	0.693
TOPSUPPORT	-0.383 (0.423)	0.365	-0.394 (0.424)	0.352	-0.596 (0.476)	0.210
EDUCATION	-0.278 (0.198)	0.161	-0.280 (0.198)	0.158	-0.337 (0.260)	0.194
TRAINING	0.846 (0.288)	0.003	0.867 (0.294)	0.003	0.891 (0.303)	0.003
PRICE			0.164 (0.426)	0.700	0.202 (0.457)	0.659
SIZE-1					-0.206 (1.031)	0.842
SIZE-2					-0.382 (0.993)	0.700
OWNERSHIP-1					0.855 (0.586)	0.144
SECTOR-1					0.129 (0.664)	0.846
SECTOR-2					-0.062 (0.780)	0.937
SECTOR-4					0.525 (0.899)	0.559
LR chi	19.24^{**}		19.39^{**}		22.44	
Pseudo R2	0.096		0.097		0.112	

Note: Data in parentheses is standard error; ** Significant at 5% level

7. Conclusions

This study identifies major determinant factors for the companies to practice ESAs and conducted an empirical analysis in Taicang, China. The defined factors are partly supported by the econometric analysis, which recognised the energy management level of companies in the same sector and frequent internal training on energy saving as significant determinants. The *TESA* does not seem to vary in terms of a company's characteristics, such as organisation size, ownership and sector belongings. The weak role of pressure from the government suggests that Chinese policymakers should gradually extend the regulative requirements of energy saving of large companies, such as energy saving quotas and mandatory energy saving auditing, to SMEs. Providing economic incentives and technical support should be emphasised to enhance company capacity, particularly that of the SMEs, to operate more energy efficiently.

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Chapter 5:

A survey study of energy saving activities of companies in the Republic of Korea*

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Chapter Highlights:

- This chapter outlines an analysis of energy saving activities of Korean companies using the data collected from 66 of the biggest energy consumers.
- The surveyed companies prefer to practice energy saving activities by managerial measures; energy-saving efforts are still not incorporated into their business cycles, i.e., there is no strategic cooperation with business partners.
- Under a context of laggard regulations, company energy saving practices are mainly attributed to internal motivations.
- Providing technical support is useful for enhancing energy saving capacity and is appreciated by the companies. The respondents expect financial support from the government for energy saving investments.

1. Introduction

Growth in the Republic of Korea's economy was fueled by energy (Kim et al., 2011), the use of which sharply increased in the recent past – it is now the world's tenth largest (as of 2005) energy consumer. Its national total CO_2 emissions have also substantially increasing since 1990. The most CO_2 emissions-related industries contribute to around 30% of the gross domestic product (GDP) of Korea. In spite of a temporary lull in CO_2 emissions during 1997/98, the upward trend in emissions is far steeper than that of other OECD countries (OECD, 2008).

The national energy efficiency strategy of Korea is outlined in its 'Energy Use Rationalisation Act', enacted in 1979 soon after the global oil crisis in the late 1970s. To date, four master plans for rational utilisation of energy have been consecutively launched since 1993. Accordingly, a series of policies have been introduced and implemented, including the support of diffusion of energy efficient facilities and equipment, energy audits, voluntary agreements between the government and industry and the ESCO (Energy Service Company) projects. In the 4th master plan for 2008–2012, the Voluntary Agreement (VA) for energy efficiency improvements is emphasised for companies using more than 20,000 toe (tonnes of oil equivalent) of energy per

* The main content of this chapter was published as: Suk, S.H., Liu, X.B., Sudo, K., 2013. A survey study of energy saving activities of industrial companies in the Republic of Korea. Journal of Cleaner Production 41(2013): 301-311.

year. This policy will be gradually expanded to companies with annual energy consumptions of 5,000–20,000 toe. The 'National Energy Plan (2008–2030)', as the country's long-term strategy for energy security, specifies three energy policy goals: to improve the overall energy intensity in units of toe/1,000 USD to 0.185 by 2030 from 0.341 of 2007; to reduce the share of fossil fuels in the total energy mix from 83% to 61%; and, to increase the share of renewable energies up to 11% from 2.4% during the same period.

Korea announced a new national vision of "Low Carbon GreenGrowth" in 2008 and pledged in 2009 to reduce its greenhouse gas (GHG) emissions by 30% based on a business as usual (BAU) scenario by 2020 compared to 2005 levels. The national overall reduction target was split into specific targets of 25 types of businesses in seven sectors: industry, energy conversion, transportation, building, agriculture, waste and other public sectors in July 2011. As a key measure for realising these targets, the Target Management Scheme (TMS) was recently initiated to limit the energy consumptions and GHGs emissions of major entities and business sites of each sector. The targets of TMS include entities emitting above 125,000t-CO_2 or using more than 500TJ of energy annually and business sites with emissions above 25,000t-CO_2 or energy use of 100TJ per year. As of the end of 2011, a total of 471 entities were designated as TMS targets, whose GHGs emissions accounted for 61.3% of the national total of 2007 (620 Million t-CO_2). Their energy consumptions shared 42.4% of the national total of 2008 (10,087 thousand TJ). Of these, 372 entities are from the industrial and power sectors, with GHG emissions and energy consumption accounting for 96.3% and 97% of all the TMS targets, respectively. The number of small and medium-sized enterprises (SMEs) under the TMS is 120, with a share of 32.1% of the entities from industrial and power sectors. The TMS targets from these two sectors will be 560 and the share of SMEs will increase to 40% by 2014 (MKE, 2010). These entities are managed by the monitoring, reporting and verification (MRV) system of the Ministry of Knowledge Economy.

Korea's government has been deliberating on market-based instruments (MBIs) to enhance industrial energy saving and GHG mitigation, particularly the carbon tax and emission trading scheme (ETS). In 2008, the Korea Institute of Public Finance (KIPF) proposed an initial carbon tax with rates of 34−96 KRW/l for fossil fuels (Kim et al., 2008). KIPF further suggested this policy be implemented from 2012 to replace the extant transportation tax ending in 2012 (Kim and Kim, 2010). The most recent GHG ETS proposal, slated to kickoff from 1 January 2015, has been approved by the parliament after incorporating comments from industry. GHG ETS in Korea is designed to cover entities with certain amounts of energy use or GHG emissions but with flexible policy targets to account for global trends. All allowances will be allocated for free in the initial period and emissions exceeding the allowances are subject to a penalty below three times the average market price.

Under such burgeoning policy progress, Korean companies should be more motivated to integrate their energy saving into daily business operations. However, the company's green strategies were found still at an early stage since they were seldom required to do so in the past (Kim, 2009). The gap between the rapid policy progress and the laggard response of industry to energy and climate issues in Korea bears more research (Lee et al., 2010). This study seeks to identify the major factors determining a company's energy saving practices in Korea by a survey mainly targeting SMEs from energy-intensive industries. Two topics are discussed in this chapter: a) the current status of energy saving activities (ESAs) of Korean companies; and, b) the determinant factors predicting the level of a company's involvement in ESAs.

2. Methodology

2.1 Analytical framework of this study

The analytical framework of this study, as depicted in fig. 5.1, is similar to the analysis of energy saving practices of Chinese companies in chapter 4 (Liu et al, 2012). This model admits the importance of externally coercive, normative and mimetic pressures, and adds three internal factors – a company's energy saving strategy orientation, top support and learning capacity – to jointly explain a company's ESAs. Aiming to analyse the differences in ESAs of the companies with various characteristics, the company's size, ownership, sector belongings, involvement status of TMS and level of energy price are selected as control variables in this analysis.

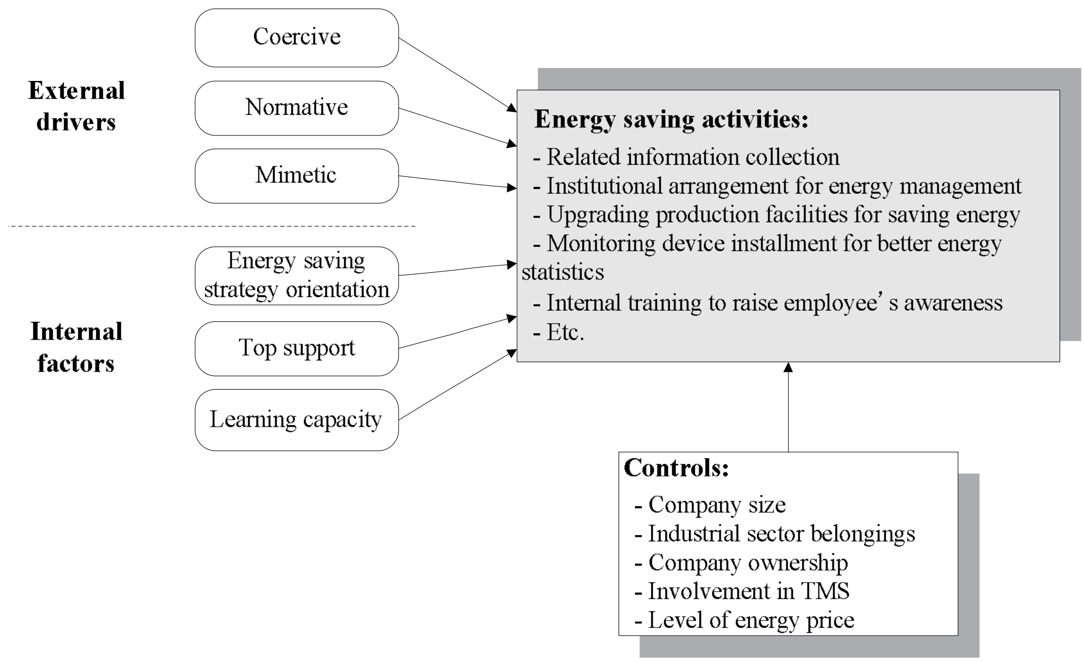

Figure 5.1 Overall analytical framework of this study

2.2 Econometric approach

2.2.1 Valuation of the variables

2.2.1.1 Dependent variable

The overall level of ESAs of a company, abbreviated as *TESA*, is the dependent variable in this analysis. A series of ESAs, which may reflect a company's energy saving involvement, are listed in the questionnaire. The number of ESAs under implementation is defined as the proxy indicating a company's *TESA*. Table 5.1 lists 15 representative ESA items for Korean companies in our survey, each one being assumed to contribute equally to a company's *TESA*. A value of '1' is given to an activity if the company has adopted it, otherwise a score of '0' is assigned. Each ESA, therefore, obtains a score of '1' or '0', and the sum of the scores of all 15 ESAs is used to indicate a company's *TESA*.

Table 5.1 Description of energy saving activities and the valuation

Item	**Description**	**Valuation**	
		0	**1**
ESA1	Collect information on energy saving and carbon mitigation policies		
ESA2	Establish internal energy management institution with full-time energy management staffs		
ESA3	Establish internal management regulations on energy saving and carbon mitigation		
ESA4	Conduct energy auditing for understanding internal energy use situation and to identify energy-saving potentials		
ESA5	Adjust the structure of energy consumption by using cleaner energy		
ESA6	Considering to invest in upgrading the production facilities for energy-saving		
ESA7	Having invested in new production facilities to reduce energy use and carbon emissions		
ESA8	Strengthen daily maintenance of production equipment to reduce energy use		
ESA9	Install monitoring devices for major energy-consuming equipment for better statistics of internal energy use		
ESA10	Promote eco-design and develop energy efficient products		
ESA11	Optimise the transportation of raw materials and products to reduce energy use of logistics		
ESA12	Arrange internal training of employees to raise their energy-saving awareness		
ESA13	Organise the employees to practice daily energy-saving activities in office (such as lighting, air-conditioner, etc.)		
ESA14	Participate in energy-saving training and pilot projects arranged by national or local governments		
ESA15	Apply for energy-saving subsidies at national or local level		

2.2.1.2 Independent variables

The independent variables include coercive, normative and mimetic pressures as external factors, and energy saving strategy orientation, top management support and learning capacity as internal factors. The proxies of these variables are listed in panel A of table 5.2 and the descriptions of independent variables were used as-is as the survey items in the questionnaire. Although a company's energy saving actions ESA are directly influenced by mandatory energy efficiency requirements imposed by the government, global pressure may also create a coercive pressure. In this study, the strength of governmental requirements on energy saving and the level of product exports are defined as domestic and international coercive drivers, respectively. The influence of industrial associations is used to represent the normative pressure. Since companies are likely to mimic the practices of leading companies and major business competitors in the same sector, the overall energy management level of the sector is used to indicate mimetic pressure. A company's willingness to improve its energy efficiency is defined as the proxy for the company's orientation of energy saving strategy. The operations of SMEs are mainly decided by top managers and 'Top manager's support' is selected as another internal factor influencing ESAs of SMEs targeted by this survey. The education level of employees and the frequency of internal training specific for energy saving are used as proxies for learning capacity.

Table 5.2 Description and valuation of determinant factors and control variables

Variable		**Description and abbreviation of the proxy**	**Valuation**					
			0	**1**	**2**	**3**	**4**	**5**
Panel A: Independent variables								
External pressures	Coercive	Strength of governmental requirements of energy saving (REGULATION)						
		Export rate of the product (EXPORT)						
	Normative	Influence of association of industrial sector (ASSOCIATION)						
	Mimetic	Energy management level of competitors (COMPETITOR)						
Internal factors	Strategy orientation	Willingness to improve energy efficiency (WILLINGNESS)						
	Top support	Top manager's support for energy saving activities (TOPSUPPROT)						
	Learning capacity	Average education level of employees (EDUCATION)						
		Frequency of internal training on energy saving (TRAINING)						
Panel B: Control variables								
Characteristics of the company		Company size (SIZE)						
		Industrial sector belongings (SECTOR)						
		Company's ownership (OWNERSHIP)						
		Involvement in the TMS (TMS)						
		Level of current energy price (PRICE)						

A five-level point method was applied for the valuation of independent variables. The companies were requested to present a value to measure the level or strength degree of each factor, with '1' = very low; '2' = relatively low; '3' = moderate; '4' = relatively high; and, '5' = very high. There are two exceptions in the survey: One is the export ratio of the product, which used a five-level classification with '5' representing more than half of the products being exported; '4' meaning a 30–50% export ratio; '3' meaning a 20–30% export ratio; '2' being a 10–20% export ratio, and '1' being an export ratio of less than 10%, and the other exception is the average level of education of the employees, with '5' representing more than 70% of employees holding a college level diploma or above, '4' being a ratio of 50–70%, '3' being a ratio of 30–50%, ‘2’ meaning a ratio of 10–30%, and ‘1’meaning a ratio of under 10%.

2.2.1.3 Control variables

As indicated in panel B of table 5.2, a company’s size, sector belongings, ownership, involvement status of TMS, and level of energy price are defined as controls and are individually represented by SIZE, SECTOR, OWNERSHIP, TMS and PRICE. For the valuation, company size is divided into small, medium and large. The sector belongings are categorised into four types: petro-chemicals, pulp & paper, power and other. Firm ownership is grouped into two types: domestically private and other. The respondents are sorted into TMS and non-TMS targets. Regarding the variable of PRICE, the companies were requested to evaluate the current energy price level, with ‘1’ = very low; ‘2’ = relatively low; ‘3’ = moderate; ‘4’ = relatively high; and, ‘5’ = very high.

2.2.2 Empirical model for the analysis

The regression capturing the functional relationships between the *TESA* and the classified variables can be constructed and expressed by the following equation, where ε represents the error term and β_0 is the constant.

$$\begin{aligned} TESA = \beta_0 &+ \beta_1 REGULATION + \beta_2 EXPORT + \beta_3 ASSOCIATION \\ &+ \beta_4 COMPETITOR + \beta_5 WILLINGNESS \\ &+ \beta_6 TOPSUPPORT + \beta_7 EDUCATION + \beta_8 TRAINING + \beta_9 SIZE \\ &+ \beta_{10} SECTOR + \beta_{11} OWNERSHIP + \beta_{12} TMS + \beta_{13} PRICE + \varepsilon \end{aligned}$$

3. Outline of the questionnaire survey and the samples

The data in this study was collected by a questionnaire survey with the principal objectives of monitoring a company’s ESAs and identifying the pre-classified determinants. The questionnaire format consists of four major components: general information of the company including the size, ownership, sector belongings, involvement status of TMS; activities of the companies in energy saving and GHG mitigation; the degrees of external pressures and internal factors of the company; and, some additional questions for clarifying related issues such as financial subsidies received and barriers to and optional policy measures for practicing ESAs. The questionnaire was sent to a total of 362 business sites of 244 companies via fax and email over a period of three weeks from 28 January to 17 February, 2011. Of the responses, 66 business sites were confirmed to be valid and used for this analysis. The distribution of the usable samples is summarised in table 5.3.

The samples from power, petro-chemical and paper sectors account for more than 60% of the total. TMS targets numbered 54. The majority of samples (86.4%) were small or medium-sized companies and the large ones had a share of 13.6%.

Table 5.3 Distribution of the valid respondents

Classification criteria		Number of respondents	Percentage (%)
Sector	Steel	6	9.1
	Power	11	16.7
	Petrochemicals	21	31.8
	Pulp and paper	10	15.2
	Cement	6	9.1
	Nonferrous metal processing	5	7.6
	Machinery	4	6.1
	Oil refining	3	4.5
	Total	66	100.0
Involvement status of TMS	Yes	54	81.8
	No	12	18.2
	Total	66	100.0
Size	Large	9	13.6
	Medium	49	77.3
	Small	8	9.1
	Total	66	100.0

4. Results and discussions

Stata10 was used for the statistical analysis in this study, the results of which are discussed below.

4.1 Energy consumption status of the samples

In the survey, the companies were requested to show the range of their annual energy consumption amounts. The results indicate that 97% of the respondents consume more than 2,000 toe of energy and 41% use more than 100,000 toe in 2010. According to Kim (2009), only the top 2.2% of the SMEs in Korea consumed more than 2,000 toe; 85% of the remaining SMEs used less than 200 toe in 2009. This implies that the respondents of this survey may represent the heavy energy-consuming SMEs in Korea.

4.2 Statistics of company ESAs

The reliability of construct of the 15 ESA items was tested using Cronbach's alpha. A scale coefficient of 0.78 confirmed the reliability of a company's answers on their ESAs according to the criteria of an alpha larger than 0.7 (Nunnally and Bernstein, 1994). Figure 5.2 provides a statistical summary of ESAs adopted by the surveyed companies.

As in the previous study in China (Liu et al, 2012), the surveyed Korean companies prefer to practice ESAs by institutional and managerial measures probably because these activities usually incur lower costs and less resources compared with ESAs involving technology and engineering. Specifically, ESA13 (Organise the employees to practice daily energy-saving activities offices, such as lighting, air-conditioning) and ESA1 (Collect information on energy saving and carbon mitigation policies) are the most adopted ESA items, with 'YES' answer figures of 95.5% and 93.9%, respectively. More than half of the surveyed companies participated in ESA6 (Considering investment in upgrading the production facilities for energy-saving, with a share of 78.8%), ESA7 (Having invested in new production facilities to reduce energy use and carbon emissions, 62%) and ESA8 (Strengthen daily maintenance for the reduction of energy use of production equipment, 66.7%). Three other ESAs with participation ratios slightly above 50% are ESA2 (Establish internal energy management institution with full-time energy management staffs), ESA9 (Install monitoring devices for major energy-saving activities) and ESA12 (Arrange internal training of employees to raise their energy-saving awareness). The moderate participation of ESA12 is consistent with statistics of the independent variable of TRAINING as shown in the following section 4.3, where the companies admit a relatively low frequency of internal training on energy saving.

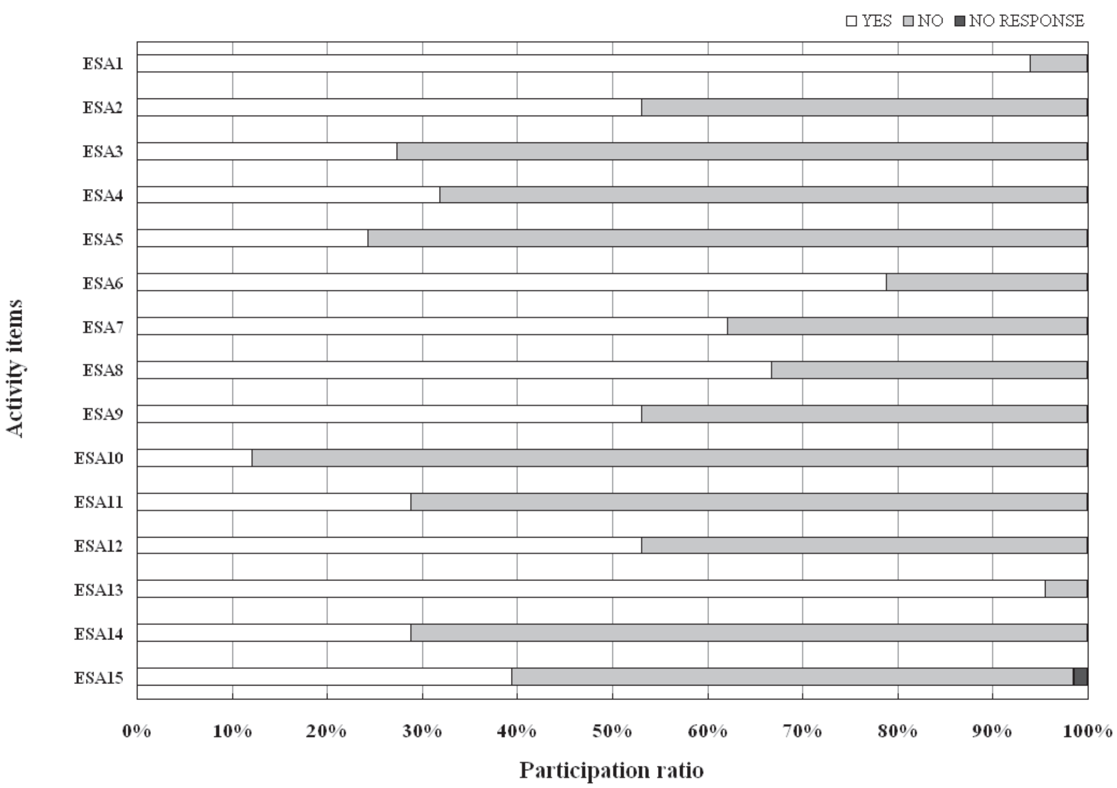

Figure 5.2 Distribution of company energy saving activities (N=66).

On the other hand, the item with the lowest ratio of 'YES' answers is ESA10 (Promote eco-design and develop energy efficient products). ESA3 (Establish internal management regulations on energy saving and carbon mitigation), ESA5 (Adjust the structure of energy consumption by using cleaner energy), ESA11 (Optimise the transportation of raw materials and products to reduce energy use of logistics) and ESA14 (Participate in energy-saving training and pilot projects arranged by national or local governments) achieved participation ratios of less than 30%. This implies that the involvement of ESAs of the sampled SMEs is at an early stage. The company's energy saving practices cannot be merged into their business cycles, such as in the research and development of the products or strategic cooperation with external business partners. The low participation ratio of ESA14 may be partly attributed to a lack of training opportunities provided by the government for SMEs. Korea Energy Management Corporation (KEMCO), which operates under MKE, offers Energy Educational and Training Programmes for persons responsible for energy management in companies that use more than 2,000 toe of energy annually. Nevertheless, SMEs complain that energy saving-related training and information dissemination is largely inadequate (Hong, 2010; KDI, 2008). Dias et al. (2004) clarified that education is the best way to bring about a human behavioural shift in favour of more rational use of energy. Governments therefore need to provide ongoing technical support to enhance the awareness of SMEs and assist them in the appropriate practice of ESAs.

Figure5.3 further shows the distribution of a company's *TESA*. The average *TESA* is 7.5, indicating a moderate level of ESA adoption overall. Only 3.3% of the respondents practiced all 15 activities, and one company had even failed to carry out any of the pre-listed ESA. Half of the samples practiced 4 to 7 ESA items and 30% of the companies implemented 8 to 11 items.

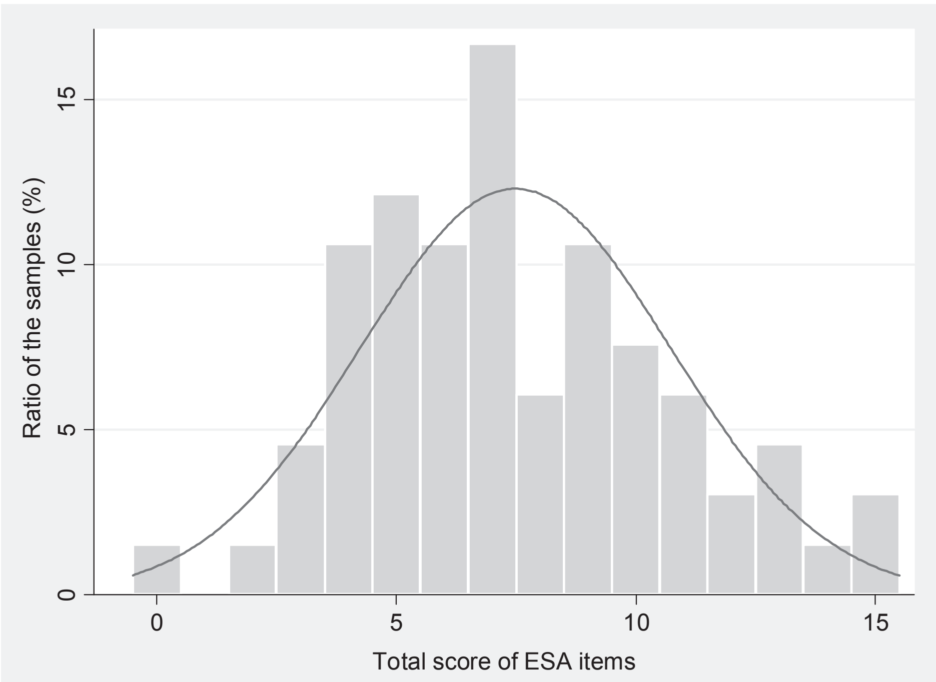

Figure 5.3 Distribution of overall scores of energy saving activities (N=66)

4.3 Statistics of the independent and control variables

Table 5.4 summarises the statistics of independent variables and the quantitative control. The skewness and kurtosis values were listed to show the shape of the distribution of scores achieved by these variables, which results in a skewness range of -1.51 to 0.01, with the absolute values less than 3. The kurtosis ranges from 1.47 to 4.58, with the absolute values less than 10. The skewness and kurtosis of the adopted variables were found to be not significant (Kline, 1998).

Table 5.4 Statistical summary of independent variables and the quantitative control

Variable		Obs.	Mean	Std. Dev.	Min.	Max	Skewness coefficient	Kurtosis coefficient
Independent	REGULATION	66	3.80	0.79	1	5	-0.78	4.44
	EXPORT	64	2.92	1.58	1	5	0.03	1.47
	ASSOCIATION	66	4.13	1.16	1	5	-1.51	4.58
	COMPETITOR	66	3.67	0.84	2	5	-0.23	2.49
	WILLINGNESS	66	4.31	0.66	3	5	-0.44	2.26
	TOPSUPPORT	66	4.15	0.82	2	5	-0.45	2.06
	EDUCATION	66	3.30	1.15	1	5	0.31	1.68
	TRAINING	66	2.65	0.94	1	4	-0.28	2.24
Control	PRICE	66	4.05	0.59	3	5	0.01	2.87

The external factor 'ASSOCIATION' achieved a high score, indicating the significance of industrial associations in influencing the companies within the same sector in Korea. Governmental requirements regarding energy efficiency strongly impacted on the companies, with an average 'REGULATION' score of 3.80. This reveals the positive role of discussions and implementation of various energy saving policies, enacted recently, reinforcing a company's perception of coercive pressure from the government. The sampled companies believed their competitors practiced energy management to a certain extent, with the variable of 'COMPETITOR' presenting a mean of 3.67. 'EXPORT' achieved a moderate mean, implying that the products of the companies are mainly supplied to the domestic market; the exporting companies account for only 22.7% of the total.

For the internal factors, the respondents expressed high willingness to save energy, with a 'WILLINGNESS' mean of 4.31. The top managers support energy management of the companies, with 'TOPSUPPORT' having another high mean of 4.15, which is encouraging since companies would be more likely to adopt environmentally innovative strategies if their managers prioritised environment issues (Fergusson and Langford, 2006). The low score given to the variable of 'TRAINING' means internal training on energy saving has been arranged occasionally in the surveyed companies. The education level of employees is moderate, with an 'EDUCATION' average score of 3.30.

The companies felt highly pressured by current energy prices, based on the control of 'PRICE' reaching a mean of 4.05. Regarding the other controls indicating a company's characteristics, as described in section 4, most samples are SMEs, although 81.6% of them are affiliated with large companies. Large companies, with more than 1,000 employees, only share 13.6% of the total. By ownership, 63.6% are domestically private corporations; the remaining 36.4% are state-owned, joint-ventures and fully foreign-funded. The ratios of respondents from petrochemicals, power, paper and pulp and other sectors are 31.8%, 16.7%, 15.2% and 36.4% individually.

4.4 Correlation matrix and bi-variable results

A pair-wise correlation was calculated to preliminarily explore the relationships between *TESA*, independent variables and the quantitative control. The results are listed in table 5.5. There is no indication for an unacceptable level of multi-collinearity between these variables, as the highest correlation coefficient is 0.502. Harmful levels of multi-collinearity are not expected until the correlation coefficient reaches ±0.8 or ±0.9 (Farrar and Glauber, 1967). The correlation matrix indicates that 'WILLINGNESS' (Willingness to improve energy efficiency) is significantly and positively associated with *TESA* at $P<0.01$. The other variables showing significant relationships with *TESA*, with a significance level of $P<0.01$, are 'COMPETITOR', 'TRAINING' and 'TOPSUPPORT'.

Table 5.5 Correlation matrix and bi-variable results

	TESA	REG.	EXP.	ASS.	COM.	WIL.	TOP.	EDU.	TRA.	PRI.
TESA	1.000									
REGULATION	0.212[c]	1.000								
EXPORT	0.258[b]	0.012	1.000							
ASSOCIATION	0.166	0.097	-0.003	1.000						
COMPETITOR	0.351[a]	0.225[c]	0.238[c]	0.063	1.000					
WILLINGNESS	0.502[a]	0.122	0.069	0.043	0.413[a]	1.000				
TOPSUPPORT	0.345[a]	0.212[c]	-0.041	0.218[c]	0.359[a]	0.277[b]	1.000			
EDUCATION	0.150	0.186	-0.006	0.199	0.058	0.236[c]	-0.033	1.000		
TRAINING	0.406[a]	0.197	0.102	0.200	0.317[a]	0.332[a]	0.427[a]	-0.066	1.000	
PRICE	0.060	0.019	-0.100	-0.032	0.184	0.159	-0.046	-0.035	-0.165	1.000

[a] Significant at 1% level; [b] Significant at 5% level; [c] Significant at 10% level

4.5 Factor analysis of ESA items

An exploratory factor analysis was conducted on the 15 ESAs to check whether these items had further dimensions, and the Kaiser-Meyer-Olkin (KMO) test was carried out to assess appropriacy of the factor analysis. The rotated component matrix of the analysis and KMO values are listed in table 5.6.

The KMO values are generally greater than 0.5, indicating a satisfactory factor analysis to proceed. Four principal component factors were extracted. The first factor accounts for 57.4% of the variance in total and the other three account for about 17%, 13% and 11% individually. ESA2 to ESA4 and ESA6 to ESA13 are highly associated with factor 1. ESA 14 and ESA15 are highly associated with factor 3. ESA1 and ESA5 are related to factor 2 and factor 4, respectively. Based on the factor analysis result, four sets of ESA constructs may be defined. The ESA items highly associated with factor 1 are internally independent ESAs of the companies. ESA14 and ESA15, associated with factor 3, are the ESAs practiced in cooperation with the government. We thus classified the ESAs into four categories, as defined in table 5.7. Besides the overall level of ESA, *TESA*, the variables representing the involvement of sub-categories of ESAs are also used as dependent variables for multivariate regressions to observe their respective relationships with the predictive factors.

Table 5.6 Rotated component matrix of factor analysis and KMO values

Energy saving activities	Components				KMO value
	1	2	3	4	
ESA1	0.243	0.404	0.127	-0.107	0.532
ESA2	0.537	0.125	-0.065	-0.143	0.678
ESA3	0.618	-0.039	0.165	-0.146	0.750
ESA4	0.625	-0.116	-0.239	-0.045	0.763
ESA5	0.299	-0.163	-0.133	0.449	0.508
ESA6	0.434	0.306	-0.093	0.144	0.597
ESA7	0.573	0.202	0.144	0.188	0.680
ESA8	0.544	0.16	-0.198	-0.13	0.751
ESA9	0.549	-0.013	0.106	-0.206	0.740
ESA10	0.465	-0.433	0.193	0.085	0.726
ESA11	0.53	-0.306	-0.024	0.027	0.741
ESA12	0.496	-0.182	-0.211	-0.046	0.725
ESA13	0.34	0.256	-0.188	0.114	0.610
ESA14	0.226	-0.077	0.389	-0.223	0.620
ESA15	0.243	0.148	0.421	0.337	0.440

Table 5.7 Definition and valuation of ESA sub-category items

Abbreviation	Description of the sub-category	Valuation
ESA_{IN}	Firm's internally independent energy saving activities	Sum of scores of ESA2 to ESA4 and ESA6 to ESA13
ESA_{EX}	Energy saving activities in cooperation with governments	Sum of scores of ESA14 and ESA15
ESA_{INF}	Information collection for energy saving	Score of ESA1
ESA_{SA}	Company's efforts to adjust energy consumption structure	Score of ESA5

4.6 Multivariate analysis with *TESA* and sub-categories of ESAs as dependent variables

As the dependent variables, *TESA* and sub-categories of ESAs are ordinal measurements, ordered logistic regressions were performed. The analysis results of *TESA* and ESA_{IN} are listed in table 5.8 and 5.9, respectively. The results for $ESA_{EX,}$ ESA_{INF} and ESA_{SA} are not listed since they were not significantly related to the identified factors. Robustness of the results was tested by repeating the regression with certain variables omitted. Three models were adopted: Model 1 excludes all the control variables; Model 2 adds the quantitative control, 'PRICE'; and Model 3 includes all the variables discussed earlier. There are no obvious differences between the results of the three regressions, confirming the robustness of results. The total number of observations of econometric analysis is 64 due to lack of data from two respondents.

Table 5.8 Ordered logistic regression result with *TESA* as dependent variable (N=64)

	Model 1			Model 2			Model 3		
	Coef.	Std. Err.	P	Coef.	Std. Err.	P	Coef.	Std. Err.	P
REGULATION	0.233	0.293	0.427	0.214	0.295	0.468	0.141	0.303	0.643
EXPORT	0.345	0.157	0.028	0.353	0.158	0.026	0.113	0.224	0.614
ASSOCIATION	0.130	0.195	0.504	0.133	0.197	0.501	0.156	0.210	0.457
COMPETITOR	-0.122	0.348	0.725	-0.135	0.349	0.698	-0.118	0.380	0.756
WILLINGNESS	1.301	0.429	0.002	1.245	0.446	0.005	1.182	0.489	0.016
TOPSUPPORT	0.485	0.334	0.147	0.506	0.337	0.134	0.703	0.373	0.060
EDUCATION	0.147	0.215	0.493	0.161	0.215	0.456	0.306	0.252	0.225
TRAINING	0.451	0.298	0.130	0.476	0.302	0.114	0.575	0.323	0.075
PRICE				0.188	0.408	0.644	0.385	0.450	0.392
SIZE_Large							2.157	1.189	0.070
SIZE_Medium							1.552	0.833	0.063
SECTOR-Paper							-0.167	1.130	0.883
SECTOR-Chemical							1.014	1.052	0.335
SECTOR-Other							0.642	1.123	0.567
TMS							-0.063	0.708	0.930
OWNERSHIP-Domestic private							0.417	0.612	0.496
LR chi		31.51			31.72			37.13	
Pseudo R^2		0.099			0.100			0.117	

The results in table 5.8 and 5.9 indicate that the identified determinant factors influence a company's *TESA* and ESA_{IN} in a similar manner, and are therefore discussed together below. As with our survey of Chinese SMEs (Liu et al, 2012), there is no significant relationship between *TESA* (ESA_{IN}) and coercive pressures, including 'REGULATION' (The pressure of governmental requirements of energy saving) and 'EXPORT' (The level of product export). This implies that the regulative pressure strongly perceived by the surveyed Korean companies has little actual effect on their ESAs in practice. To date, the regulations specific to industrial energy efficiency and GHG reductions in Korea have focused on large companies rather than the SMEs targeted by this survey (Hong, 2010). Although the newly initiated TMS targets some SMEs with large energy consumptions and GHG emissions, time is needed for the companies to actually respond to this regulation and implement its directives. The companies under TMS were determined in 2010 but the specific reduction targets and measures weren't declared until after mid-2011. As this survey was conducted in early 2011, the surveyed companies might not have known how to prepare for this new regulation at the time of the survey. In spite of the efficacy of regulations in enhancing a company's energy performance confirmed in some other literature (Jones, 2010; Pellegrini-Masine and Leishman, 2011), the surveyed SMEs in Korea are still not sufficiently influenced by regulative pressures at present.

As the proxy for normative pressure, the variable of 'ASSOCIATION' shows no significant influence on a company's energy saving practices. As SMEs usually lack the funds and expertise for investment and technological innovation, they most likely rely on available networks, including industrial associations in the same sector, for external support and cooperation (Hong, 2004). Therefore, industrial associations have a strong impact on business operations of the SMEs in this survey (Palm and Thollander, 2010). Our survey thus shows that industrial associations are important for the companies in Korea but don't play a significant role in coercing SMEs to improve their energy efficiency. Such industrial associations, however, can act as a bridge between government and individual companies since they are intimately familiar with all the opportunities and actual needs of the companies, whereas the government usually is not (Chappin et al, 2008). In the near future, Korea's industrial associations, as representatives of the sector, are anticipated to play a much more active role in supporting energy saving at the company level. In contrast with the previous study in China, there is no significant relationship between the externally mimetic pressure, with 'COMPETITOR' as the proxy, and a company's energy saving practice level (Liu et al., 2012).

Regarding the internal factors, 'WILLINGNESS' shows a significant and positive relationship with *TESA*. This reveals that the level of ESA involvement of Korean companies is partly attributed to the strategy orientation of individual companies under the current situation of laggard government regulations and weak normative pressure from industrial associations. The positive and significant impact of 'TOPSUPPORT' confirms the need for support from top managers in a company's energy saving practices, especially for the SMEs in this survey. While 'EDUCATION', as a variable representing learning capacity, has no significant relationship with *TESA* (ESA_{IN}), 'TRAINING', as another proxy, indicates a significant and positive influence on a company's energy saving practices. Zografakis et al. (2008) confirmed that education can transform human behavior towards a more rational use of energy and increase energy literacy. In this survey, the average education level of company employees is not significant probably because energy saving takes place via internal training (Liu et al., 2012).

Table 5.9 Ordered logistic regression result with ESA_{IN} as dependent variable (N=64)

	Model 1			Model 2			Model 3		
	Coef.	Std. Err.	P	Coef.	Std. Err.	P	Coef.	Std. Err.	P
REGULATION	0.113	0.284	0.690	0.105	0.284	0.712	-0.031	0.296	0.916
EXPORT	0.278	0.156	0.074	0.289	0.157	0.065	0.039	0.223	0.863
ASSOCIATION	0.083	0.196	0.670	0.089	0.198	0.655	0.099	0.211	0.641
COMPETITOR	-0.094	0.337	0.780	-0.125	0.340	0.713	-0.211	0.379	0.578
WILLINGNESS	1.264	0.432	0.003	1.207	0.439	0.006	1.163	0.479	0.015
TOPSUPPORT	0.634	0.339	0.061	0.666	0.342	0.051	0.939	0.392	0.017
EDUCATION	0.164	0.212	0.441	0.182	0.212	0.390	0.314	0.254	0.217
TRAINING	0.450	0.293	0.124	0.489	0299	0.101	0.628	0.326	0.054
PRICE				0.264	0.395	0.504	0.627	0.453	0.166
SIZE_Large							2.560	1.205	0.034
SIZE_Medium							2.140	0.873	0.014
SECTOR-Paper							-1.318	1.159	0.255
SECTOR-Chemical							0.505	1.054	0.632
SECTOR-Other							0.152	1.141	0.894
TMS							-0.020	0.704	0.977
OWNERSHIP-Domestic private							0.464	0.626	0.459
LR chi		30.7			31.15			40.05	
Pseudo R^2		0.103			0.105			0.135	

Company size is significantly associated with *TESA* (ESA_{IN}) in this survey. The large and medium-sized companies have better energy saving practices in comparison with the small ones. This finding follows the resource-based perspective and is consistent with empirical studies documenting that company size has a significant effect, with larger organisations being more likely to adopt proactive environmental practices (Sharma, 2000). None of the other company characteristics, including sector belongings, ownership and the involvement status of TMS, are significantly associated with *TESA* (ESA_{IN}). Differing from the result of Prindle (2010) and Liu et al. (2012), who found energy price to be influential on company energy efficiency, 'PRICE' indicates no significant relationship with energy saving practices of Korean companies in this survey.

4.7 Statistics of supplementary survey questions

4.7.1 Status of energy saving subsidies received by the companies

MKE provides subsidies and tax credits to support company energy efficiency investments and in 2011 had a total budget of 600 billion KRW (KEMCO, 2011). According to the result in fig.5.2, approximately 40% of the respondents had applied for energy-saving subsidies from the government. During the survey, the companies were requested to answer two additional questions to elicit their awareness of this incentive policy and how successful they were in obtaining such subsidies from the government, as shown in fig.5.4.

More than half of the respondents (56.1%) knew about the subsidy policy aimed at company energy saving. However, probably due budgetary limits, nearly half of the surveyed companies had received no energy saving grants. The ratio of the samples that had received one subsidy from the central government is 39.4% and the figure related to local governments is much lower. This confirms the limited nature of governmental financial sources for industrial energy saving in Korea, despite that fact that economic incentives are the preferred choice for businesses.

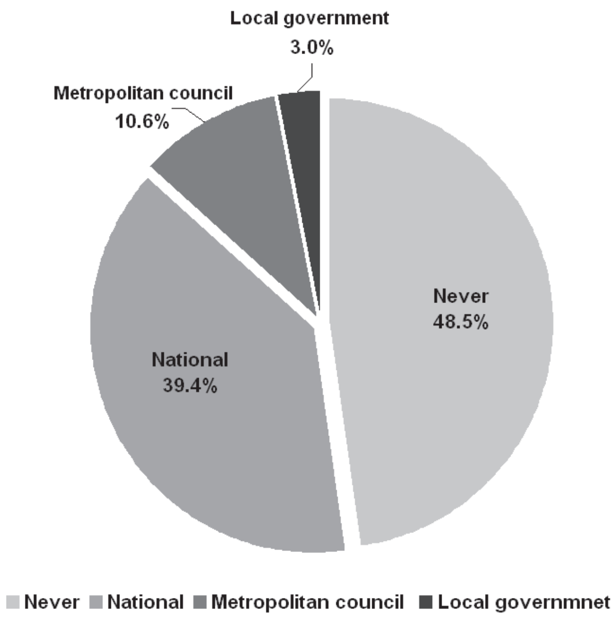

Figure 5.4 Status of energy saving subsidies received by the companies (N=66)

4.7.2 Major barriers for company energy saving

To measure the factors hindering a company's practice of ESAs the surveyed companies were asked to rank seven listed barriers using a scale from one to five, with '1' representing not important at all to '5' being very important. Table 5.10 summarises the statistics of the responses.

The respondents present moderate evaluations to all the barriers. The barriers of 'Lack of economic incentive from the governments' and 'Low energy efficiency of out-of-date production facilities' achieved the highest mean of 3.62 and 3.61. 'Lack of funds for upgrading production facilities' achieved a relatively high score (averaged at 3.47). The sampled companies viewed their production facilities as being of low efficiency. To encourage company investments in advanced energy efficiency technologies, financial incentives may be essential. Since it can be difficult for SMEs to obtain commercial funding, they tend to adopt the mindset that financial support from the government for energy efficiency improvements would act as a kind of public good. Other barriers with high scores include 'Lack of energy management specialists' (averaged at 3.48), implying that the lack of capacity restricts energy saving efforts of the surveyed SMEs.

Table 5.10 Statistics of barriers for companies ESAs (N=66)

Barriers	Obs.	Mean	Std. Dev.	Min.	Max.
Unclear of internal energy use status and saving potentials	66	3.06	1.11	1	5
Lack of awareness of employees on energy saving	66	3.21	1.02	1	5
Low energy efficiency due to out-of-date production facilities	66	3.61	1.04	1	5
Lack of funds for upgrading production facilities	66	3.47	1.13	1	5
Lack of information related to energy saving	66	2.97	0.86	1	5
Lack of energy management specialists	66	3.48	1.03	1	5
Lack of economic incentive from the governments	66	3.62	0.91	2	5

4.7.3 Effective measures enhancing company energy saving

In this survey we asked the companies to rate the effectiveness of optional measures for them to practice ESAs better, with a score of one to five; '5' being very effective and '1' meaning no effect. The statistical results are shown in table 5.11.

Table 5.11 Statistics of effective measures for company energy saving

Possible measures	Obs.	Mean	Std. Dev.	Min.	Max.
Promote the establishment and enforcement of regulations	66	3.94	0.76	2	5
Providing subsidies for energy saving	66	4.29	0.82	2	5
Providing credit for energy saving efforts	66	3.86	0.91	2	5
Providing advantage for financing (soft loans, etc.)	66	3.82	1.01	2	5
Support to set up firm's internal energy management system	66	3.98	0.92	1	5
Proving technical support such as energy audits	66	3.74	0.97	1	5
Providing information support for energy saving	66	3.92	0.88	1	5
Strengthening training for energy saving	66	3.86	1.08	1	5
Cooperate with business partners for energy saving	66	3.62	1.02	1	5

Comparatively, 'Providing subsidies for energy saving' was ranked as the most effective method, with a mean of 4.29. Providing technical assistance satisfies the actual needs of SMEs in capacity building for energy saving and achieved relatively higher evaluations of effectiveness, as exemplified for the items 'Support to set up company internal energy management system' and 'Providing information support for energy saving', which also obtained high means of 3.98 and 3.92, respectively. Overall, the companies view the listed measures as useful and gave all of them relatively high scores

5. Conclusions

This study provides a synopsis of the current status of energy saving practices of Korean SMEs with high energy intensities and identifies the determinant factors. The surveyed SMEs have become aware of the importance of energy efficiency and expressed strong willingness for energy saving. However, as regards energy saving, they appear to prefer the managerial route, based on the lower participation ratios of technological ESAs, which incur higher levels of cost and complexity (KDI, 2008). The newly launched TMS, as the major mandatory regulation for large energy-consuming companies, as well as emerging discussions over carbon taxes and GHG ETS, have generated pressures for the companies. However, in the context of laggard regulations and industrial associations with only weak functions, company energy saving practices are mainly attributed to their internal motivations at present.

Providing technical support is useful for enhancing the capabilities for energy saving and appreciated by the surveyed companies. Probably due to the difficulty of commercial financing, the respondents have high expectations for the government to provide subsidies. With regulations putting pressure on laggard companies, energy saving subsidies may function as a strategy to encourage higher levels of performance (Lee et al., 2010). Due to the limited budget available and the transitory nature of subsidy policies, it is necessary to consider alternative economic instruments which may appropriately define the externalities of energy use and carbon emissions. The government of Korea needs to expand the scope of mandatory regulations to gradually embrace a broader scope of companies to bring about lower levels of energy consumption via enhancing energy saving practices through regulative tools.

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Chapter 6:

A survey analysis of energy saving activities of companies in Hyogo, Japan*

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Chapter Highlights:

- This chapter provides an analysis of energy saving activities of companies based in Hyogo Prefecture of Japan. The data was collected from 230 of the biggest energy consumers.
- The sampled companies practice nearly all the pre-listed energy saving activities well. The classified factors are partly confirmed by the econometric analysis.
- Generally, energy saving efforts of companies in Hyogo are mainly due to their individual business strategies and energy saving motivations. Large companies perform better than their small and medium-sized counterparts.
- Public organisations, e.g., the government, need to be more proactive in urging the companies to operate with higher energy efficiencies.

1. Introduction

Japan is gearing its national policy framework to embrace countermeasures for climate change. Since energy-related CO_2 emissions account for 89% of Japan's total, the country's climate policy is primarily concerned with energy efficiency (OECD, 2009). For Japan's industries, the 'GHG Accounting and Reporting System' mandates the large greenhouse gases (GHG) emitters to calculate and report their emissions to the government on a yearly basis. In 2009, over 11,000 businesses in Japan reported their emissions under this system, accounting for about half of the country's total (Kauffmann et al., 2012). To date, measures taken by Japan's industries against global warming have been mainly based on Keidanren's 'Voluntary Action Plan on the Environment' (Keidanran: Federation of Japanese Businesses), formulated in 1997. The main aim of this plan involves members of the industrial and energy conversion sectors (28 industries in 1997; 34 in 2010) reducing their GHG emissions below 1990 levels by 2010. Sub-industries declared their voluntary reduction targets in the form of absolute amounts or relative intensities.

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* The main content of this chapter was published as: Liu, X.B., Yamamoto, R., Suk, S.H., 2014. A survey analysis of energy saving activities of industrial companies in Hyogo, Japan. *Journal of Cleaner Production* 66(2014): 288-300.

In 2010, the GHG emissions of the participating industries accounted for nearly 83% of the total for the industry and energy conversion sectors. Based on the latest figures, total emissions from the participating industries in 2010 were 443.47 Mt-CO_2, a drop of 12.3% compared to 1990 (including 13.75 Mt-CO_2 of credits acquired via market mechanisms) (Keidanren, 2012). Keidanren renewed its commitment to a low carbon society in December 2009 (Keidanren, 2009). In terms of economic instruments, the government of Japan provides various incentives to support the efforts of industry in energy saving and carbon mitigation, including direct financial subsidies and tax credits. The climate subsidies come mainly from bodies such as METI, MOEJ and NEDO (Ministry of Economy, Trade and Industry; Ministry of the Environment, Japan; The New Energy and Industrial Technology Development Organisation) (Tanaka, 2011). On the other hand, certain policies that exert economic pressures to achieve industrial energy saving have also been introduced, such as the long-standing energy-related tax (Liu et al., 2011) and the 'Global Warming Countermeasure Tax' (or 'Environmental Tax'), which was imposed on 1 October 2012. The rate of the latter tax is low at 289 JPY/t-CO_2 and the tax is scheduled to be implemented in three stages (MOEJ, 2012).

The rationale for energy efficiency and climate policies to focus on industry is that this sector consumes significant amounts of primary energy (IEA, 2010). However, research into the factors that contribute to energy saving within industry or help develop effective policies, especially for small and medium-sized enterprises (SMEs), is sparse (Thollander et al., 2007), as is that covering empirical analysis of factors affecting industrial efforts in energy efficiency throughout Asia, including Japan as a developed country. This chapter attempts to close such gap through a study of Japanese companies. Hyogo Prefecture (the base of our research centre) was selected as the study area based on the ease of securing assistance from companies for the survey. We had two major objectives: one was to measure the extent to which companies had embraced energy saving activities (ESAs); the other was to identify the determinant factors indicating strong linkages with the level of a company's ESAs.

2. Literature review

In chapter 4, we conducted a thorough literature review to clarify the research progress related to industrial energy efficiency. Based on this, research was found to be focused on the reasons why application of best available technologies had failed at the very outset. The analyses later extended to industrial energy programmes as a common means for promoting energy efficiency within industry. Various drivers, such as cost saving potential, and barriers, such as limited access to capital and information, have been identified as factors affecting energy efficiency in industry. Nevertheless, most research targeted companies in Europe and the U.S.

This section summarises the latest publications related to industrial energy efficiency. Abdelaziz et al. (2011) presents a comprehensive literature review covering industrial energy saving realised through management, technology and policy measures. Payback periods of various energy saving approaches have been confirmed to be economically viable in most cases. Blomberg et al. (2012) discussed their empirical results in relation to the outcomes of a Swedish voluntary energy efficiency programme and concludes that future energy efficiency programmes should explicitly target the promotion of technological progress and address the informational and behavior-related failures. Walsh and Thornley (2012) documented the presence of technical and non-technical barriers blocking improvements in energy efficiency in industry. Consultations with stakeholders in the UK indicated that cost, return on investment and technology performance are major barriers. A number of institutional factors were identified for explaining why efficiency measures with environmental and economic benefits are not implemented. Abadie et al. (2012) analysed decisions in energy efficiency investments by SMEs in the U.S., and concluded that payback time and investment costs are the main determinants. In practice, the adoption of efficient technologies is not the only route to improving energy efficiency. Backlund et al. (2012) found that a cost-effective approach is to combine investments in energy-efficient technologies with continuous energy management practices. Trianni et al. (2013) identified barriers to energy efficiency in 65 foundries in Europe. Perception of a lack of resources and existence of other priorities, such as guaranteeing business continuity, were confirmed to be the biggest hurdles to improvements in energy efficiency. Smaller companies indicate a greater perception of barriers than larger ones. Performing energy audits can raise the awareness within such companies for improving their energy efficiency. Cagno and Trianni (2013) analysed the drivers for 71 Italian SMEs to adopt energy-efficient technologies and practices. This research highlights the importance of allowances and public financing as well as the economic pressures of increases in energy prices and fees on emissions. It found that companies prefer to adopt energy-efficient technologies that may provide long-term benefits, and that the presence of highly ambitious or entrepreneurial staff within a company, as well as a management receptive to such issues, constituted additional drivers. Gulbrandsen and Stenqvist (2013) examined to what extent the EU-ETS has influenced the climate strategies of two Nordic paper companies. Rising prices of electricity are perceived as the greatest effect of this scheme. The EU-ETS has served to reinforce commitments at the company level to raising energy efficiency but has yet to initiate meaningful exploration of innovative low-carbon solutions.

The research represented by the wide-ranging literature reviewed above, however, does not cover the factors determining industrial energy efficiency in the context of Asia. This chapter thus attempts to bridge this knowledge gap, by qualitatively measuring the level of ESAs of Japanese companies and identifying the corresponding issues.

3. Analytical framework for this study

The analytical framework of this study is shown in fig.6.1 and is almost the same as that used in chapter 4. The model, which combines the external pressures and internal factors, has seen much use in previous studies on corporate environmental management (e.g., Delmas and Toffel, 2008; Liu et al., 2010) and has also been used in analysing business behavior regarding the environment. As examples, Zhu et al. (2013) sampled 377 Chinese manufacturing companies in six sectors to test the efficacy of institutional pressures in leading to the implementation of an environmental management system. Their results are consistent with the theory linking internal capacities with external pressures in determining a company's proactive environmental efforts. Ye et al. (2013) analysed the factors in reverse logistics management of companies and confirmed that institutional pressures exert a significant positive pressure on the posture adopted by top management; and Rothenberg (2007) found that environmental action taken by companies is a reaction to both institutional and technical pressures, and that the strategies adopted by environmental managers partly depend on their relative position within the company hierarchy. When assessing the function of a competitor's environmental management on a certain company, Hofer et al. (2012) found that company characteristics such as market leadership, size and profitability are all highly significant. We supplemented the external pressures identified by institutional theory with three internal factors – a company's orientation on energy saving strategy, top support and learning capacity – to explain a company's ESAs. Company characteristics are used as controls in the analytical frame.

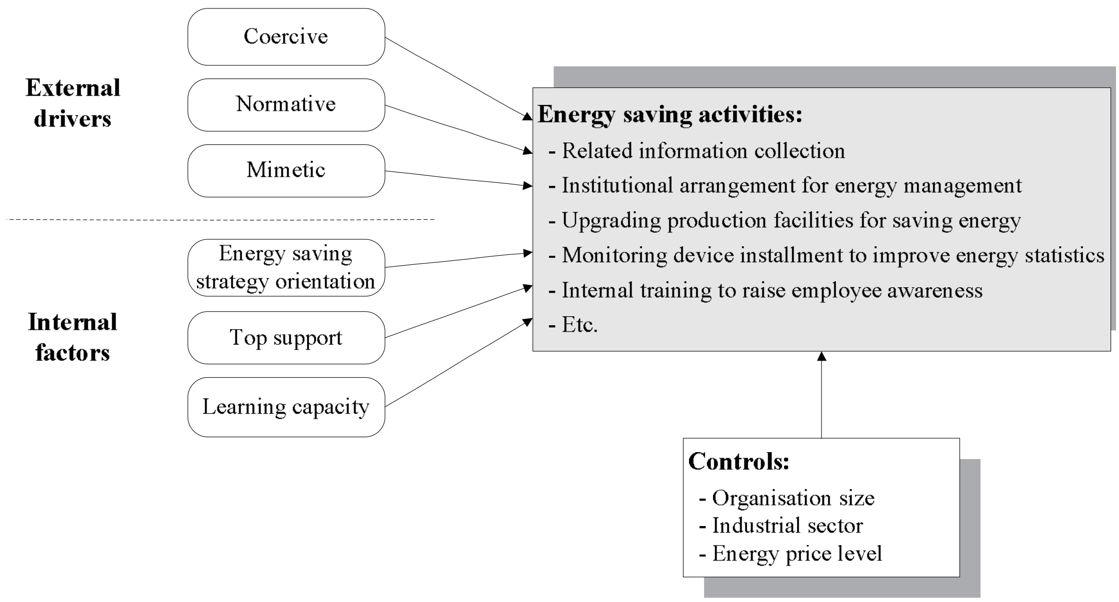

Figure 6.1 Analytical framework of the study

It should be mentioned that the practice of ESAs may also reinforce the above-identified factors as well; for example, a company's efforts in ESAs can increase its state of awareness of internal energy use and problems, and thus enhance its willingness for further energy saving. Nevertheless, the model in fig.6.1 assumes no interactivity between such variables, as this deviates from the main purpose of this analysis, which is to identify the determinant factors behind company ESAs.

4. The survey area: Hyogo Prefecture

4.1 Overview of Hyogo

This survey was carried out in Hyogo Prefecture, which is located as shown in fig.6.2. The prefecture has a land area of 8,396.13 km^2, comprising 41 municipalities, 29 cities and 8 districts (separated into 12 villages). Its population was 5,572,724, or 2,280,354 households, as of 1 November 2012. Most of the population resides on its southern coast, which itself is part of the broad Osaka-Kobe-Kyoto metropolitan region. Hyogo's total nominal and per-capita GDP for 2010 were 18,346.2 billion and 2.687 million JPY, respectively (3.5% and 1.1% higher, respectively, than the previous year). In terms of GDP by type of industry, first to third industries (Agriculture, forestry and fisheries; Mining, manufacturing and construction; Services) accounted for 0.55%, 27.99% and 71.46% in 2010, respectively (Hyogo Prefecture, 2013).

Hyogo prefecture is home to internationally renowned companies such as Kawasaki Heavy Industries and Kobe Steel; it also houses the manufacturing bases of many of Japan's giants too, Mitsubishi Heavy Industries, Toshiba Corporation, Fujitsu and Mitsubishi Electric Corporation. In 2009 there were 9,555 industrial entities (mostly SMEs) with over four employees (5.8% drop from 2008), for a total of 359,236 employees (1.0% drop from 2008). Of the above entities, those with 4–299 employees numbered 9,390 in 2009, 98.84% of the total. The remaining 1.16% (165 entities) are categorised as large companies in Japan (300 or more employees). By sector for 2009, with numbers of entities expressed as a percentage of the total number of entities, 16.8% was represented by food processing companies, 14% by metal product manufacturers, 8.5% by production machinery, 4.8% by electric machinery, and 4.8% by fiber; the five sectors in total sharing 49.1% of the total number of entities. The number of chemical and iron & steel companies was 302 and 251, with respective shares of 3.2% and 2.6% in 2009.

In terms of added value, the chemical sector generated the highest amount, 545.8 billion JPY in 2009, with a share of 11.7% of the total. Second was food processing, at 531.7 billion JPY. Third and after were general machinery (10.7%), electric machinery (8.4%) and production machinery (8.3%). These top five sectors accounted for 50.5% of the total value added in 2009 (Hyogo Prefecture, 2012a).

Figure 6.2 Geographical location of Hyogo prefecture

4.2 Industrial climate policies of the prefecture

The overall GHG emissions of Hyogo were 63.494 Mt-CO_2 in 2009, a reduction of 13.1% compared to the 1990 level (base year). Emissions from the industrial sector were 41.53 Mt-CO_2 in 2009, 65.4% of the total, a reduction in 12.9% from 1990. On the other hand, emissions from households reached 6.375 Mt-CO_2 in 2009, an increase of 6.4% from 1990. The commercial sector emitted 3.024 Mt-CO_2 in 2009, an increase of 21.4% from 1990 (Hyogo Prefecture, 2011).

To combat global warming, in July 2000 Hyogo put into effect the ‘Promotion Plan for Global Warming Prevention’, and revised it in July 2006. The plan targets a 6% reduction in GHG emissions by 2010 compared to 1990, and Hyogo has made efforts over past years to reduce the GHG emissions generated from industry, especially large energy-consuming companies. Since July 1996 any newly established entities are required to conduct a global warming impact assessment if their incremental energy use exceeds 1,500 kloe (kilolitres of oil equivalent) and notify the Hyogo government before construction starts. Further, such companies must take measures to control their GHG emissions the conduct the required measurements. Since October 2003, existing entities with an annual energy use exceeding 1,500 kloe (about 580 entities in 2009) are mandated to report their plans to mitigate GHG emissions and the results of any measures adopted. From 2007, guidance was provided for large scale entities (annual energy use of over 3,000 kloe; 200 entities in 2009) to further reduce CO_2 emissions. For SMEs that are not covered by the reporting programme, guidance has been provided to prepare plans to mitigate GHG emissions since 2007, and such guidance covers about 1,600 entities with soot and smoke generation facilities established according to the ‘Air Pollution Prevention Act’, and around 2,000 convenience stores, supermarkets, home centers and restaurants operated under 20 companies, each with total energy usages of over 1,500 kloe per year.

Besides administrative measures, Hyogo government has also used economic incentives to encourage industry to reduce its GHG emissions. From 2009 to 2010, subsidies were provided for small businesses to establish solar power systems, energy saving facilities and heat insulation equipment. In 2011, model energy saving projects were recruited in these businesses, and those selected were expected to promote climate awareness via dissemination, such as seminars. To add flexibility into the promotion of CO_2 emissions reductions, the domestic carbon credit programme is used to a certain extent. In this innovative approach, large companies are encouraged to provide technological and financial assistance to their SME counterparts that lack any voluntary action plans. Any resulting reductions achieved by this kind of cooperation are accredited to the large companies.

Other CO_2 mitigation measures were adopted too. One is the establishment of the ‘Consultative Centre for CO_2 Mitigation Cooperation Project’, which provides a comprehensive range of services covering consultation, guidance and project matching. In 2010, the centre launched a project to match the needs between large and small entities. In the scheme, the emissions reductions of several SMEs are combined and jointly transferred to large companies, which has resulted in some successful matchups (Hyogo Prefecture, 2012b).

5. Methodology

5.1 Outline of the questionnaire survey and samples

The data for this analysis was collected by a questionnaire survey from July to October, 2012. The questionnaire was designed with the major objectives of identifying, from a company’s perspective, its ESAs, awareness of various energy saving policies and the affordability of energy cost increases resulting from the start of MBIs and comprises six sections: general company information; energy use and management status; energy saving practices; barriers hindering investments in energy saving technologies; degree of awareness and acceptability of various energy saving policies; and the degree of affordability in terms of alternative energy cost increases. This chapter analyses the energy saving practices and the factors affecting such practices based on the collected data.

Ideally, it was intended for top management within the companies targeted to fill out the questionnaire as they are the best representatives of their companies. However, due to past difficulties encountered in questionnaires conducted in China and Korea (Liu et al., 2012; Suk et al., 2013), we opted to target energy managers at the mid-management level in this study, as they are responsible for internal energy management and thus would have extensive knowledge of such. In the questionnaire preface explaining the survey objectives and requirements is a request addressed specifically to energy managers to answer the questions on behalf of their companies, and their responses are assumed to accurately represent the current situation within their companies. The surveys were conducted, over a period of four months, with the assistance of two local organisations, 'Hyogo Environmental Protection Management Association' and 'Division of Global Warming Countermeasures, the Government of Hyogo', in order to obtain more comprehensive responses from the companies. Questionnaires were mailed out to all 465 industrial companies with annual energy usages exceeding 1,500 kloe, in Hyogo. Of these, 117 were environmental association members, who received the questionnaire together with a letter of the association requesting their cooperation. For the remaining 348 companies, the questionnaires were accompanied with a letter from Hyogo government requesting cooperation. Of the 230 valid responses received, 72 came from association members and 158 from the other group, for a return rate of 49.5%. The distribution of valid samples by sector and size is shown in table 6.1.

Table 6.1 Distribution of valid respondents by sector and size

Sector	Size			Number in total
	Small	Medium	Large	(%)
Food processing	0	32	10	42 (18.3)
Chemical	0	24	6	30 (13.0)
Iron & steel	0	12	8	20 (8.7)
Electronics	0	12	13	25 (10.9)
Other	4	84	25	113 (49.1)
Number in total (%)	4 (1.7)	164 (71.3)	62 (27.0)	230 (100.0)

The samples from food processing, chemical, iron & steel and electronics industries individually account for 18.3%, 13.0%, 8.7% and 10.9% of the total, with the remaining 49.1% accounted for by various other minor sectors. Of the 230 samples, only four were small companies, with staffs of under 20; 62 were large companies, with staffs exceeding 300 and registered capital exceeding 300 million JPY. The remaining 164 were medium-sized according to the criteria of 'Small and Medium-sized Enterprise Basic Act' of Japan.

5.2 Econometric approach

5.2.1 Valuation of the variables

5.2.1.1 Dependent variable

TESA is a dependent variable in this analysis. The breadth of a company's energy saving efforts may be represented by the establishment of energy saving goals and management procedures, as well as actual physical actions. However, trying to quantify a company's actual level of energy saving practiced is problematic since it doesn't necessarily equate to the sum of energy saving plans and practices. The solution to this representational issue is to list a series of ESAs that reflect on a company's engagement in various forms of energy saving; the number of practiced ESAs may then be used as a proxy for a company's *TESA*. Table 6.2 lists 15 representative ESAs for companies, the corresponding descriptions of which were used in the questionnaire to elicit whether the targeted companies practiced them or not. Since the relative importance of each activity for a company is difficult to quantify, the 15 activities in table 6.2 are assumed to equally contribute to a company's *TESA*. A value of '1' was given to an activity if the company had adopted it; '0' if not. Each ESA item thus produces a score of '1' or '0'. The sum of scores for all 15 ESAs is used to represent a company's *TESA*; the higher this score, the higher the level of energy saving practices.

Table 6.2 Description of energy saving activities and valuation

Item	**Description**	**Valuation**	
		0	**1**
ESA1	Set up targets for energy saving and GHG mitigation		
ESA2	Establish internal energy management institution with staffs having specific responsibilities		
ESA3	Establish internal management regulations on energy saving and GHG mitigation		
ESA4	Conduct energy auditing to comprehend state of internal energy use and saving potentials		
ESA5	Investment in new production facilities for energy saving		
ESA6	Strengthen daily maintenance of production equipment for energy saving		
ESA7	Install monitoring devices for the statistics of internal energy use		
ESA8	Promote eco-design and develop energy efficient products		
ESA9	Optimise the transportation of raw materials and products for energy saving		
ESA10	Arrange internal training of employees to raise their energy saving awareness		
ESA11	Promote daily energy saving activities in offices: lighting, air-conditioning, etc.		
ESA12	Collect information on energy saving and GHG mitigation policies		
ESA13	Adjust the structure of energy consumption by using cleaner energies		
ESA14	Participate in energy saving pilot projects in cooperation with universities and governments		
ESA15	Apply for energy saving subsidies from the governments and other organisations		

5.2.1.2 Independent variables

The proxies of independent variables as determinant factors are listed in panel A of table 6.3.

Table 6.3 Description of determinant factors, control variables and valuation

Variable		Description and proxy	Valuation				
			1	2	3	4	5
Panel A: Independent variables							
External pressures	Coercive	Strength of governmental requirements of energy saving (REGULATION)					
	Normative	Influence of industrial association of the same sector (ASSOCIATION)					
	Mimetic	Degree of competition of the company sales market (COMPETITION)					
Internal factors	Strategy orientation	Awareness of internal energy use and problems (AWARENESS)					
		Willingness to improve energy efficiency (WILLINGNESS)					
	Top support	Top management support of energy saving activities (TOPSUPPROT)					
	Learning capacity	Frequency of internal training on energy saving (TRAINING)					
Panel B: Control variables							
Characteristics of the firm		Company size (SIZE)					
		Industrial sector (SECTOR)					
		Current price level of energy (ENPRICE)					

The descriptions of independent variables were directly used as the survey items in the questionnaire. A five-level method was applied for the valuation of independent variables, in which companies were requested to score the level or degree of each factor using numbers 1–5: thus ‘1’ = very low; ‘2’ = relatively low; ‘3’ = moderate; ‘4’ = relatively high; and, ‘5’ = very high. There are two exceptions: The first is the influence of industrial associations within a certain sector, ‘ASSOCIATION’, as the proxy for normative pressure for a company. For this, five classifications were applied, with ‘5’ representing a major function of a company as the association member, ‘4’ an active function, ‘3’ a limited role, ‘2’ not an association member but planning to join and ‘1’ for not a member and no plans to join. The second exception is the in-house training of employees in energy saving, ‘TRAINING’, to represent a company’s learning capacity. For this, five classifications were applied, with ‘1’ = never arranged training for employees; ‘2’ = train 1 to 3 times per year; ‘3’ = 4 to 6 times per year; ‘4’ = 7 to 12 times per year; and, ‘5’ = over 12 times per year.

5.2.1.3 Control variables

As indicated in panel B of table 6.3, a company’s size, industrial sector and level of energy price are defined as controls, and are represented by ‘SIZE’, ‘SECTOR’ and ‘ENPRICE’, respectively. For the valuation, the company size is classified into SMEs and large companies since the number of small respondents was only four. They are respectively named SME and LARGE. There are five sectors: food processing, chemicals, iron & steel, electronics and other, notated as

‘FOOD’, ‘CHEMICALS’, ‘STEEL’, ‘ELECTRONICS’ and ‘OTHER’. Regarding ‘ENPRICE’, the companies were asked to allot scores to evaluate the current general price level of domestic energy, with ‘1’ = very low; ‘2’ = relatively low; ‘3’ = moderate; ‘4’ = relatively high; and, ‘5’ = very high. Companies that perceived a higher level of pressure from energy prices should theoretically be more motivated to save energy.

5.2.2 Empirical model for the analysis

The regression capturing the relationships between *TESA* and the classified variables can be expressed by the equation below, where ε represents the error term and β_0 the constant.

$$\begin{aligned} TESA = \beta_0 + \beta_1 REGULATION + \beta_2 ASSOCIATION + \beta_3 COMPETITION \\ + \beta_4 AWARENESS + \beta_5 WILLINGNESS + \beta_6 TOPSUPPORT \\ + \beta_7 TRAINING + \beta_8 SIZE + \beta_9 SECTOR + \beta_{10} ENPRICE + \varepsilon \end{aligned}$$

6. Results and discussion

6.1 Statistics of company ESAs

Figure 6.3 provides a summary of ESAs adopted by the surveyed Hyogo companies.

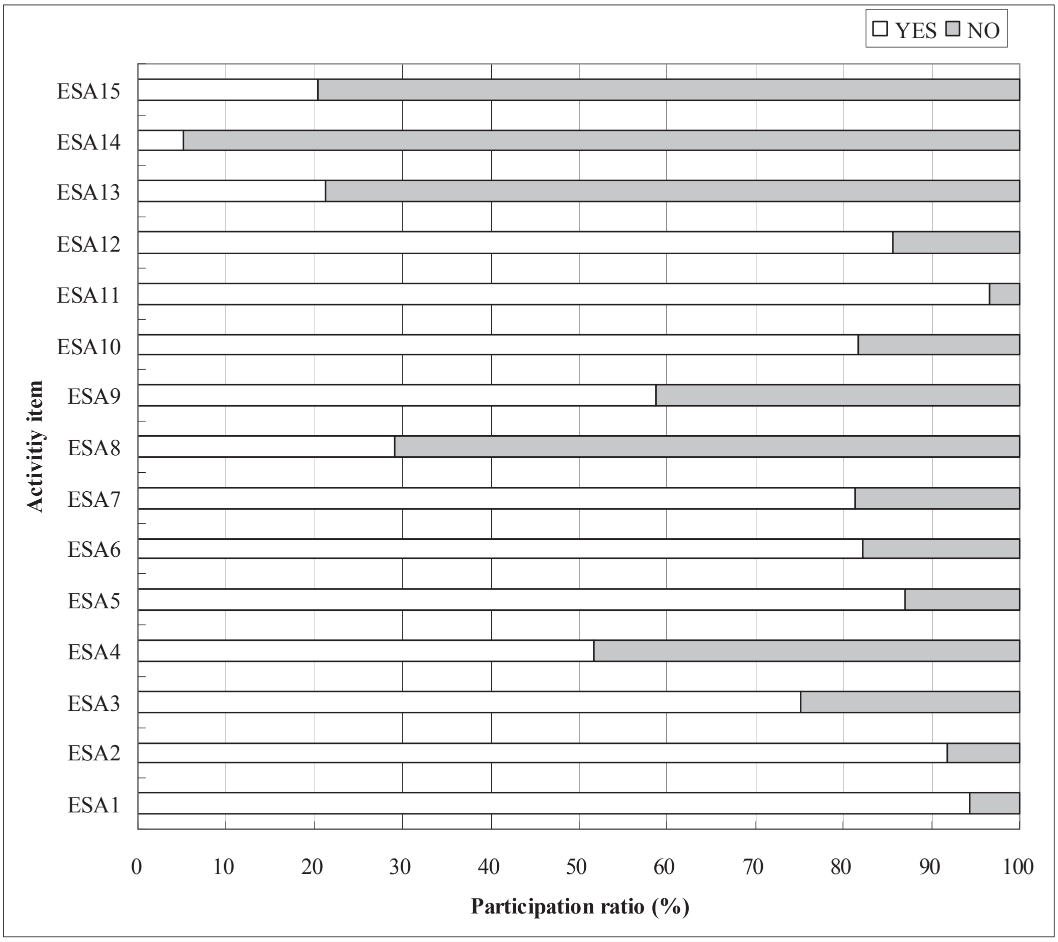

Figure 6.3 Distribution of a company’s energy saving activities (N=230)

Overall, the companies actively practiced the pre-classified ESAs. ESA11 (Promote daily energy saving activities in offices: lighting, air-conditioning, etc.) is the most adopted practice, with a 'YES' answer ratio of 96.5%. The other two ESA items with participations above 90% are ESA1 (Set up targets for energy saving and GHG mitigation) and ESA2 (Establish internal energy management institution with staff having specific responsibilities). Collectively, these three ESA items with the highest rates of participation are energy saving practices related to institutional and managerial measures. This demonstrates that such companies have adopted a common-sense approach, in that institutional and managerial ESAs usually incur lower costs than ESAs based on technology and engineering, i.e., physical measures, therefore companies initially tend to adopt these ESAs due to their simplicity. This finding is consistent with our previous surveys of companies in China and Korea (Liu et al., 2012; Suk et al., 2013).

Figure 6.3 shows that the surveyed Hyogo companies also have good practices in technological and engineering ESAs. The examples include ESA5 (Investment in new production facilities for energy saving) and ESA7 (Install monitoring devices for the statistics of internal energy use), achieving participation ratios of 87.0% and 81.3%, respectively. On the other hand, ESA14 (Participate in energy saving pilot projects in cooperation with universities and governments) received the lowest participation, with a 'YES' answer rate of only 5.2%. The other three ESA items with participation ratios less than 30% are ESA13 (Adjust the structure of energy consumption by using cleaner energies), ESA15 (Apply for energy saving subsidies from the governments and other organisations) and ESA8 (Promote eco-design and develop energy efficient products). Except for ESA8, the other ESAs with the lowest participation rates (ESA13, ESA15) are the practices that require the involvement of a company's external stakeholders, which implies that companies opt to practice the ESAs that they have control over. The low rate of practice of ESA8 may be attributed to the characteristics of the samples – most of them (84.8%) are manufacturing plants with headquarters, thus research and development of energy efficient products, including eco-design, may be not the responsibility of such companies.

Figure 6.4 further shows the distribution of *TESA*. Three of the 230 respondents (1.3%) practiced all 15 activities. Companies that have been involved in 9, 10 or 11 ESA items account for 17.0%, 13.0% and 17.8% of the total samples individually; around 10% of the samples have experienced 7, 8 or 12 ESA items.

6.2 Statistics of the independent and control variables

Table 6.4 summarises the independent and quantitative control variables. It shows that the surveyed companies have a high awareness of their internal energy use status and problems, with an average score of 3.75 for 'AWARENESS'. The respondents express high willingness as regards efforts in energy saving, with 'WILLINGNESS' averaged at 4.30. Pressure from the governments has been strongly felt by the companies for energy efficiency improvements, and the mean of ‘REGULATION’ is 3.86. Another independent variable having a high score is ‘COMPETITION’ (averaged at 4.25). The companies felt that the current energy price is already high (averaged at 4.12). Conversely, they evaluated the influence of industrial associations as moderate and present a mean of 3.51 for ‘ASSOCIATION’. As regards dedicated energy-saving internal training, this is not carried out frequently in the surveyed companies; around 70% of them perform it with a frequency of 1 to 3 times per year and 15% have never arranged any training for their employees. The support from top management is moderate for energy saving and the variable of ‘TOPSUPPORT’ achieved an average of 3.33.

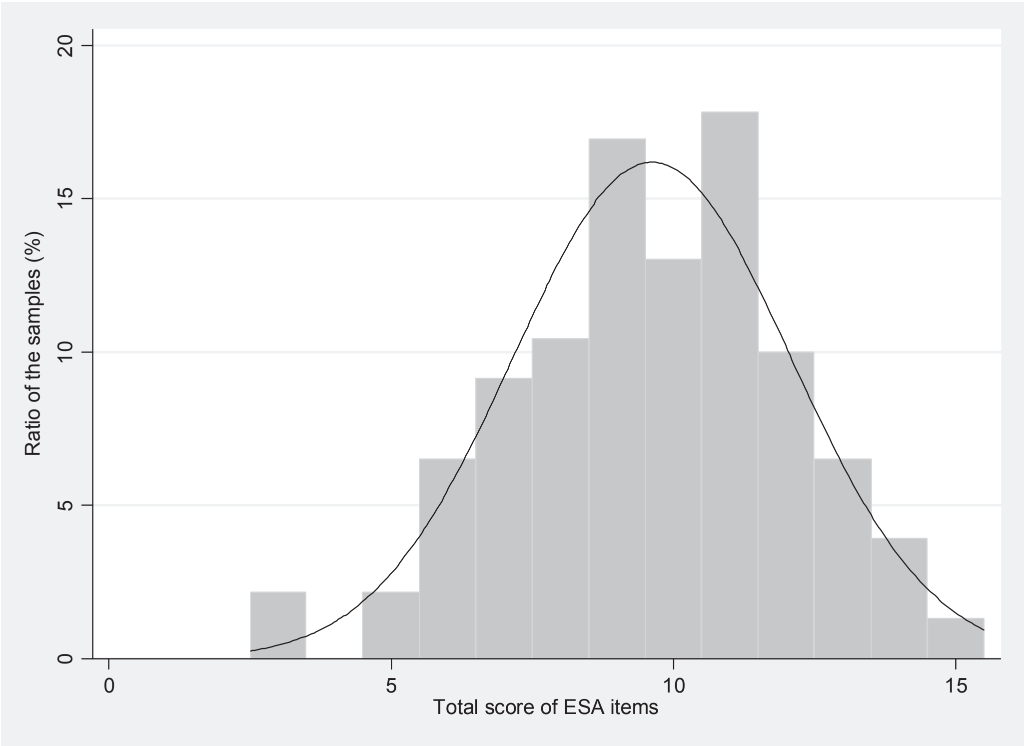

Figure 6.4 Distribution of overall scores of energy saving activities (N=230)

Regarding the categorical controls indicating a company’s characteristics, most of the samples are SMEs, as listed in table 6.1. Large companies, with more than 300 employees and a registered capital over 300 million JPY, account for 27% of the total. Small companies, with less than 20 employees, share only 1.7% of the total. The remaining 71.3% are medium-sized companies. The ratios of respondents from food processing, chemical, iron & steel, electronics sectors and other are 18.3%, 13.0%, 8.7%, 10.9% and 49.1%, respectively.

6.3 Correlation matrix and bi-variable results

Pair-wise correlation was calculated to provide an overview of the relationships between *TESA*, the independent and quantitative control variables. The correlation matrix is listed in table 6.5. There is no indication for an unacceptable level of multi-collinearity between independent and control variables as the highest coefficient is 0.367 for ‘TOPSUPPORT’ (Top manager’s support of energy saving activities) and 'WILLINGNESS' (Willingness to improve energy efficiency). Adverse levels of multi-collinearity do not occur until the correlation coefficient reaches ±0.8 or ±0.9 (Farrar and Glauber, 1967). The correlation result indicates that 'WILLINGNESS' is significantly and positively associated with *TESA* at $P<0.01$. The other variables showing positive correlations with *TESA*, significant at $P<0.01$, include 'TOPSUPPORT', 'AWARENESS', 'TRAINING' and 'ASSOCIATION'.

Table 6.4 Statistical summary of independent variables and quantitative control

Variable		Obs.	Mean	Std. Dev.	Min.	Max.
Independent	REGULATION	229	3.86	0.80	1	5
	ASSOCIATION	208	3.51	1.24	1	5
	COMPETITION	224	4.25	0.68	2	5
	AWARENESS	229	3.75	0.73	1	5
	WILLINGNESS	230	4.30	0.63	2	5
	TOPSUPPORT	229	3.33	0.61	2	4
	TRAINING	222	2.04	0.70	1	5
Control	ENPRICE	228	4.12	0.60	2	5

Table 6.5: Correlation matrix of *TESA*, dependent and control variables

	TESA	REG.	ASS.	COM.	AWA.	WIL.	TOP.	TRA.	ENP.
TESA	1								
REGULATION	0.041	1							
ASSOCIATION	0.203[a]	-0.156[b]	1						
COMPETITION	-0.003	0.200[a]	0.091	1					
AWARENESS	0.353[a]	0.091	0.168[b]	0.107	1				
WILLINGNESS	0.483[a]	-0.002	0.135[c]	-0.049	0.307[a]	1			
TOPSUPPORT	0.377[a]	0.080	0.158[b]	-0.131[c]	0.344[a]	0.367[a]	1		
TRAINING	0.234[a]	-0.063	0.089	-0.026	0.035	0.119[c]	0.131[c]	1	
ENPRICE	0.056	0.232[a]	0.042	0.278[a]	0.172[a]	0.068	0.108	-0.012	1

[a] Significant at 1% level; [b] Significant at 5% level; [c] Significant at 10% level

6.4 Factor analysis of ESA items

An exploratory factor analysis was conducted on the 15 ESA items to ascertain whether there are different dimensions to these activities. The Kaiser-Meyer-Olkin (KMO) test was used to check the appropriacy of the analysis. Table 6.6 gives the rotated component matrix of the factor analysis and KMO values.

Table 6.6 Rotated component matrix of factor analysis of ESAs and KMO values

ESA items	Factor				KMO value
	1	2	3	4	
ESA1	0.019	0.108	-0.020	0.649	0.630
ESA2	0.040	0.918	0.069	0.038	0.693
ESA3	0.019	0.334	0.201	0.345	0.743
ESA4	0.127	0.209	0.298	0.141	0.788
ESA5	0.091	0.031	0.327	0.005	0.742
ESA6	0.173	0.172	0.323	-0.030	0.717
ESA7	0.031	-0.024	0.275	-0.130	0.533
ESA8	0.107	0.148	0.513	0.140	0.802
ESA9	0.077	0.221	0.604	0.032	0.759
ESA10	0.035	0.250	0.251	0.095	0.720
ESA11	0.022	0.014	0.129	0.555	0.602
ESA12	0.112	0.438	0.215	0.155	0.769
ESA13	0.198	0.026	0.299	0.033	0.710
ESA14	0.285	0.036	0.210	0.070	0.665
ESA15	1.083	0.033	0.036	0.009	0.661

All KMO values are greater than 0.5, confirming a satisfactory factor analysis to proceed (Field, 2000). Four factors were extracted, the first of which accounts for 20.0% of the total variance and the other three each accounting for about 10%. Together, the four factors account for 45.8% of variability of the 15 ESA items. ESA14 and ESA15 are highly associated with factor 1; ESA2, ESA3 and ESA12 are associated with factor 2; ESA4 to ESA10 and ESA13 are related to factor 3 and the remaining ESA1 and ESA11 are related to factor 4. According to the result of factor analysis, four sets of ESA constructs can be categorised, as shown in table 6.7. ESA4 to ESA10 and ESA13, associated with factor 3, are the ESAs related to internally independent efforts. ESA14 and ESA15, highly associated with factor 1, are the energy saving practices carried out in cooperation with external organisations. These two groups of ESAs are therefore respectively defined as ESA_{IN} and ESA_{EX}, as used in our survey in Korea but differing from those used in the analysis of Chinese companies (Suk, et al., 2013; Liu et al., 2012). For the survey in China, the factor analysis identified two main groups of ESAs as practices instigated by managerial measures and technological approaches (Liu et al., 2012). Further, ESA2, ESA3 and ESA12 in this study are preparatory activities for energy saving, and are collectively termed ESA_{PR}. The last category is comprised of ESA1 and ESA11. ESA1 refers to the target setting of companies in energy saving and GHG emissions mitigation, and ESA11 is practiced by changing employee working habits and daily lifestyles; these we termed $ESA_{T\&H}$. Besides the overall ESA level, the level of involvement of each ESA sub-category is also used as a dependent variable in multivariate regressions to elicit any specific relationships with the determinant factors.

Table 6.7 Definition and valuation of ESA sub-categories

Abbreviation	Description of the sub-category	Valuation
ESA_{IN}	Practice level of internally independent ESAs	Sum of scores of ESA4 to ESA10 and ESA13
ESA_{EX}	Practice level of ESAs in cooperation with external organisations	Sum of scores of ESA14 and ESA15
ESA_{PR}	Practice level of preparatory ESAs	Sum of scores of ESA2, ESA3 and ESA12
$ESA_{T\&H}$	ESAs by target setting and habitual efforts	Sum of scores of ESA1 and ESA11

6.5 Multivariate analysis with *TESA* as the dependent variable

As the dependent variable of *TESA* derives from ordinal measurement, we carried out an ordered logistic regression, as shown in table 6.8. We then tested the robustness of the results by repeated regressions and omitting certain variables. Three models were adopted: Model 1 excludes all controls, Model 2 adds the quantitative control ‘ENPRICE’ for the regression, and Model 3 includes all the variables identified earlier. No obvious changes were found between the results of the three regressions. The number of observations was 199 due to incomplete data from the respondents.

The results in table 6.8 show that there are no significant relationships between *TESA* and the three external pressures. All the sampled companies have annual energy usages exceeding 1,500 kloe and are mandated to calculate and report their GHG emissions to the government according to the ‘GHG Accounting and Reporting System’. They thus felt pressure from the government, resulting in the variable of ‘REGULATION’ achieving a mean of 3.86, as listed in table 6.4. However, to date the energy saving measures taken by the industrial sector of Japan are largely the result of Keidanren’s ‘Voluntary Action Plan on the Environment’, and regulative pressure failed to function as a driver for energy saving efforts of the surveyed companies. ‘ASSOCIATION’ (Influence of industrial association of the same sector), as a normative pressure, indicates no significant relationship with *TESA*, which reveals the weak role of industrial associations in assisting Hyogo companies in energy saving practices. The insignificant role of coercive and normative pressures in determining the ESAs of the companies in Hyogo bears out in our findings from the China and Korea surveys (Liu et al., 2012; Suk et al., 2013). In our survey of SMEs based in Taicang, China, mimetic pressure was confirmed to significantly determine *TESA* (Liu et al., 2012), which implies Chinese SMEs worry about losing their comparative advantage if they fail to perform as well as their business competitors in energy efficiency. The same finding was not found in the present survey, most likely because the levels of energy efficiency of Japanese companies are roughly similar across the board. In other words, their energy saving practices cannot be differentiated by competitive pressure.

Table 6.8 Ordered logistic regression result with *TESA* as the dependent variable (N=199)

Variable	Model 1			Model 2			Model 3		
	Coef.	Std. error	P	Coef.	Std. error	P	Coef.	Std. error	P
REGULATION	0.026	0.167	0.877	0.046	0.171	0.788	0.024	0.174	0.892
ASSOCIATION	0.179	0.110	0.102	0.182	0.110	0.098	0.141	0.112	0.206
COMPETITION	0.027	0.202	0.893	0.051	0.206	0.806	0.008	0.210	0.970
AWARENESS	0.503	0.204	0.013	0.515	0.205	0.012	0.450	0.208	0.031
WILLINGNESS	1.066	0.243	0.000	1.065	0.244	0.000	0.963	0.250	0.000
TOPSUPPORT	0.550	0.240	0.022	0.551	0.239	0.021	0.554	0.241	0.022
TRAINING	0.438	0.178	0.014	0.431	0.178	0.016	0.400	0.181	0.027
ENPRICE				-0.127	0.232	0.585	-0.087	0.235	0.711
SME							-0.892	0.309	0.004
FOOD							-0.101	0.482	0.833
CHEMICAL							-0.660	0.523	0.207
STEEL							-0.213	0.619	0.731
OTHER							-0.316	0.416	0.448
LR chi		69.37[a]			69.67[a]			81.09[a]	
Pseudo R^2		0.078			0.078			0.091	

[a] Significant at 1% level.

All the internal factors, 'AWARENESS', 'WILLINGNESS', 'TOPSUPPORT' and 'TRAINING', indicate significant and positive relationships with *TESA*. The statistics of variables in table 6.4 confirm that Hyogo companies have a high awareness of their state of internal energy use and problems, as well as high willingness to improve their energy efficiency. The regression result in table 6.8 reveals that strategy orientation within companies has led to actual energy saving practices. This finding is similar to that of Suk et al. (2013) but contrasts with that of Liu et al. (2012), which documented that willingness alone does not lead Chinese SMEs to initiate real energy saving practices, due to capacity limitations. The significant and positive effect of 'TOPSUPPORT' on *TESA* in this survey confirms the usefulness of support from top managers in enhancing a company's energy saving practices, especially for SMEs. Similarly to Liu et al. (2012), the training of employees specific for energy saving enhances the ability of Hyogo companies to practice ESAs and is significantly associated with *TESA*.

As shown in table 6.8, 'ENPRICE' is not significantly associated with *TESA*. This contrasts with the results of Fisher-Vanden et al. (2004), Prindle (2010) and Liu et al. (2012), who confirmed that energy price pressure and motivation for energy cost reductions act as principal drivers for improving the energy efficiency of industry. Nevertheless, organisation size is significantly associated with *TESA* in this analysis. Compared with large companies, SMEs demonstrated less involvement in energy saving practices, a result that agrees with the resource-based perspective and previous studies confirming that larger organisations are more likely to adopt proactive environmental practices (Sharma, 2000). There is no significant difference in energy saving practices of companies from various sectors, probably because our survey targeted companies within a small area and the respondents from different industries exhibited similar levels of performance in energy saving.

We also calculated the marginal effects of the determinant factors in influencing a company's *TESA*. As shown in fig.6.4, a total of 12 score categories are shown for *TESA*. Table 6.9 lists the marginal effects of related factors, including the four internal factors and organisation size, for each *TESA* value.

The results reveal that enhancement of the internal factors ('AWARENESS', 'WILLINGNESS', 'TOPSUPPORT' and 'TRAINING') would decrease the possibility for companies to practice nine or less ESA items but increase the possibility of a *TESA* of 10 and over. Compared with large companies, SMEs could be categorised as laggard ESA performers since they are more likely to practice 10 or less ESA items. 'WILLINGNESS' indicates higher marginal effects in influencing a company's *TESA*, confirming that improvement in a company's willingness to save energy is more effective for enhancing their ESAs.

Table 6.9 Calculation results of marginal effects of factors affecting *TESA*

Score of	Marginal Effects (%)					Predicted
TESA	AWARENESS	WILLINGNESS	TOPSUPPORT	TRAINING	SME	Possibility (%)
3	-0.45	-0.97	-0.56	-0.4	0.76	1.02
5	-0.55	-1.17	-0.67	-0.49	0.92	1.26
6	-1.74	-3.72	-2.14	-1.54	2.97	4.23
7	-2.08	-4.46	-2.57	-1.85	3.65	5.7
8	-3.04	-6.51	-3.74	-2.7	5.59	10.35
9	-3.11	-6.66	-3.83	-2.76	6.7	19.61
10	0.09	0.2	0.11	0.08	1.19	16.88
11	4.66	9.99	5.75	4.14	-7.77	24.4
12	3.41	7.3	4.2	3.03	-7.31	9.87
13	1.42	3.04	1.75	1.26	-3.32	3.5
14	1.05	2.25	1.3	0.93	-2.56	2.43
15	0.33	0.71	0.41	0.3	-0.83	0.75

6.6 Multivariate analysis with the sub-categories of ESAs as the dependent variables

In the section covering factor analysis, four sets of ESAs are constructed and defined as ESA_{IN}, ESA_{EX}, ESA_{PR} and $ESA_{T\&H}$ individually. The regression analysis was repeated by replacing *TESA* in Eq. (2) with each ESA sub-category as the dependent variable. The results of analysis for ESA_{IN}, ESA_{EX} and ESA_{PR} are listed in tables 6.10, 6.11 and 6.12, respectively. $ESA_{T\&H}$ is omitted here since significant relationships between this ESA category and the identified factors were not found.

ESA_{IN} in table 6.10 is not explained here as since this was already covered with regards to *TESA* in section 6.5. The pre-classified factors influence ESA_{EX} and ESA_{PR} in a different manner. As shown in table 6.11, both external pressures and internal factors indicate no significant relationship with ESA_{EX}. However, 'ENPRICE' (the pressure of domestic energy prices) is significantly and positively associated with this type of ESA. Companies in the iron & steel sector practice ESA_{EX} better than those in the electronics sector, which implies that energy-intensive companies are more motivated to seek the cooperation and support from external organisations such as the government in pursuit of higher energy efficiency.

Table 6.10 Ordered logistic regression result with ESA_{IN} as the dependent variable (N=199)

Variable	Model 1			Model 2			Model 3		
	Coef.	Std. error	P	Coef.	Std. error	P	Coef.	Std. error	P
REGULATION	-0.120	0.166	0.469	-0.096	0.171	0.574	-0.091	0.170	0.592
ASSOCIATION	0.090	0.107	0.398	0.092	0.107	0.391	0.065	0.109	0.551
COMPETITION	-0.071	0.201	0.725	-0.042	0.207	0.840	-0.066	0.211	0.755
AWARENESS	0.410	0.203	0.043	0.420	0.204	0.039	0.361	0.206	0.080
WILLINGNESS	0.821	0.239	0.001	0.823	0.240	0.001	0.770	0.248	0.002
TOPSUPPORT	0.516	0.242	0.033	0.521	0.241	0.031	0.492	0.244	0.044
TRAINING	0.524	0.182	0.004	0.515	0.183	0.005	0.491	0.186	0.008
ENPRICE				-0.140	0.235	0.550	-0.108	0.235	0.645
SME							-0.875	0.307	0.004
FOOD							-0.232	0.499	0.642
CHEMICAL							-0.701	0.520	0.178
STEEL							-0.601	0.626	0.337
OTHER							-0.192	0.423	0.649
LR chi		52.25[a]			52.61[a]			63.66[a]	
Pseudo R^2		0.069			0.070			0.085	

[a] Significant at 1% level

The results shown in table 6.12 confirm that certain internal factors, especially 'AWARENESS' and 'WILLINGNESS', are significantly and positively related to ESA_{PR}. On an intuitive level, this would be natural, however, since any company with an energy-based strategic orientation would need to at least perform some kind of preparations, such as in the collection of related information and the establishment of an internal energy management system. Chemical companies are behind the electronics sector in the preparatory ESAs.

Table 6.11 Ordered logistic regression result with ESA_{EX} as the dependent variable (N=199)

Variable	Model 1			Model 2			Model 3		
	Coef.	Std. error	P	Coef.	Std. error	P	Coef.	Std. error	P
REGULATION	0.374	0.256	0.143	0.254	0.260	0.329	0.143	0.258	0.579
ASSOCIATION	0.214	0.160	0.180	0.225	0.163	0.166	0.180	0.165	0.277
COMPETITION	0.439	0.285	0.123	0.304	0.295	0.304	0.279	0.305	0.360
AWARENESS	0.096	0.271	0.724	0.056	0.285	0.845	0.118	0.289	0.684
WILLINGNESS	0.352	0.333	0.290	0.345	0.331	0.297	0.156	0.354	0.660
TOPSUPPORT	0.258	0.334	0.441	0.232	0.339	0.494	0.294	0.355	0.407
TRAINING	0.184	0.236	0.437	0.208	0.242	0.391	0.222	0.243	0.362
ENPRICE				0.730	0.337	0.030	0.687	0.341	0.044
SME							-0.573	0.394	0.146
FOOD							0.133	0.715	0.852
CHEMICAL							0.365	0.740	0.622
STEEL							1.561	0.772	0.043
OTHER							0.228	0.617	0.712
LR chi		12.60[c]			17.52[b]			24.92[b]	
Pseudo R^2		0.048			0.067			0.096	

[b] Significant at 5% level; [c] Significant at 10% level

Table 6.12 Ordered logistic regression result with ESA_{PR} as the dependent variable (N=199)

Variable	Model 1			Model 2			Model 3		
	Coef.	Std. error	P	Coef.	Std. error	P	Coef.	Std. error	P
REGULATION	0.020	0.208	0.922	0.069	0.214	0.748	0.037	0.224	0.868
ASSOCIATION	0.118	0.137	0.387	0.124	0.137	0.367	0.107	0.143	0.455
COMPETITION	-0.113	0.258	0.663	-0.067	0.264	0.801	-0.082	0.271	0.762
AWARENESS	0.688	0.252	0.006	0.723	0.258	0.005	0.754	0.269	0.005
WILLINGNESS	0.820	0.301	0.006	0.838	0.304	0.006	0.707	0.316	0.025
TOPSUPPORT	0.382	0.299	0.202	0.409	0.302	0.176	0.444	0.309	0.150
TRAINING	0.045	0.208	0.828	0.039	0.209	0.853	0.053	0.216	0.806
ENPRICE				-0.281	0.298	0.346	-0.265	0.303	0.382
SME							-0.428	0.411	0.297
FOOD							-0.716	0.785	0.362
CHEMICAL							-1.268	0.768	0.099
STEEL							-1.004	0.874	0.251
OTHER							-1.173	0.715	0.101
LR chi		35.04[a]			35.94[a]			41.88[a]	
Pseudo R^2		0.098			0.101			0.118	

[b] Significant at 5% level; [c] Significant at 10% level

7. Conclusions

This chapter sought to identify the determinant factors for industrial companies to practice ESAs and involved an empirical study in Hyogo Prefecture, Japan. The pre-classified factors are partly confirmed by the econometric analysis. External pressures from government, industrial associations and business competitors are insignificant in determining a company's energy saving practices, which implies that public organisations in Japan need to take a more proactive stance and urge companies to operate with higher energy efficiency. The energy saving efforts of the sampled companies may be mainly due to individual business strategies and energy saving motivations, based on the finding of significant and positive relationships between the four internal factors and *TESA*. Large companies perform better in energy saving than their small and medium-sized counterparts. No variation in overall level of energy saving practices was found over companies in different sectors.

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PART IV:

AWARENESS AND ACCEPTABILITY OF COMPANIES ON MARKET-BASED INSTRUMENTS

Chapter 7:

Awareness and acceptability of Chinese companies on market-based instruments for energy saving: A survey analysis by sector*

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Chapter Highlights:

- This chapter provides a survey analysis of Chinese companies on their awareness and subjective acceptability of market-based climate policies, targeting energy-intensive iron & steel, cement and chemical sectors.
- Data from a total of 170 respondents was collected for the econometric analysis. Overall, the companies reveal low to moderate awareness of MBIs, particularly for the carbon pricing policies under discussion.
- The sampled Chinese companies show good acceptability to industrial energy saving policies in general. The economic incentives and voluntary approaches are appreciated more.
- The companies highly expect energy saving investments to be profitable, with acceptable payback times ranging from 1–3 years.
- The companies would take internal efforts to relieve the economic burdens from the pricing of carbon emissions rather than simply passing on the costs on to their clients. This confirms implementing carbon pricing policies would be effective in practice.

1. Introduction

The adoption of MBIs for improving energy efficiency and mitigating CO_2 emissions has been much slower in Northeast Asia, including China (Liu et al., 2011). Expert-level discussions on carbon tax policy have taken place in China's related ministries (Wang et al., 2009); however, the proposed tax rates are very conservative, meaning that the policy efficacy would be marginal (Su et al., 2009). To gradually establish an integrative domestic carbon market has been mentioned in the country's 12th Five-Year Plan for National Economic and Social Development

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* The main content of this chapter was published as: Liu, X.B., Wang, C., Zhang, W.S., Suk, S.H., Sudo, K., 2013. Awareness and acceptability of Chinese companies on market-based instruments for energy saving: A survey analysis by sector. *Energy for Sustainable Development* 17(2013): 228-239.

(2011-2015), endorsed in March 2011. In October 2011, the National Development and Reform Commission (NDRC) launched pilots for carbon emissions trading in five metropolitan areas (Beijing, Tianjin, Shanghai, Chongqing and Shenzhen) and two provinces (Guangdong and Hubei) (NDRC, 2011), but no specific decisions on how to set emissions caps have been made and there is no fixed timetable for formal introduction of domestic GHG ETS. On the other hand, a large potential remains for Chinese manufacturing industries to improve their energy efficiencies due to the irrational structure and obvious technology gaps (Cai et al., 2008). China would thus benefit from gradual introduction of MBIs to enhance its industrial energy saving efficiently.

Studies solely based on economics may not offer sufficient evidential credibility in support of practical policy decisions. For instance, Henriksson and Söderholm (2009) confirmed that an electricity tax could function better in energy-intensive companies while an energy management system would be more effective in companies with low energy intensities due to their lack of prior experience of energy efficiency measures. Krarup and Ramesohl (2002) examined agreement schemes for industrial energy efficiency in five European countries and confirmed that voluntary agreements can play a useful role if integrated into a climate policy mix. Since company awareness and acceptability of a policy largely determine the whether such policy succeeds or not, it is vital to conduct policy analysis at the company level (Dieperink et al., 2004). Previous studies have analysed the effectiveness of MBIs in affecting a company's efforts in energy saving in developed economies (Blok, 1993; De Groot et al., 2001; Klok et al., 2006).

However, research identifying the success conditions of industrial energy efficiency policies is still very limited, especially as regards the practice of MBIs in developing countries. In order to identify such conditions this chapter measures the awareness and acceptability of Chinese companies on MBIs related to industrial energy saving. Three sectors, iron & steel, cement and chemicals, were targeted due to their high energy intensities and significance in realising the country's overall target of energy efficiency. Three topics are discussed in this chapter: a) Company awareness and acceptability levels of the pre-listed MBIs for energy saving; b) Relationships between a company's policy awareness, acceptability and the classified determinants; and, c) Company behavioral changes of energy management in response to MBIs.

The remainder of this chapter is structured as follows. Section 2 develops the analytical framework and identifies the determinants of a company's policy awareness and acceptability, section 3 outlines the background of the three target sectors, section 4 explains the methodologies, section 5 discusses the statistics of company policy awareness and acceptability, and the econometric analysis results and section 6 concludes this survey analysis.

2. Development of analytical framework

2.1 Development of analytical framework of this study

The analytical framework of this study is developed as in fig.7.1.

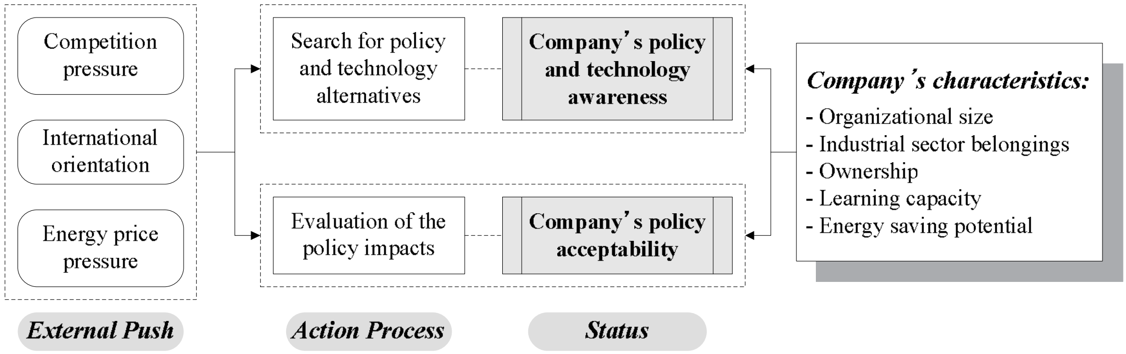

Figure 7.1 Analytical framework of this study

Institutional theory elucidates the overall context for discussing a company's environmental behaviors (Liu et al., 2010). Following the institutional perspective, our model acknowledges the importance of external pressures for driving a company to identify its energy management problems and correspondingly to search for energy efficiency related policies and technologies as a form of strategic information. A company's policy awareness depends on the extent of related information collected and absorbed into the company. It is thus rational to infer that a company's acceptability to a policy would be determined by the company's evaluation of the policy's impacts on its comparative competitiveness, either actually experienced or perceived. The external pressures may determine a company's policy acceptability by influencing its forecast of the policy impacts. Although better awareness of a specific policy would be useful for a company to more finely evaluate the policy impacts, it should be kept in mind that higher policy awareness does not necessarily lead to higher policy acceptability.

In terms of the general social-political context, governmental regulations and expectations from special groups, such as industrial associations, are viewed as essential external pressures for enhancing a company's environmental behaviors (Liu et al., 2010). However, the existing governmental requirements relating to industrial energy efficiency still fail to regulate small and medium-sized enterprises (SMEs), which share a large portion of the samples in this survey. The industrial associations are currently weak in China; their functions in assisting the companies in energy saving practices are very limited (Liu et al., 2012). This is why we excluded the coercive and normative pressures from the analytical frame of this study. Meanwhile, some evidence points to the fact that market competition operates as an incentive for the companies to obtain strategic information (De Groot et al., 2001), and factors related to international environmental aspects were also confirmed to positively influence a company's proactive environmental strategy (Aguilera-Caracuel et al., 2012). One of our previous surveys in China confirmed the usefulness of business competitors and energy price pressure for encouraging a company's energy saving practices, including the collection of information on energy saving policies and technologies (Liu et al., 2012). Three factors – competition pressure, international orientation and energy price pressure – are therefore classified as external pressures in this frame.

Besides the external pressures, a company's organisational capabilities are required for appropriately reacting to environmental policies (Christensen and Rosenbloom, 1995). Small companies are usually at a disadvantage in obtaining strategic information (Gruber and Brand, 1991). Further, smaller and financially constrained companies are more susceptible to economic incentives than their larger or financially less constrained counterparts (Skuras et al., 2006). The industrial energy saving policies in China focus on the large energy-consuming companies, which have more experience in dealing with energy efficiency programmes (Price et al., 2008). Henriksson and Söderholm (2009) found that if a voluntary agreement and a tax on energy are in place, the companies with high energy cost shares tend to opt for the former, which implies that the energy-intensive sectors are more sensitive to carbon pricing instruments. This is why carbon tax policy proposals always recommend certain relief measures for these sectors (Liu et al., 2011). In addition, companies with higher energy saving potentials can more flexibly deal with climate-related costs through self-reduction efforts. With the aim of identifying differences in policy awareness and acceptability due to company characteristics, organisational size, sector belongings, ownership, learning capacity and energy-saving potential are added as controls in this model.

2.2 Industrial energy saving policies included in this survey

The descriptions and abbreviations of policies in this survey are listed in table 7.1.

There are seven MBI policy items in table 7.1: MBI01 (Financial subsidies and rewards for energy saving investment and projects) to MBI05 (Differential electricity prices according to the company's energy efficiency levels) that are already in force, and MBI06 (Carbon tax policy) and MBI07 (Carbon emissions trading scheme), which are under discussion. MBI06 is separated into two sub-categories, MBI06A and MBI06B, respectively representing a carbon tax with no relief measures and that with tax revenues fully recycled into energy saving efforts. MBI07 is also divided into two: MBI07A refers to the scheme that solely targets large carbon emitting companies and MBI07B refers to the trading of voluntary emissions reductions (VERs). Two other types of energy saving policies are listed in the survey document, which are used to compare a company's acceptability of these policies in practice and MBIs. One category is command and control regulations (CCRs), including CCR01 (Set up comprehensive energy use thresholds by sectors) to CCR04 (Energy evaluation system for the new projects and energy-intensive equipment); the other is voluntary approaches (VOLs), including VOL01

(Certification of energy saving products and energy efficiency labeling) to VOL03 (Voluntary agreements of the companies and government on energy saving). The policy descriptions in table 7.1 are listed as-is in the questionnaire survey.

Table 7.1 Descriptions and abbreviations of policies in this survey

Category	Descriptions	Abbreviations
Command and Control Regulations (CCRs)	Set up comprehensive energy use thresholds by sector	CCR01
	Set up energy use thresholds for energy-intensive equipments and products	CCR02
	Energy saving target setting and evaluation for the key energy-using companies	CCR03
	Energy evaluation system for the new projects and energy-intensive equipments	CCR04
Market-based Instruments (MBIs)	Financial subsidies and rewards for energy saving investment and projects	MBI01
	Financial subsidies for research and development of energy saving technologies	MBI02
	Preferable tax policy for energy saving products and technologies	MBI03
	Adjust rebate ratios of tariffs to limit the export of energy-intensive products	MBI04
	Differential electricity prices according to the company's energy efficiency levels	MBI05
	Carbon tax policy with no relief measure and revenue recycling	MBI06A
	Carbon tax policy with the revenue fully recycled for energy saving	MBI06B
	Carbon emissions trading scheme targeting the key energy-consuming companies	MBI07A
	Voluntary emissions reductions and trading scheme	MBI07B
Voluntary Approaches (VOLs)	Certification of energy saving products and energy efficiency labeling	VOL01
	Government procurement of energy saving products	VOL02
	Voluntary agreements of the companies and government on energy saving	VOL03

3. Background of the three target sectors

China has been the largest steel producer and consumer in the world since 1996. In 2010, the total production of crude steel in China reached 627 million tonnes, accounting for about 45% of the total from all 66 steel-producing countries globally. In spite of large improvements to product structures in last decade, the ratio of high added-value plates and strips to the total of steel products was 50.8% in China in 2009, which is much lower than that of developed economies (CISA, 2010). China's iron and steel industry is highly fragmented overall, although is showing signs of market consolidation. The sector contained 7,773 companies in 2009, the production of domestically private companies of which had a share of over 88% of the total. The market concentration rate (CR) of the top four steel makers increased to 27.8% and the ratio of the top ten companies was 48.6% in 2010 (CISA, 2010). Coal is the most-used fuel in the iron & steel industry and accounted for about 70% of total energy use in 2000, including 46.1% coking coal and 24.9% power coal. In 2004, the energy use mix of China's steel industry was coal 69.9%, electricity 26.4%%, fuel oil 3.2% and natural gas 0.5% (CISA, 2004). The energy consumption of the iron & steel industry has a share of 10–15% of the national total during 1995–2004 and this figure increased to 18.4% in 2009 (NBSC, 2010). There has been a remarkable reduction in the energy intensity of China's iron & steel industry over the past two decades; the total energy consumption per tonne of steel production decreased from 997 Kgce (Kg coal equivalent) in 1990 to 697 Kgce in 2009 for large and medium-sized companies. However, there is still a large difference in the energy efficiency level of China's steel industry and that of the world's best, implying that there is significant potential for energy saving in this sector (NBSC and NDRC, 2010). Accordingly, the energy costs of China's iron & steel companies are relatively high. The proportion of energy cost to the total production cost of large and medium-sized steel companies ranges from 20 to 30% (Lei, 2009). Using the average heat values of China's fossil fuels and carbon emission coefficients obtained from IPCC, the CO_2 emissions from China's iron & steel industry was estimated at 1232.9 million tonnes in 2007, 15.9% of the nation's total (WRI, 2009).

Cement is the most important building material in China; its output represents a share of over half in the building materials industry. China has been the world's top cement producer since 1985, and in 2008 it produced nearly 1.4 billion tonnes of it – about half of the total global output (CCA, 2008). The Chinese cement sector is characterised by its low industrial concentration; the production of the ten largest cement companies accounts for only 18.75% of total domestic output, while the three largest companies in the world produce more than 50% of global total. The average scale of a cement company in China is 200 kt, much lower than the world average of 900 kt (Cai et al., 2009). As unprecedented macro-control measures have been implemented, such as phasing out of out-of-date production capacities, the ratio of New Suspension Pre-heated Dry Process (NSP) has grown from 13.7% in 2000 to 55% in 2007 (CCA, 2008). In 2009, total energy consumption of China's cement industry was about 153 million tce, of which coal took the largest share of 86.2%, followed by electricity at 11.0%. Usually, coal and electricity cost account for more than 50% of the total production cost of cement companies (Zhou, 2008). China's cement sector emitted a total of 153.5 million tonnes of CO_2 in 2009, accounting for 2.2% of the national's total (WRI, 2009).

The gross output of China's chemical industry has reached about 5,230 billion Yuan, overtaking that of the U.S. to become the largest chemical production country in the world in 2010. There were 20,022 chemical companies in 2005, and by 2010 the number had risen to 31,443 (NBSC, 2006; 2011). In 2009, the chemical companies used 303.83 million tce in total, accounting for about 10.5% of the national total energy consumption (NBSC, 2010). As sub-sectors of the chemicals industry, synthetic ammonia, caustic soda, sodium carbonate, yellow phosphorus and calcium carbide are categorised as the top five energy-intensive products, which in total represent 43% of the total energy consumption in the chemicals industry in 2007 (CPCIF, 2010).

China's chemicals sector is leading the nation's industrial energy saving efforts as the energy use per unit of product has dropped over the past five years. For example, the energy used in refining a tonne of petroleum in 2009 had decreased by 5.3% compared to 2006; the energy consumption intensity for ethylene dropped by 5.8%, for pure alkali 17.2%, and for calcium carbide 10.8% (Jia, 2010). However, the total CO2 emissions from China's chemical industry, which in 1995 were about 420.1 million tonnes, had increased to 746.4 million tons by 2009, with a share of 10.6% of the nation's total as estimated by WRI (2009).

4. Methodologies

4.1 Outline of the questionnaire survey and samples

The data were collected by a questionnaire survey during August to December, 2011. A questionnaire was designed with the main objective of measuring company awareness and acceptability MBIs, and to identify the individual determinants. The format consists of four major components: general information of the company; status of company energy use and energy management; awareness and acceptability degrees of companies to various policies; and the determinant factors, as depicted in fig.7.1.

The survey was conducted via two routes, over a period of five months. One route involved recruiting students from Tsinghua University as voluntary interviewers, as its School of Environment functions as the local partner for this research. Each of the participating students was asked to select, based on company sector and size, three companies located in their hometowns as survey candidates. The students were trained beforehand on how to answer the pre-designed questionnaire. Then they established contact and visited the candidate companies during the summer holidays. The company's environmental and energy managers were directly interviewed for filling in the questionnaire. Using this route, 34 valid samples were gathered from various locations around the country. The other route involved requesting assistance from local institutes at the provincial level. Two provinces were selected, Shandong Province on the east coast and Shanxi Province in the west. 'Shandong Association of Resource Comprehensive Utilisation' and 'Shanxi Academy for Environmental Planning' coordinated the delivery and collection of questionnaires in the two provinces, respectively. In response, 57 companies in Shandong Province and 79 from Shanxi Province actively replied. A total of 170 respondents were confirmed to be useful for the analysis, the distribution of which is listed in table 7.2 by sector and size.

The respondents from iron & steel, cement and chemical sectors individually account for 30.6%, 19.4% and 22.4% of the total. Our survey did not exclude the other sectors. Paper makers have a share of 8.8% and the remaining 18.8% is from other industries. Three companies failed to provide full information on their number of staff, total capital and annual sales for judging the company size. Of the other 167 samples, 70 are small companies, having staffs of less than 300, an annual turnover below 30 million Yuan or a registered capital of less than 40 million Yuan, 22 are large companies with more than 2,000 employees, an annual turnover of more than 300 million Yuan and a registered capital of over 400 million Yuan, and the remaining 75 are medium-sized companies according to the classification criteria of China's National Bureau of Statistics.

Table 7.2 Distribution of samples by sector and size

Sector \ Size	Number of samples				Number in total (%)
	Small	Medium	Large	Unclear	
Iron & steel	14	27	10	1	52 (30.6)
Cement	24	7	1	1	33 (19.4)
Chemical	12	21	4	1	38 (22.4)
Paper	1	8	6	0	15 (8.8)
Other	19	12	1	0	32 (18.8)
Number in total (%)	70 (41.2)	75 (44.1)	22 (12.9)	3 (1.8)	170 (100.0)

4.2 Econometric approach

4.2.1 Valuation of the variables

The abbreviations, descriptions and valuations of the variables used in this analysis are listed in table 7.3. The dependents of econometric regressions include company awareness of energy saving technologies and MBIs and company acceptability of the MBIs. They are individually shortened to AWAREEXTTECH, AWARENEWTECH, AWAREMBI and ACCEPTMBI. During the survey, we requested the companies to evaluate their awareness of existing energy saving technologies and new technologies in their sector to generate scores for AWAREEXTTECH and AWARENEWTECH. A similar question was posed for the companies to evaluate their level of awareness of each MBI item and acceptability degree of energy saving policy tools. A five-likert point method was adopted for the valuation. The scores presented for the technology and policy awareness are: '5' = very clear; '4' = clear; '3' = moderate understanding; '2' = don't know well; and, '1' = completely unknown. The scale for policy acceptability is: '5' = fully acceptable; '4' = relatively acceptable; '3' = moderate acceptance; '2' = hardly acceptable; and, '1' = completely unacceptable.

Three external pushes are defined as independent variables. A five-likert scale was applied to evaluate two of them, COMPETITION and ENPRICE, with '1' = very low; '2' = relatively low; '3' = moderate; '4' = relatively high; and, '5' = very high. The export ratio of the product, EXPORT, is used as the proxy of a company's international orientation. Five classifications were applied, with '5' representing more than half of the products exported; '4' meaning a

30–50% ratio; ‘3’ meaning a 20–30% ratio; ‘2’ being a 10–20% ratio and ‘1’ for an export ratio of less than 10%.

Table 7.3 Abbreviation, description and valuation of the variables

Category	Abbreviation	Description	Valuation				
			1	2	3	4	5
Dependent	AWAREEXTTECH	Company’s awareness of existing energy saving technologies					
	AWARENEWTECH	Company’s awareness of new energy saving technologies					
	AWAREMBI	Company’s awareness of market-based instruments					
	ACCEPTMBI	Company’s acceptability of market-based instruments					
Independent	COMPETITION	Competition degree of the company’s sales market					
	EXPORT	Export rate of the product					
	ENPRICE	Perception of domestic energy price levels					
Control	SAVPOTENTIAL	Energy saving potential of the company					
	EDUCATION	Average education level of the company’s employees					
	SIZE	Company’s size					
	SECTOR	Industrial sector belongings of the company					
	OWNERSHIP	Ownership status					

Regarding the controls, the company’s size, SIZE, is classified into small, medium-sized and large, individually named SMALL, MEDIUM and LARGE. The company’s sector belongings, SECTOR, have five types: iron & steel, cement, chemicals, paper and other, which are presented as STEEL, CEMENT, CHEMICAL, PAPER and OTHER. The ownership consists of three types, state-owned, domestically private and foreign-funded (Joint-ventures and fully foreign-funded), which are abbreviated as STATEOWNED, DOMPRIVATE and FOREIGN. Average educational level of the employees, EDUCATION, was used as the proxy for a company’s learning capacity. Five classifications were applied, with ‘1’ = the ratio of employees with education of college-level or above being less than 10%; ‘2’ = 10–20%; ‘3’ = 20–30%; ‘4’ = 30–50%; and, ‘5’ = over 50%. A four-level score was presented for the company’s energy saving potential, SAVPOETNTIAL, with‘1’ = hardly for further saving; ‘2’ = limited potential; ‘3’ = relatively large potential; and, ‘4’ = very high potential.

4.2.2 Empirical models for the econometric analysis

The regression capturing the relationships between the company’s policy and technology awareness, AWAREMBI, AWAREEXTTECH and AWARENEWTECH, and the classified determinants and controls can be constructed as Eq. (1), where ε represents the error term and β_0 is the constant.

$$AWAREMBI\ (AWAREEXTTECH\ or\ AWARENEWTECH)$$
$$= \beta_0 + \beta_1 COMPETITION + \beta_2 EXPORT + \beta_3 ENPRICE + \beta_4 SAVPOTENTIAL + \beta_5 SIZE + \beta_6 SECTOR + \beta_7 OWNERSHIP + \beta_8 EDUCATION + \varepsilon \quad (1)$$

Similarly, the regression identifying the relationships between the company's policy acceptability, ACCEPTMBI, and the classified variables can be established as Eq. (2), where ζ represents the error term and λ_0 is the constant.

$$ACCEPTMBI = \lambda_0 + \lambda_1 COMPETITION + \lambda_2 EXPORT + \lambda_3 ENPRICE + \lambda_4 SAVPOTENTIAL + \lambda_5 SIZE + \lambda_6 SECTOR + \lambda_7 OWNERSHIP + \lambda_8 EDUCATION + \zeta \quad (2)$$

All the dependent variables in equation (1) and (2) are measured in an ordinal manner and there are no abrupt changes in their cumulative probabilities. An ordered probit model was applied as a reasonable choice for the analyses in section 5 (Greene, 1997). Among the explanatory variables, SIZE, SECTOR and OWNERSHIP are categorical ones. The analyses assume that the influence of other independent variables and controls are the same across these variables. All the dummies are hypothesised to only change the intercept of regressions rather than the slope.

5. Results and discussions

5.1 Energy use status of the samples

The surveyed companies were requested to elaborate on the types of energies and their corresponding ratios to total energy use. Companies were reluctant to answer this question, and only 104 (total 170; slightly over 60%) provided complete information on their energy use status. The energy use structure of the samples overall and by sector is summarised in fig.7.2.

The results confirm that coal is the largest energy source for the surveyed companies as a whole, with an average share of 53% of total energy use. Electricity is the second and accounts for nearly 25% of total energy use. Third is oil with a share of about 10%, then natural gas, steam and others comprising the remaining 12% as minor sources. There are some differences between the energy use structures of the three target sectors; coal accounts for about 62% of total energy use in iron & steel and cement companies, while this ratio is 32% on average for the chemicals sector. Oil is a major energy source for chemical companies, sharing nearly 35% of total energy use. Around 30% of the total energy used by iron & steel and cement industry is electricity. The ratio of electricity use is less than 20% for chemical companies.

Figure 7.3 shows the distribution of energy cost shares of total sales of the samples by sector. The surveyed companies indicate high ratios of energy costs in sales; only 10% of the samples have an energy cost ratio of under 5%. Nearly 15% of companies have an energy cost ratio of 5–10%. The companies with energy cost ratios of 10–20%, 20–50% and over 50% individually have a share of around 25%. Among the sectors, more than 60% of iron & steel companies have an energy cost ratio of over 20%. Only 15% of iron & steel companies have an energy cost ratio of less than 10%. The cement sector also exhibits relatively high energy intensities. Only 10% of cement companies have an energy cost ratio below 5%. Nearly 25% have an energy cost ratio of 5–10%, and more than 40% of cement companies have energy cost ratios of over 20%. Chemical companies have an even distribution of energy cost ratios. About 25% of chemical companies have a ratio of below 5%, while more than 30% of them have a ratio of over 50%.

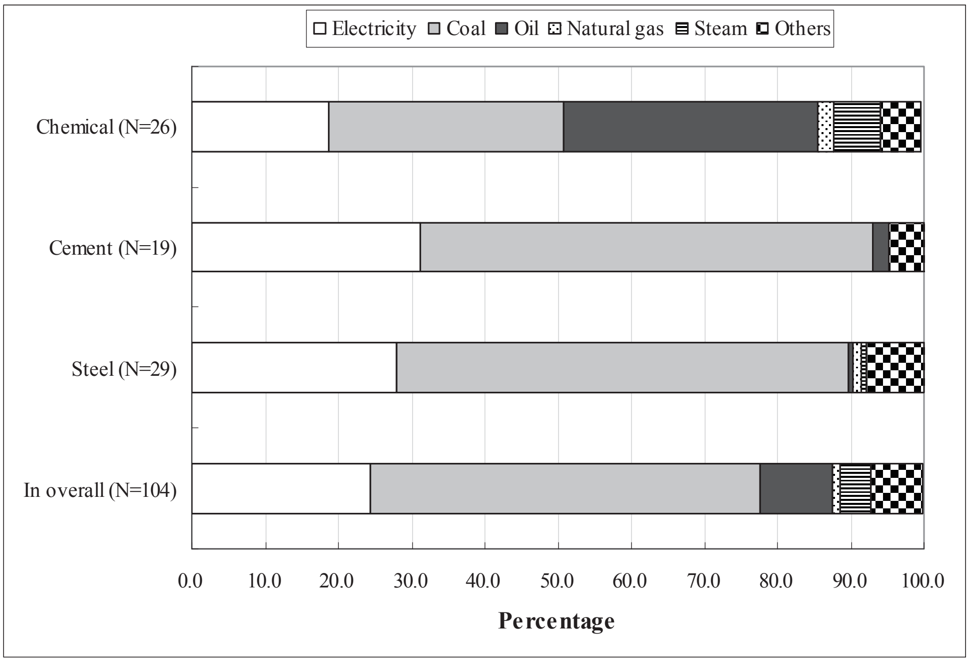

Figure 7.2 Energy use structure of the samples by sector

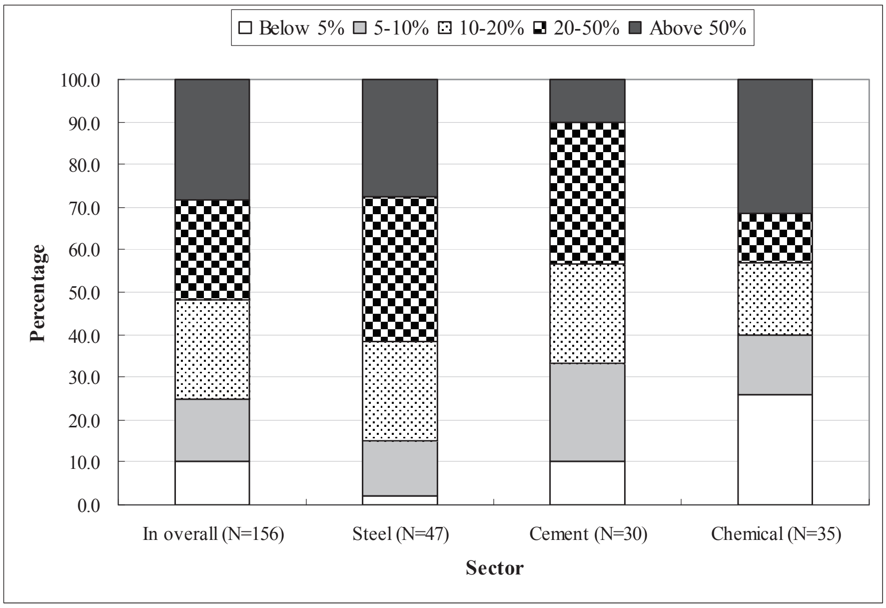

Fig.7.3 Distribution of energy cost shares of total sales by sector

5.2 Barriers for company investment in energy saving technologies

To clarify the barriers hindering a company to invest in energy efficient technologies and equipment, we requested the companies to indicate which factors they perceived prevented them from making the corresponding investments. Ten barriers are listed in the questionnaire, allowing the companies to provide individual evaluations. The barriers may be classified into three categories: general barriers; financing constraints; and, barriers related to uncertainties of the technologies and policies. A five-point scale is applied for the barrier evaluations, with '5' = very important barrier; '4' = important; '3' = moderate importance; '2' = low importance; and, '1' = completely unimportant. The average scores of the barriers are depicted in fig.7.4.

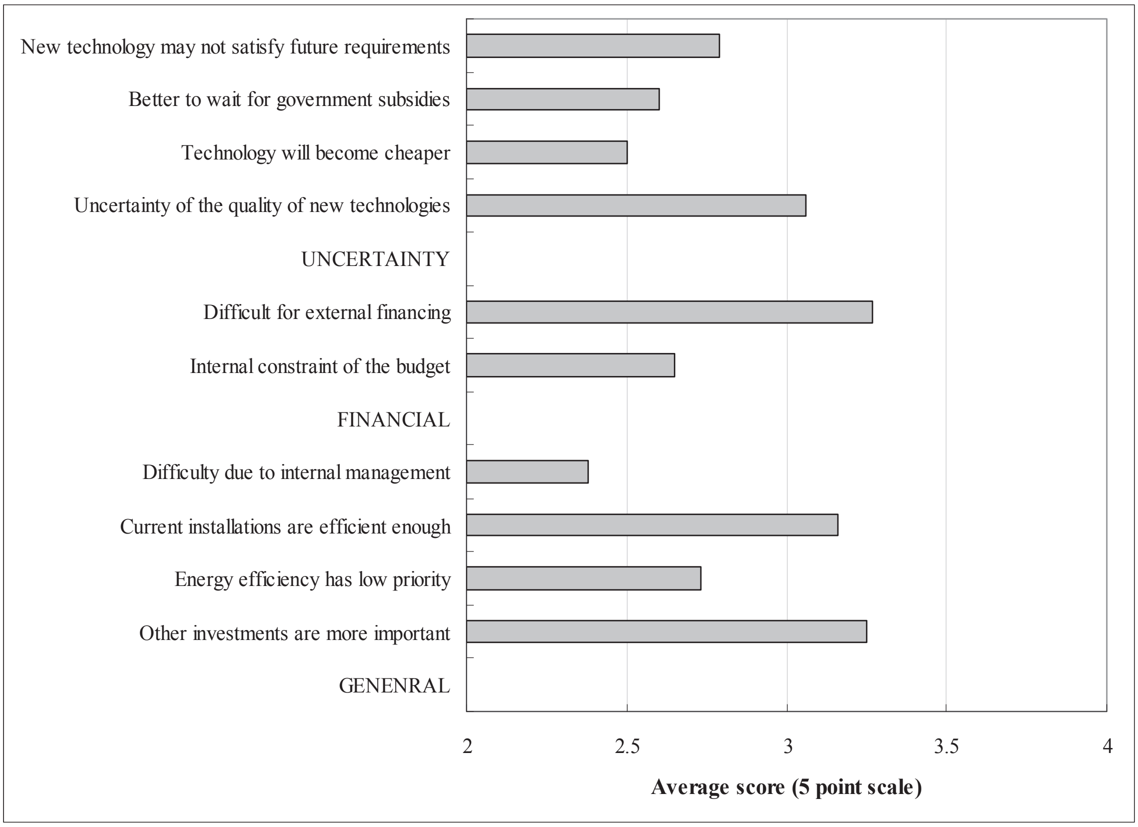

Figure 7.4 Barriers for companies to invest in energy saving technologies (N=153)

The companies presented low to moderate scores to all the barriers. Comparatively, the most important barrier is the difficulty for external financing, with a score of 3.27 on average. Two general barriers, the existence of other more promising investment opportunities and the resistance to replacing existing facilities, are the obstacles with relatively high importance (averaged at 3.25 and 3.16 respectively). This result is consistent with the previous survey of Dutch companies (De Groot et al., 2001), in which it was revealed that uncertainty over the quality of new technologies hinders a company's investment decision to a certain degree, with a mean of slightly over 3.0. Providing subsidies may be supportive in leading a company's investment towards better energy efficiency. Our survey indicates that the companies do not believe waiting for government subsidies is a good choice, as only a minor score of 2.60 on average was given. If an energy saving investment was viewed profitable and quality-ensured, the companies would try to budget for it.

As energy saving projects may reduce a company's energy cost by recovering the initial investment within a certain period, 'payback time' is usually used as the criteria for the companies to make decisions in energy saving investment (Harris et al., 2000). During the survey, we asked the companies to show their acceptable payback period for energy saving projects. A total of 127 companies answered this question (distribution is depicted in fig.7.5), which revealed that 80% of them would accept a payback time of less than three years, nearly 20% of them expect to recoup the investment within a period as short as one year and less than 5% of them would accept a payback period of over five years. This result is similar to that of Thollander and Ottosson (2010), indicating that most Swedish energy-intensive companies apply a payback criterion of three years or less for energy efficiency investments, and a survey of U.K. companies, which revealed an average payback time of 3–5 years (Martin et al., 2012). This expectation of high profitability as demonstrated by the surveyed Chinese companies to energy saving projects may thus hinder their investment decisions.

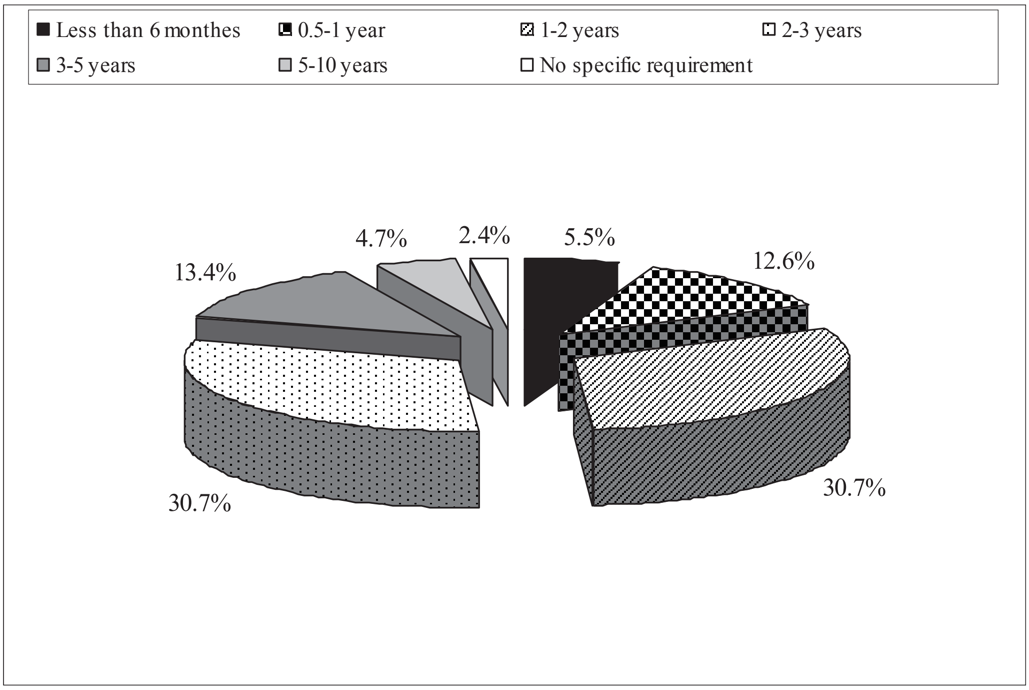

Figure 7.5 Distribution of the samples by payback time of energy saving investment (N=127)

5.3 Statistics of the variables and correlation matrix

The statistics of a company's policy awareness and acceptability are described in sections 5.5 and 5.6, respectively. Table 7.4 summarises the statistics of company awareness of technologies, external factors as independent variables and the quantitative controls.

Table 7.4 Statistics of technology awareness, determinants and the quantitative controls

Variable		Obs.	Mean	Std. Dev.	Min.	Max.
Technology awareness	AWAREEXTTECH	159	3.57	0.81	1	5
	AWARENEWTECH	159	3.19	0.77	2	5
External factors	COMPETITION	162	4.07	0.83	1	5
	EXPORT	145	1.30	0.83	1	5
	ENPRICE	162	4.12	0.70	1	5
Control	SAVPOTENTIAL	160	2.62	0.63	1	4
	EDUCATION	162	2.62	1.36	1	5

The company's understanding of energy saving technologies is not optimistic and the variables of AWAREEXTTECH and AWARENEWTECH only achieved means of 3.57 and 3.19 individually. In more detail, approximately 15% of the respondents are unaware of energy saving technologies currently in use and one third of them indicate a moderate understanding of such. Nearly 20% of the samples have no knowledge of new energy saving technologies and almost half selected the answer of moderate awareness. This result confirms a minor role of formal organisations, such as governments and industrial associations, in providing the companies technology information for energy saving in present-day China. The responsibilities of governments at various levels thus need to be enhanced to disseminate this kind of information, as it pertains to the nature of public good (De Groot et al., 2001).

The surveyed companies felt strongly pressured by energy prices and competitors in the same sector, and presented the highest scores for ENPRICE (The level of domestic energy prices), with a mean of 4.12. COMPETITION achieved another high mean of 4.07. The products of the surveyed companies are mainly supplied to the domestic market. More than 85% of the samples have an export ratio of below 10%. The variable of EXPORT achieved a mean of 1.30. A mean of 2.62 for SAVPOTENTIAL reveals that the sampled companies are using production technologies of domestically average level and have a relatively large potential for energy efficiency improvement. A mean of 2.62 for EDUCATION confirms low education levels of the companies. More than half of the samples have less than 20% of employees with an education level of college and above. The distribution of the samples by size and sector is listed in table 2 and was described above. The ratios of samples with ownerships of state-owned, domestically private and foreign-funded are 31.5%, 63.0%, and 5.5%, respectively.

Pair-wise correlation was calculated to explore the relationships between the variables in table 7.4. The correlation matrix is listed in table 7.5. There is no indication for an unacceptable level of multi-collinearity between these variables since the highest coefficient is 0.601 for AWARENEWTECH (Awareness of new energy saving technologies) and AWAREEXTTECH (Awareness of existing energy saving technologies) at $P<0.01$. Harmful levels of multi-collinearity are not anticipated until correlation coefficients reach ± 0.8 or ± 0.9 (Farrar and Glauber, 1967).

Table 7.5 Correlation matrix of technology awareness, determinants and quantitative controls

	AWA.EXT.	AWA.NEW.	COM.	EXP.	ENP.	SAV.	EDU.
AWAREEXTTECH	1						
AWARENEWTECH	0.601[a]	1					
COMPETITION	-0.092	-0.062	1				
EXPORT	0.055	0.112	0.051	1			
ENPRICE	-0.032	-0.030	0.145[c]	0.030	1		
SAVPOTENTIAL	-0.157[b]	-0.208[a]	-0.122	-0.190[b]	0.013	1	
EDUCATION	0.291[a]	0.130	-0.057	0.045	-0.080	-0.295[a]	1

[a]: Significant at 1% level; [b]: Significant at 5% level; [c]: Significant at 10%.

5.4 Multivariate analysis with company technology awareness as the dependent variables

Ordered probit regressions were performed to identify whether a company's awareness of energy saving technologies varies due to the external pressures and the company's characteristics. The analysis robustness was tested by adopting two models: Model 1 includes the independents and quantitative controls and Model 2 introduces all the variables listed in equation (1). The results are listed in table 7.6.

A significant but negative relationship between a company's energy saving potential and its knowledge of energy-efficient technologies was revealed. In certain cases, a company's understanding of energy saving technologies may influence its perception of its own saving potential. Nevertheless, companies with higher saving potentials can experience problems in energy management and usually are laggard in adopting energy-efficient technologies. The lack of energy saving experience of these companies may explain their lower awareness of energy saving technologies, both existing and new. It is confirmed that large companies have a higher awareness of energy saving technologies than small ones. The educational level of the companies is significantly and positively associated with the awareness of existing technologies. This finding is in line with the literature addressing the organisational factors in determining a company's ability to obtain strategic information (De Groot et al., 2001). The cement sector indicates a higher awareness of new energy saving technologies than the paper industry, which is used as the reference. China's cement industry has undergone profound structural and technological improvements in past years, something that may urge cement companies to exhibit more concern over the latest progress in energy efficient technologies (Zhou, 2011).

Table 7.6 Regression results with company technology awareness as dependent variables

	Independent variables and controls	Dependent: AWAREEXTTECH Model 1	Dependent: AWAREEXTTECH Model 2	Dependent: AWARENEWTECH Model 1	Dependent: AWARENEWTECH Model 2
Independent	COMPETITION	-0.032	-0.098	-0.033	-0.052
	EXPORT	0.020	0.050	0.103	0.116
	ENPRICE	0.056	0.132	-0.001	0.039
Firm's characteristics	SAVPOTENTIAL	**-0.312**[c]	**-0.279**[c]	**-0.388**[b]	**-0.422**[b]
	EDUCATION	**0.169**[b]	**0.203**[b]	0.020	0.027
	MEDIUM		**0.449**[c]		0.016
	LARGE		**0.585**[c]		**0.865**[b]
	STEEL		0.516		0.403
	CEMENT		0.690		**0.728**[c]
	CHEMICAL		0.248		0.523
	OTHER		0.110		**0.709**[c]
	STATEOWNED		0.526		0.264
	DOMPRIVATE		0.522		0.470
	Obs.	142	142	142	142
	LR chi	**12.99**[b]	**23.87**[b]	**8.66**[c]	**19.04**[c]
	Pseudo R^2	0.040	0.073	0.028	0.059

[b] Significant at 5% level; [c] Significant at 10%

5.5 Company awareness of MBIs and the determinant factors

5.5.1 Statistics of company awareness of MBIs

As an important part of the survey, the companies were asked to indicate their awareness of MBIs. Besides MBI01 to MBI05, the Clean Development Mechanism (CDM) was added since it is the only mechanism by which Chinese companies can participate in the international carbon market. MBI06 and MBI07 were listed to represent carbon tax policy and GHG ETS overall. The statistics of company awareness of MBIs is shown in table 7.7.

Several differences exist between company awareness of various MBIs. The respondents are well aware of MBI01 (Financial subsidies and rewards for energy saving investment and projects) and MBI05 (Differential electricity prices according to the company's energy use levels) well, as both achieved a high mean of 3.75 and 3.73, respectively. The policy items MBI02 and MBI03 had relatively high awareness among the companies; both presented scores of around 3.50 on average. As expected, as the items of MBI06 and MBI07 are still being deliberated on, they obtained lower scores than the other MBIs in implementation.

Table 7.7 Statistics of company awareness of MBIs

No.	Items of MBIs	Obs.	Mean	Std. Dev.	Min.	Max.
1	MBI01	159	3.75	1.11	1	5
2	MBI02	158	3.45	1.12	1	5
3	MBI03	156	3.56	1.09	1	5
4	MBI04	155	3.15	1.19	1	5
5	MBI05	157	3.73	1.13	1	5
6	CDM	157	3.26	1.17	1	5
7	MBI06	157	2.87	1.16	1	5
8	MBI07	157	2.86	1.13	1	5

5.5.2 Multivariate analysis with company policy awareness as dependent variables

Econometric regressions were conducted to identify the determinant factors of company awareness of MBIs using the ordered probit model. The regression results are listed in table 7.8. The following explanations are restricted to the sign and significance of the parameter values due to the inherent difficulty of interpreting the coefficients of ordered probit estimations (Greene, 1997).

The regression results of MBI01, MBI03, MBI05, CDM and MBI06 are statistically significant. Differing from De Groot et al. (2001), who suggests that competition acts as a driver for the companies to obtain strategic information, this study found no significant relationships between company awareness of MBIs and the external pushes overall, with the exception of a significant and positive influence of EXPORT on a company's awareness of MBI05 (Differential electricity prices according to the company's energy efficiency levels). Compared with MBI01, MBI03 and CDM, which may bring momentary incentives for the companies, MBI05 maintains an ongoing influence over a company's operating cost. Companies with higher export ratios may be more concerned about policies the have a long-term impact on their competitiveness in the international market.

The variable of EDUCATION (Education level of the company's employees) is significantly and positively associated with company awareness of MBI03. The larger companies reveal a deeper understanding of the MBIs. Company size is significantly and positively associated with company awareness of all five MBIs, with regressions statistically significant. This finding is consistent with the extant literature concluding that larger companies have better access to the resources required for proactive environmental strategies (Aragón-Correa et al., 2008). There is no obvious gap in the policy awareness among different sectors. However, a company's ownership influences the company's understanding of MBIs. The foreign-funded companies are less aware of MBI01, probably because financial subsidies and rewards for energy saving mainly flow to the large domestic companies thus this policy was overlooked by foreign-funded companies. The domestic companies, both state-owned and domestically private, indicate higher awareness of MBI05, CDM and MBI06. Comparatively, foreign-funded companies are more energy-efficient than Chinese domestic ones. These three polices would incur a comparatively adverse impact on domestic companies. This result confirms that companies exhibit more concern over policies with higher relevance and selectively collect information related thereto.

Table 7.8 Multivariate regression results with awareness of MBIs as dependent variables

	Independent variables and controls	Dependent variables: AWAREMBI							
		MBI01	MBI02	MBI03	MBI04	MBI05	CDM	MBI06	MBI07
Independent	COMPETITION	-0.053	-0.057	-0.049	-0.017	0.006	0.027	-0.141	-0.111
	EXPORT	0.062	0.070	0.065	0.237^{b}	**0.239^{b}**	-0.005	0.120	0.073
	ENPRICE	-0.010	-0.012	0.033	-0.048	0.098	0.113	0.016	-0.056
Firm's characteristics as controls	SAVPOTENTIAL	-0.197	-0.238	-0.110	-0.188	-0.043	0.022	-0.220	-0.104
	EDUCATION	0.036	0.029	**0.231^{a}**	-0.016	0.118	0.036	0.093	0.072
	SMALL		-0.712^{b}	**-0.700^{b}**		**-0.982^{a}**		**-0.743^{b}**	
	MEDIUM	**0.771^{a}**	-0.140	-0.118	0.074	-0.234	**0.973^{a}**	**-0.559^{b}**	0.297
	LARGE	**1.242^{a}**			0.487		**1.350^{a}**		0.851^{b}
	STEEL	0.045	0.205	-0.149	-0.137	-0.582	-0.248	0.234	-0.099
	CEMENT		0.136	-0.141	-0.339	0.115		0.181	
	CHEMICAL	0.055	0.171	-0.126	-0.002	-0.291	-0.329	0.180	-0.008
	PAPER	0.351					-0.232		-0.214
	OTHER	-0.288	-0.009	**-0.736^{c}**	-0.474	-0.582	-0.424	-0.381	-0.303
	STATEOWNED		0.269			**1.003^{c}**	0.641	**1.234^{b}**	0.787
	DOMPRIVATE	0.014	0.459	0.295	-0.073	**1.392^{a}**	**0.924^{c}**	**1.022^{b}**	0.902^{b}
	FOREIGN	**-0.914^{c}**		-0.386	-0.374				
	Obs.	141	140	138	138	139	139	140	139
	LR chi	**36.63^{a}**	17.84	**34.35^{a}**	17.06	**29.53^{a}**	**30.86^{a}**	**26.83^{b}**	16.51
	Pseudo R^2	0.093	0.044	0.089	0.041	0.077	0.074	0.064	0.040

Note: ^{a} Significant at 1% level; ^{b} Significant at 5% level; ^{c} Significant at 10% level

5.6 Company acceptability of energy saving policies and the determinant factors

5.6.1 Statistics of company acceptability of energy saving policies

In this survey, we requested the companies to indicate their subjective acceptability to all the policy items listed in table 7.1. The average scores are depicted in fig.7.6.

All the policies achieved a mean of over 3.30, indicating high receptivity to energy saving policies. Economic incentives are obviously preferable and presented the highest scores. MBI01 (Providing financial subsidies and rewards for energy-saving investments and projects), MBI02 (Providing financial subsidies for research and development of energy-saving technologies) and MBI03 (Preferable tax policy for energy-saving products and technologies) obtained high means of around 4.20. Although MBI04 (Adjust rebate ratios of tariffs for limiting the exports of energy-intensive products) may reduce the benefits of some companies exporting energy-intensive products, it has a relatively high acceptance with a mean of 3.88. Similarly with Morgenstern et al. (2004), few companies would bear a disproportionate burden of a carbon tax or similar policy like ETS. However, the acceptability of carbon taxes would largely increase if relief measures and revenue recycling could be undertaken as this would minimise the policy's negative impacts on company profitability. MBI06B (Carbon tax policy with the revenue fully recycled for energy saving) is much more acceptable than MBI06A with no relief measures or revenue recycling. This reveals that companies are really concerned over the distributional effects of these carbon pricing policies.

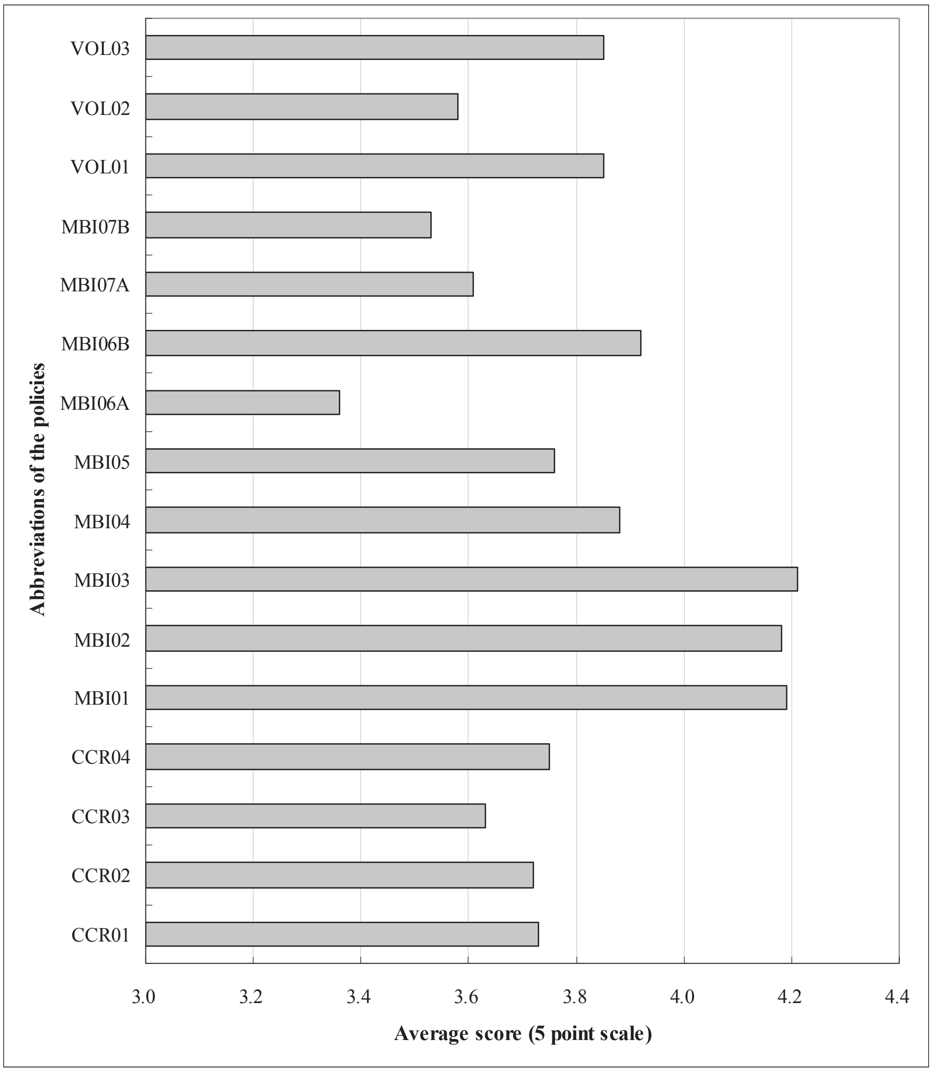

Figure 7.6 Company acceptability of energy saving policies (N=152)

VOL01 and VOL03 presented the same mean of 3.85, implying that companies want to maximise their freedom in managing the governmental requirements for energy saving. As with a previous study of Danish companies by Klok et al. (2006), our survey also confirms that MBIs and voluntary approaches are more appreciated in contrast to the ‘command and control’ regulations. Nevertheless, the samples indicate good acceptability to the regulative tools as CCR01 to CCR04 obtained means of around 3.70, which implies that the companies acknowledged the need for some mandatory requirements (Klok et al., 2006).

5.6.2 Multivariate analysis using company acceptability of MBIs as dependent variables

Multivariate regressions were performed to identify whether a company’s acceptability of MBIs varies due to external pressures or due to characteristic differences between the companies. The ordered probit model was applied and the regression coefficients are as listed in table 7.9.

Table 7.9 Multivariate regression results with acceptability of MBIs as dependent variables

Independent variables	and controls	Dependent variables: ACCETPMBI								
		MBI01	MBI02	MBI03	MBI04	MBI05	MBI06A	MBI06B	MBI07A	MBI07B
Independent	COMPETITION	-0.041	-0.033	-0.015	-0.081	-0.142	-0.046	-0.099	-0.125	-0.127
	EXPORT	0.012	-0.013	0.005	-0.079	0.015	-0.089	-0.110	0.012	0.022
	ENPRICE	-0.182	-0.233	-0.216	-0.093	-0.208	-0.129	**-0.231**^{c}	0.037	-0.110
Firm’s characteristics	SAVPOTENTIAL	-0.041	-0.149	-0.204	-0.031	-0.140	-0.130	-0.187	-0.002	-0.021
	EDUCATION	0.108	0.145	**0.152**^{c}	-0.004	-0.062	-0.096	-0.020	-0.040	0.015
	SMALL	**-1.273**^{a}	**-0.928**^{b}	**-0.888**^{c}	-0.198					
	MEDIUM	**-0.641**^{c}	-0.571	-0.560	-0.050	0.046	0.141	0.381	0.167	0.189
	LARGE					0.528	0.306	**0.679**^{c}	0.053	0.453
	STEEL	-0.400	-0.032	-0.376	0.122	0.259	0.028	0.028	-0.570	0.240
	CEMENT	0.097	0.231				-0.448		-0.854^{b}	
	CHEMICAL	-0.573	-0.348	**-0.642**^{c}	-0.054	0.570^{c}	0.150	-0.353	-0.596	0.035
	PAPER			-0.178	0.625	0.899^{b}	-0.138	0.013		0.849^{b}
	OTHERS	-0.315	-0.294	-0.430	-0.042	0.031		-0.482	-0.620	-0.291
	STATEOWNED		0.277			0.353	0.717	0.567		
	DOMPRIVATE	0.170	0.549	0.364	-0.054	0.230	0.621	0.530	0.079	-0.038
	FOREIGN	-0.518		-0.378	-0.364				-0.127	-0.765
	Obs.	140	137	139	138	139	139	140	140	136
	LR chi	**24.46**^{b}	**20.73**^{c}	**20.77**^{c}	6.95	19.17	11.76	**20.39**^{c}	7.63	17.25
	Pseudo R^2	0.073	0.064	0.063	0.019	0.049	0.029	0.055	0.021	0.047

Note: ^{a} Significant at 1% level; ^{b} Significant at 5% level; ^{c} Significant at 10% level

The regression results of MBI01 to MBI03 and MBI06B are statistically significant and thus discussed here. ENPRICE, the pressure of domestic energy price, is significantly but negatively associated with company acceptability of MBI06B, which implies that a company would be reluctant to accept an additional policy burden if it felt energy prices were already high. A significant and positive relationship between EDUCATION and company acceptability of MBI03 was found, which means that companies with higher educational levels of employees are more capable of adopting energy saving technologies and engaging in climate-related innovations. MBI03 provides incentives for R&D of energy efficient technologies and products and thus would be more appreciated by these companies. This finding agrees somewhat with that of Henriksson et al. (2012), who suggest that the Swedish pulp and paper industry opts for policy instruments that stimulate innovation, as private R&D has an energy saving impact in the medium and long run. Further, company policy acceptability is significantly and positively associated with the organisational size. Large companies have more resources for energy saving investments, which usually means they are more energy efficient than their small and medium-sized counterparts. The financial subsidies (MBI02 and MBI03) and MBI06B as an economic pressure policy would put the large companies at a comparative advantage, which probably explains their higher acceptability to these policy tools. Some differences in the acceptability of MBI03 were observed between different sectors. Compared with the cement sector, it is less likely for chemical companies to accept MBI03, which may be attributed to the policy's differentiated influences on various industries. The result confirms that chemical companies are less likely to receive preferential taxes for energy efficient products and equipment.

5.7 Company behavioral responses to energy cost increases due to MBIs

A company's energy cost would increase if a carbon tax policy and GHG ETS were introduced. To measure the possible responses of companies to these two MBIs, which are still under discussion in China at the time of the survey, we requested the companies to consider possible alternative actions. A five-point scale was applied, with '5' = very possible; '4' = relatively possible; '3' = moderate possibility; '2' = low possibility; and '1' = completely impossible. The statistics are shown in fig.7.7.

In the questionnaire, we did not specify the policy scenarios for the samples but simply assumed a precondition that a carbon tax and/or GHG ETS would be introduced unilaterally. In this sense, the collected answers may only represent the company's behavioral reactions to energy cost increases attributed to carbon pricing. The result shows that the companies would avoid the kneejerk reactions of reducing production, moving production to areas with looser policies, closing production facilities, and taking no action and accept the losses as these four choices presented average scores of under 2.60. Conversely, the companies would take internal measures to save energy to mitigate the policy's negative impacts. Practicing managerial energy-saving activities is the most feasible option, with a mean of 4.48. To invest in energy efficient technologies, use less carbon-intensive energies and adjust to a less energy-intensive product structure are preferable responses with higher possibilities. Another selection with a high score is to reduce a product's unit energy cost by raising levels of production. This result seems to contradict that of earlier literature, which suggests that lowered levels of production is a more appropriate response to energy taxes (Baumol and Oates, 1988). However, De Groot et al. (2001) argues that companies may plan for larger average levels of production and anticipate some competitors leaving the market. Another meaningful observation is that the companies would not simply offload the burden onto their clients, as the option of raising product prices for cost shifting only achieved a moderate mean of 3.10. This result differs from that of De Groot et al. (2001), who document that, given an energy tax is put into place, Dutch companies would be more likely to pass on the additional costs to their customers. Our finding may be attributed to the high levels of competition facing the surveyed Chinese companies, who might be highly concerned over losing out in the market if product prices are increased unilaterally.

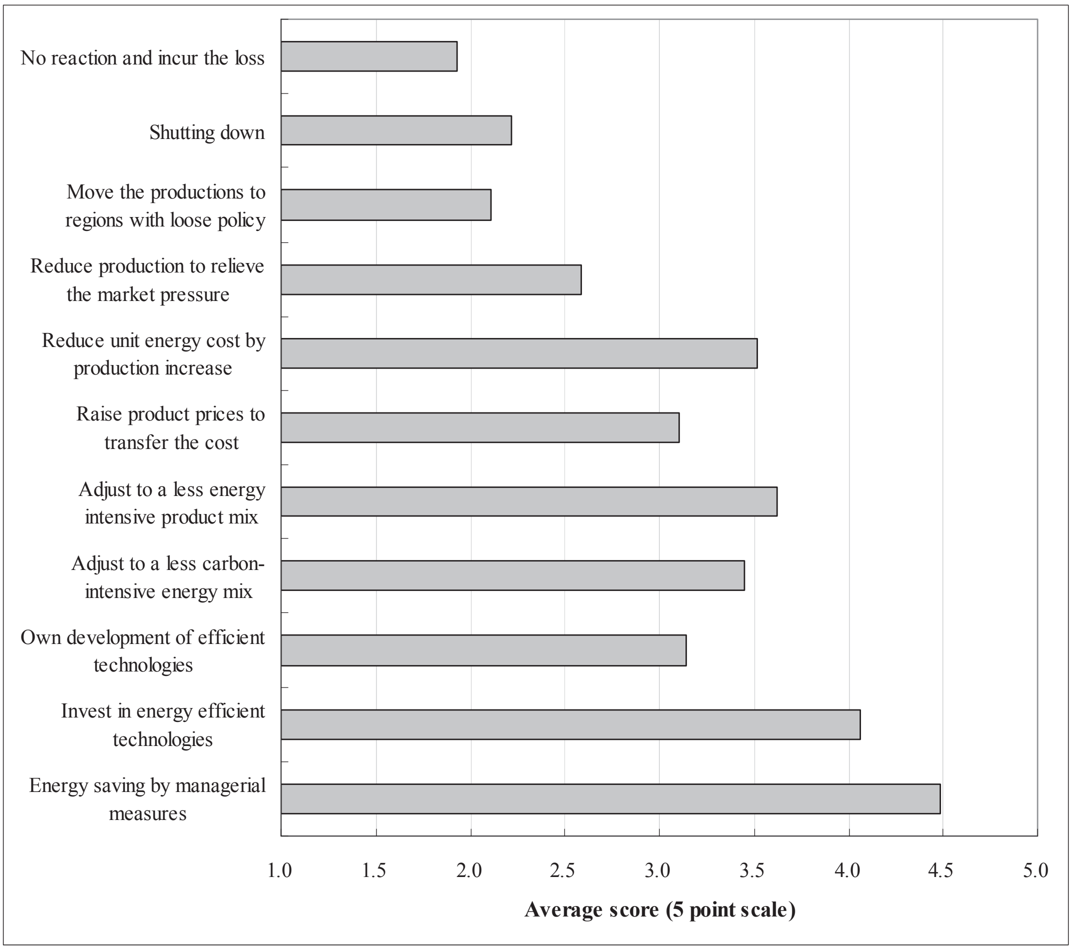

Figure 7.7 Company behavioral responses to MBIs (N=149)

6. Conclusions

This chapter measured company awareness and acceptability of MBIs via an empirical analysis mainly targeting three energy-intensive sectors in China. The pre-classified determinants are partly confirmed by econometric analyses. The organisational factors function as determinants for companies to obtain information concerning energy saving technologies and policies. Large companies have higher levels of awareness of energy saving technologies and policies than the small ones. Our analysis confirmed that the companies are mainly concerned with policies that would directly affect them. The surveyed companies show good receptivity to industrial energy saving policies. MBIs and voluntary approaches are more appreciated in contrast to the regulative tools. Significant relationships were confirmed between a company's acceptability of MBIs and its organisational size. This adds some weight to the theory that a company's policy acceptability is actually determined by its perception of the policy influence on its comparative advantages. This research suggests that industrial energy saving policies need to be diverse to satisfy the specific expectations of a wide range of companies and that such diversity is essential to garnering their support.

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Chapter 8:

Awareness and acceptability of Korean companies on market-based instruments for energy saving: A survey analysis by sector

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Chapter Highlights:

- This chapter measures the awareness and subjective acceptability of Korean companies to market-based climate policies using the data collected from 62 respondents in iron & steel, cement and petro-chemical sectors.
- Korean companies highly expect energy saving investments to be profitable and most samples would accept a payback period within two years.
- The surveyed companies indicate moderate awareness of the pre-listed MBIs. Recent discussions of GHG ETS in Korea have received attention from the companies, while carbon tax policy still obtains a relatively low recognition.
- Economic incentives are most preferred for the companies. Certain voluntary approaches are appreciated. In contrast, the samples resist carbon pricing tools, including carbon tax policy and GHG ETS.

1. Introduction

Korea's economy heavily relies on energy consumption (Kim, 2011). The country's GHG emissions have substantially increasing since 1990 and this upward trend remains far more pronounced than for other OECD countries (OECD, 2008). For this reason and to enable the national mitigation targets to be met effectively, the country initiated the Target Management Scheme (TMS), which is as a mandatory system designed to limit GHG emissions of large energy-consuming entities. Korea's government has also been considering implementing MBIs, particularly carbon taxes and the GHG emissions trading scheme (GHG ETS).

In reality, industry as a whole strongly resists carbon pricing policies. Its main concern is reduced industrial competitiveness due to increased production costs and increasing powerlessness in the face of ever stricter climate and energy policies. Our previous survey confirmed that small and medium-sized enterprises (SMEs) in Korea are still at an early stage in energy saving. Strategic cooperation with external partners is not merged into their business operations. As the determinants for ESAs, company willingness and top management support function significantly and positively. Korea's company energy saving practices are mainly attributed to individual strategies under laggard government regulations and weak normative pressure from industrial associations (Suk et al., 2013).

In order for climate and energy policies to succeed, therefore, the perception of companies on MBIs must first be obtained. This research measures the awareness and acceptability of Korean companies on MBIs related to industrial energy saving. Three energy-intensive sectors: iron & steel, cement and chemical industries, were targeted due to their key significance for realising the country's GHG mitigation target. Three topics are discussed in this chapter: a) Company awareness and acceptability levels of the pre-listed MBIs for energy saving; b) Relationships between a company's policy awareness, acceptability and the classified determinants; and c) Company behavioral responses in energy management due to the introduction of carbon pricing policies.

This chapter is arranged as follows. Section 2 explains the analytical framework and the policy items in this study, section 3 describes the background of the three target sectors in Korea, section 4 outlines the questionnaire survey and the distribution of samples, section 5 discusses the statistics of company awareness and acceptability of MBIs, and the results of econometric analyses of determinant factors. Lastly, section 6 concludes this empirical analysis.

2. Analytical framework and the policies in this study

2.1 Analytical framework of this study

The analytical framework of this study is similar to that applied for the analysis of Chinese companies in chapter 7, as shown in fig.8.1.

This model admits the usefulness of external pressures in driving a company to identify its internal energy management problems and search for related policies and technologies as a form of strategic information. It is rational to infer that a company's acceptability of a specific policy would be determined by the company's evaluation of the policy's impacts on its comparative competitiveness, whether actually experienced or perceived. External pressures may determine a company's policy acceptability by influencing the company's assessment of the policy impacts. Governmental regulations and industrial associations were confirmed as insignificant in determining the energy saving efforts of Korean companies in a previous survey (Suk et al., 2013). The regulative and normative pressures are excluded from this analytical frame. Market competition works as a driver for the companies to obtain strategic information to a certain extent (De Groot et al., 2001). The earlier study in China confirmed the significance of competitors and energy price pressure in encouraging Chinese company energy management, including the collection of information on policies and technologies (Liu et al., 2012). Three factors – competition pressure, international orientation and energy price pressure – are classified as external pushes in this study.

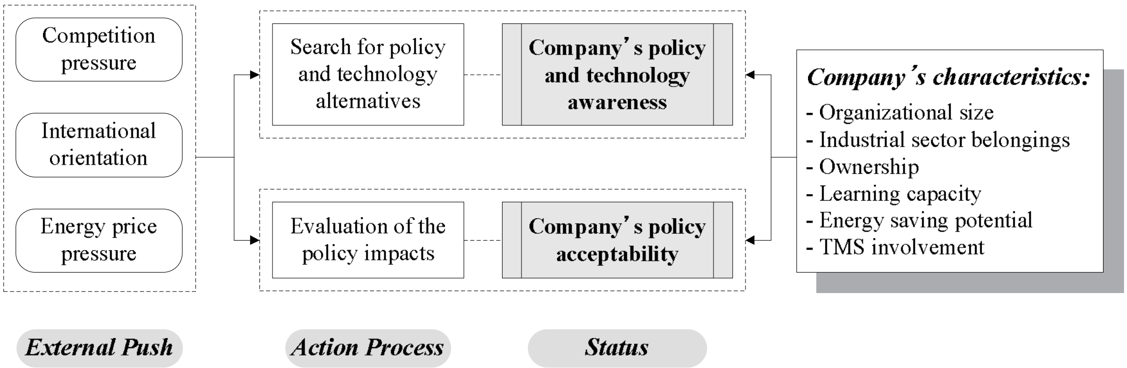

Figure 8.1 Analytical framework of this study

A company needs to be able to organise itself in order to react to the policies appropriately. Small companies are usually at a disadvantage in obtaining strategic information (Gruber and Brand, 1991), and further, are more finance-constrained and therefore more susceptible to economic incentives than their larger and financially less constrained counterparts (Skuras et al., 2006). Given a choice between a voluntary agreement and an energy tax, companies with high energy cost shares would opt for the former (Henriksson and Söderholm, 2009), which implies that energy-intensive companies are more sensitive to carbon pricing policies and is also why carbon tax proposals usually recommend relief measures for energy-intensive sectors (Liu et al., 2011). Companies with higher energy saving potentials may be more able to cope with policy costs by self-reductions. Organisational size, sector belongings, learning capacity, energy saving potential and TMS involvement are classified as controls to identify the difference in policy awareness and acceptability due to company characteristics.

2.2 Industrial energy saving policies in this survey

The descriptions and abbreviations of policies in this survey are listed in table 8.1, of which nine items are MBIs. Two other categories of industrial energy saving policies are also included in the survey document: One is command and control regulations (CCRs) and the other is voluntary approaches (VOLs). The policy descriptions in table 8.1 are directly used in the questionnaire and these policy measures are described briefly as follows.

2.2.1 Command and control regulations (CCRs)

Five CCRs are listed in this survey. CCR01 is a GHG/energy target management system (TMS). TMS started in 2011 and is led by the Ministry of Environment of Korea (MOEK) under its 'Framework Act on Green Growth'. This system controls the large energy consumers by capping their GHG emissions and energy consumptions. CCR02 (Energy use reporting system) is a mandatory requirement for companies and buildings consuming more than 2000 toe (tonnes of oil equivalent) annually. They are requested to report their annual energy consumption, energy saving, investments in facilities and production to the government. As a technological consultation approach coping with high oil prices through energy saving, CCR03 (Energy audit requirement) was adopted in August 2004. This policy requires business sites to identify their energy consumption status and saving potentials and prepare plans for improvements in energy efficiency by receiving consultative services. Based on the 'Energy Use Rationalisation Act' of Korea, the energy efficiency management system (CCR04) was implemented in 1992. This system selects major energy-consuming equipment and allows the manufacturers to publicly announce their energy efficiency targets. There are three programmes under this system: the energy efficiency ranking system, high efficiency equipment certification programme and e-standby programme. The fifth CCR is the minimum energy performance standard (CCR05), which is a regulation comprising performance requirements for energy-using devices aimed at avoiding the production of low energy-efficiency products.

Table 8.1 Descriptions and abbreviations of policies covered in this survey

Category	Description	Abbreviation
Command and control regulations (CCRs)	GHG/energy target management system	CCR01
	Energy use reporting system	CCR02
	Energy audit requirement	CCR03
	Energy efficiency management system	CCR04
	MEPS: Minimum energy performance standard	CCR05
Market-based instruments (MBIs)	Subsidies for maintenance, improvement and replacement of energy saving facilities	MBI01
	Soft loan for investment in energy saving facilities	MBI02
	Soft loan and grant for installing high-efficiency production facilities and equipments	MBI03
	Soft loan for demand side management investment programs	MBI04
	Grant for high energy-efficiency products (i.e. LED, inverter, transformer and freezer)	MBI05
	Soft loan for energy saving companies (ESCO) projects	MBI06
	Tax reduction for investment in energy-saving facilities	MBI07
	Carbon tax policy	MBI08
	GHG emission trading scheme	MBI09
Voluntary approaches (VOLs)	Environmental management system (ISO14001)	VOL01
	Voluntary agreement on energy saving	VOL02
	Training for energy managers	VOL03
	Green credit	VOL04

2.2.2 Market-based instruments (MBIs)

Seven economic incentives are listed in this survey – MBI01 to MBI07. MBI01 is the subsidy for the maintenance, improvement and replacement of energy saving facilities. Companies designated as TMS targets, investment projects of SMEs designated as 2013 TMS targets and green credit projects are eligible for this subsidy. For the green credit projects, subsidies are limited to SMEs that participate in relevant projects and request financial support.

MBI02 is soft loans for investment in energy saving facilities. MBI02 targets the companies involved in a total of 68 categories of projects, such as energy management systems (EnMS) construction, heat cogeneration facilities, regeneration combustion equipment, compressors, far-infrared radiation dryers and projects related to implementation of selected-day vehicle use. The TMS target companies are excluded from MBI02. MBI03 is soft loans and grants for SMEs to invest in facilities and equipment for manufacturing products with the highest ratings in energy efficiency. MBI04 is a soft loan for the DSM (Demand Side Management) investment programme, and covers projects for maximum demand management monitoring control equipment, storage cooling equipment, gas cooling facilities and absorption-type cooling facilities.

MBI05 is a grant for high energy-efficiency equipment and products. This policy was started in 1994 as a high-efficiency lighting support project by the Korea Electric Power Corporation (KEPCO) and then changed to a joint project with KEMCO in 2002. Currently, it is pursued as a solo project of KEPCO. The candidate product categories change yearly and included lighting equipment (LED emergency lighting and LED lights), high efficiency inverters and chillers in 2012. A total of 378.6 billion KRW was spent from 2000 to 2010; 49 billion KRW was spent in 2011 and 50 billion KRW was planned for 2012.

In Korea, soft loans are also provided for ESCO projects (MBI06). MBI06 targets the investment projects with a performance guarantee contract or a performance sharing contract between the ESCOs and energy users. Six categories of projects may be funded under this policy, including energy-saving facility replacement projects, insulation renewal/maintenance projects, IT-utilized energy saving projects, new/renewable energy facility projects, installation projects for GHG reduction facilities and miscellaneous energy efficiency improvement projects.

MBI07 is the tax reduction for investment in energy-saving facilities. This policy enhances the business competitiveness by providing tax deductions at a certain percentage of the investments in energy saving. If a domestic company invested in a designated energy-saving facility (i.e., as designated by presidential decree) by 31 December 2013, 10% of the investment will be deducted from the corporate income tax. From 2007 to 2011, 1,119 companies received a total of 1,095 billion KRW in tax deductions under this scheme.

Two carbon pricing policies are analysed in this study. MBI08 is carbon tax policy and has been considered in Korea as a possible measure for GHG mitigation in recent years. The Korea Institute for Public Finance (KIPF) studied green fiscal reform in Korea by addressing the negative externalities of the extant taxation system and suggested a carbon tax policy be introduced in 2013 to replace the transportation-energy-environment tax due to end in 2012 (Kim and Kim, 2010). Considering the policy acceptance and policy impact on the economy, a recent report from KIPF suggested a low tax rate be imposed in the early stage at level of 1/8 that of the initial proposal, with the tax revenue equaling 2% of Korean GDP (Kim and Kim, 2010).

MBI09 is GHG ETS. In May 2012, the Korean National Assembly approved the 'Greenhouse Gases Emissions Allocation and Trading Act', which paved the way for formal introduction of GHG ETS in 2015. The scheme is obligatory for entities emitting over 125,000t-CO_2 and business sites emitting over 25,000t-CO_2 yearly. All allowances will be allocated for free in the primary period, and banking of the emission credits within and between planning periods, as well as borrowing within the planning periods will be allowed. Emissions exceeding allowances will incur a fine of three times the average market price but less than 100,000 KRW/t-CO_2. The scheme allows for domestic and foreign individuals or corporations to participate as parties for carbon allowance transactions at a point from six years after the start. Carbon leakage sectors are to be given 100% free allocation. Further, early actions towards GHG reductions will be recognised.

2.2.3 Voluntary approaches (VOLs)

Four VOLs are covered in this analysis. VOL01 is an environmental management system (ISO14001) related to energy efficiency, which is a type of environmental performance. The second VOL is a voluntary agreement on energy saving (VOL02) and is based on the 'Energy Use Rationalisation Act' of Korea. In 1998, the National Energy-saving Promotion Committee decided to adopt a voluntary agreement system to accelerate energy saving of companies. After the pilot in 1998, VAs came into effect in 1999. The initial target for the scheme was business entities with annual energy demands of 5,000 toe or more but this has since been reduced to 2,000 toe or more. The agreement is effective for five years once concluded, and recommends a total energy reduction of no less than 5% to be achieved within the agreement period. Business sites with VAs numbered about 1,300 and 2,481 agreements were made from 1998 to 2009. Training for energy managers (VOL03) provides training for company energy managers, which embraces courses such as energy efficiency improvements, climate change conventions and renewable energy. Green credits (VOL04) allow large companies to provide technology and financial assistance to SMEs, and partially attributes the GHG reductions realised by SMEs as those of large companies. This mechanism links the interests of large companies, which tend to have low GHG reduction potential, with SMEs, which tend to have high potential but lack the necessary financing and technology.

3. Background of the three target sectors

Korea's economy has grown, for over a half century, mainly on the back of its energy-intensive manufacturing industries – iron & steel, petro-chemicals and cement (Kim et al., 2011). Total exports of these energy-intensive industries amounted to 75.0 billion USD in 2007, 20.2% of Korea's total exports in the same year (Park and Kim, 2009). In particular, the output from the iron & steel industry increased from 1 trillion KRW in 2000 to 29 trillion KRW in 2010, accounting for 9.2% of the total manufacturing industry output and 2.8% of national GDP. Exports of this sector increased from 4.2 billion USD in 1990 to 25 billion USD in 2010, accounting for 6.0% of the total exports (sourced from: http://www.kosa.or.kr). As a major product of the petro-chemical industry, Korea's ethylene production increased to 7.3 million tons by 2009 and ranked fifth in the world with a share of 5.5% in the global market in 2007. This subsector is the fourth largest domestic manufacturing industry in Korea, with a share of 5.8% in 2008. The export of ethylene in 2009 amounted to 27.4 billion USD, accounting for 6.5% of the total exports (Sourced from: http://kpia.or.kr/index.html). Regarding the cement sector, there are currently 10 companies in Korea, which together produce about 6.2 million tonnes of cement per year for exporting to the U.S., Japan and Africa (sourced from: http://www.cement.or.kr).

The manufacturing industry of Korea used more than 55% of the country's total energy in 2008, and its share of total energy demand of the industry was over 94% in the same year (Kim et al., 2011). While the share of energy use of energy-intensive industries expressed as a proportion to total energy consumption of Korea increased from 32% in 1997 to 38% in 2006, this number dropped from 23% to 22% during the same period for the OECD countries as a whole (Park and Kim, 2009). The three target sectors in this study are major energy-consuming industries in Korea. In 2009, Korea's petro-chemical industry used 50.904 million toe of energy. Of this, 42.313 million toe (83.1%) was non-energy oil and 3.445 million toe was electricity (6.8%) (KEEI, 2011). Bituminous coal is the most consumed energy source for the iron & steel industry. Of the total of 19.35 million toe of energy used by this sector in 2009, 75% was bituminous coal. The shares for electricity, city gas and oil were 15.6%, 7.5% and 1.8% individually. As with the iron & steel industry, the energy use of the cement sector is also dominated by bituminous coal. In 2010, the cement industry consumed 3.966 million toe of energy overall, of which bituminous coal shared 71.7% and electricity accounted for 27.8% (KEEI, 2011). Park and Kim (2009) analysed the energy efficiency of Korean industries. During 1990–1997, the energy intensity of the three target sectors improved steadily. Specifically, the petro-chemical sector's energy intensity was improved with an annual ratio of 3% from 1990 to 1997. The iron & steel industry achieved a 1% improvement in energy intensity annually and the cement sector improved its energy intensity in a similar manner, by 0.9% per year. This encouraging trend, however, came to a halt in the Asian financial crisis of 1997. The consumption amounts by energy type and their corresponding prices are used for roughly estimating the energy costs of the three target industries: for petro-chemicals the figure was 23.744 billion KRW (2009), for iron & steel, 4.206 billion KRW (2009), and for cement producers, 0.9136 billion KRW (2010) (KEEI, 2011).

Due to the large amount of fossil fuels consumed, the three sectors are major CO_2 emitters in Korea. Of the total of 233 million tons of CO_2 emissions from the manufacturing industry in 2007, the petro-chemicals sector emitted 50.7 million tonnes, with a share of 21.7%. Iron & steel and cement industries emitted 86.0 and 42.2 million tonnes, sharing 36.9% and 18.1%, respectively. The three sectors totally accounted for more than 75% of CO_2 emissions from the manufacturing industry in 2007 (MOEK, 2011a). According to the MOEK estimation, the BAU (Business As Usual) emissions of the petro-chemicals sector will reach 63.47 million tonnes of CO_2 by 2020, an increase of 25% from 2007, and that of iron & steel and cement industries are 121.35 and 41.48 million tons of CO_2 by 2020, an increase of 41.1% and a slight decrease of 1.7% from the 2007 level, respectively. Aiming to realise the country's 30% GHG mitigation goal, the petro-chemicals, iron & steel and cement sectors are required to reduce their emissions (compared to their BAU emissions) by 7.5%, 6.5% and 8.5%, respectively, by 2020 (MOEK, 2011b).

4. Methodologies

4.1 The questionnaire survey and samples

A questionnaire was designed with the main objective of measuring the awareness and acceptability of Korean companies on MBIs, and to identify the determinants. The questionnaire format consists of four major components: general information of the company; company energy use and management status; awareness and acceptability degrees of companies to various policy tools; and, the determinant factors, as depicted in fig.8.1.

The data was collected by a questionnaire survey from 25 January to 10 February 2012, which were sent via fax or email to a total of 205 companies, comprising 137 TMS-targeted companies and 68 non-TMS companies. Environmental or energy managers were targeted in the survey. A total of 62 answers were collected and confirmed to be valid. The distribution of the usable samples by company characteristics is summarised in table 8.2.

The respondents from cement, iron & steel and chemical sectors individually account for 17.7%, 25.8% and 56.5 % of the total. According to the classification criteria of the 'Minor Enterprises Act' of Korea, which bases size solely on the number of employees, 27 are medium-sized companies with a staff of more than 50 but less than 300 and an annual turnover of less than 8 billion KRW. Small companies, with less than 50 staff, number only 2. Thirteen companies are large ones with more than 1,000 employees, an annual turnover of more than 150 billion KRW and a registered capital of over 50 billion KRW. The remaining 20 are large medium-sized, i.e., between large and medium-size companies. Of the total 62 samples, 58 respondents are TMS target companies.

Table 8.2 Distribution of usable respondents by sector, size and TMS target

Company's characteristics		Number of samples				Number in total
		Small	Medium	Large medium	Large	(%)
Number in total (%)		2 (3.2)	27 (43.5)	20 (32.2)	13 (21.0)	62 (100.0)
Sector	Cement	2	6	2	1	11 (17.7)
	Steel	-	8	5	3	16 (25.8)
	Petro-chemicals	-	13	13	9	35 (56.5)
TMS	TMS	2	26	17	13	58 (93.5)
	Non-TMS	-	1	3	-	4 (6.5)

4.2 Econometric approach

4.2.1 Valuation of the variables

The abbreviation, description and valuation of the variables are listed in table 8.3. The dependent variables of econometric regressions include the company's awareness of energy saving technologies and MBIs, and the company's acceptability of MBIs, which are abbreviated as AWAREEXTTECH, AWARENEWTECH, AWAREMBI and ACCEPTMBI. A five-likert point method was adopted for the valuation of these variables. The points presented to the technology and policy awareness mean: '5' = 'very clear'; '4' = 'clear'; '3' = 'moderate understanding'; '2' = 'don't know well'; and, '1' = 'completely unknown'. The scales for the policy acceptability are as follows: '5' = fully acceptable; '4' = relatively acceptable; '3' = moderate acceptance; '2' = hardly acceptable; and, '1' = completely unacceptable.

A five-likert scale was applied to evaluate two of the three external pushes, COMPETITION and ENPRICE, with '1' = very low; '2' = relatively low; '3' = moderate; '4' = relatively high; and, '5' = very high. A four-level point was presented to energy saving potential, SAVPOETNTIAL, with '1' = hardly for further saving; '2' = limited potential; '3' = relatively large potential; and, '4' = very high potential. The main market of the product, EXPORT, is used as the proxy for a company's international orientation. Companies with products destined for the domestic market are presented a value of '0' and '1' is for the export-oriented companies.

The company's size, SIZE, is classified into small, medium, large-medium and large, which are individually named as SMALL, MEDIUM, LMEDIUM and LARGE. The company's sector belongings, SECTOR, have three types – iron & steel, cement and chemicals – which are presented as STEEL, CEMENT and CHEMICAL. The ownership consists of two types, domestically private and foreign-funded, which are abbreviated as DOMPRIVATE and FOREIGN. Average educational level of the employees, EDUCATION, was used to indicate a company's learning capacity. Five classifications were applied, with '1' = the ratio of employees with educations of college and above being less than 10%; '2' = 10–20%; '3' = 20–30%; '4' = 30–50%; and, '5' = over 50%. The status of TMS involvement is indicated as TMS for TMS target companies and non-TMS for the others.

Table 8.3 Abbreviation, description and valuation of the variables

Category	**Abbreviation**	**Description**	**Valuation**					
			0	**1**	**2**	**3**	**4**	**5**
Dependent	AWAREEXTTECH	Company's awareness of existing energy saving technologies						
	AWARENEWTECH	Company's awareness of new energy saving technologies						
	AWAREMBI	Company's awareness of MBIs						
	ACCEPTMBI	Company's acceptability of MBIs						
Independent	COMPETITION	Competition degree of the company's sales market						
	EXPORT	Main market of the products						
	ENPRICE	Perception of domestic energy price levels						
Control	SAVPOTENTIAL	Energy saving potential of the company						
	EDUCATION	Average education level of the company's employees						
	SIZE	Company's size						
	SECTOR	Industrial sector belongings of the company						
	OWNERSHIP	Ownership status						
	TMS	TMS involvement						

4.2.2 Empirical models for the econometric analysis

The regression capturing the relationships between the company's policy and technology awareness and the classified determinants and controls can be constructed as Eq. (1), where ε represents the error term and β_0 is the constant.

$$\begin{aligned} &AWAREMBI\ (AWAREEXTTECH\ or\ AWARENEWTECH) \\ &\quad = \beta_0 + \beta_1 COMPETITION + \beta_2 EXPORT + \beta_3 ENPRICE + \beta_4 SAVPOTENTIAL \\ &\qquad + \beta_5 SIZE + \beta_6 SECTOR + \beta_7 OWNERSHIP + \beta_8 EDUCATION + \beta_9 TMS + \varepsilon \end{aligned} \quad (1)$$

The regression identifying the relationships between the company's policy acceptability, ACCEPTMBI, and the classified variables can be established as Eq. (2), where ζ represents the error term and λ_0 is the constant.

$$ACCEPTMBI = \lambda_0 + \lambda_1 COMPETITION + \lambda_2 EXPORT + \lambda_3 ENPRICE + \lambda_4 SAVPOTENTIAL + \lambda_5 SIZE + \lambda_6 SECTOR + \lambda_7 OWNERSHIP + \lambda_8 EDUCATION + \lambda_9 TMS + \xi \quad (2)$$

5. Results and discussions

5.1 Energy use status of the samples

The companies were requested to elaborate on the types of energies they use and ratios of such in terms of total energy use. The energy use structure of samples is statistically summarised in fig.8.2.

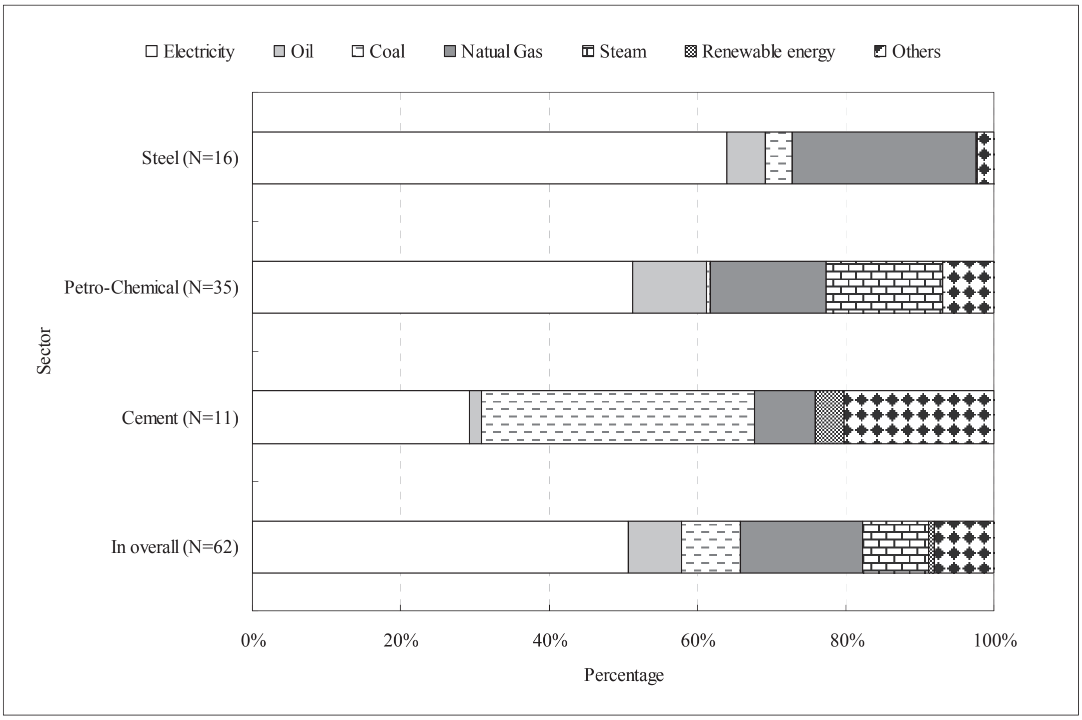

Figure 8.2 Energy use structure of the samples by sector

The results confirm that electricity is the largest energy source for the surveyed companies as a whole, with a share of 51% of total energy use. Natural gas is second and accounts for 17%; third is steam with a share of about 9%; and oil and coal have shares of around 7% each. Renewable energy accounts for less than 1% as minor sources. The remaining 8% include LNG, Petro Cokes, etc. There are some differences between the energy uses of the three target sectors. Iron & steel and chemical industries mostly use electricity, with a share of 64% and 51% respectively. The ratio of electricity used by cement companies is less than 30%. Coal is a major energy source for cement companies, accounting for about 37 % of total energy use, while this ratio is less than 5% for chemical and steel sectors. Steel companies in this survey use natural gas as the second largest energy source, accounting for about 25%. Natural gas and steam are used at similar ratios of 15.5% as the second largest energy source for chemical companies.

Figure 8.3 shows the distribution of energy cost shares of total sales of the samples by sector. Overall, the samples have an even distribution of energy cost ratios up to 20%. Nearly 30% of companies have an energy cost ratio of 5–10%; the companies with energy cost ratios of less 5% and 10–20% individually have a share of around 25%. The remaining 16% of samples have an energy cost ratio of 20–50%. The surveyed cement companies indicate high ratios of energy costs in sales. Around 55% of cement companies have an energy cost ratio of 20–50%; 9% of them even have costs of above 50% of sales; 27% answered that their energy cost ratios range between 10–20%, and the remaining 9% have energy costs of 5–10% in total sales. For the chemical sector, around 90% of surveyed companies have an energy cost ratio below 20%. The chemical companies with energy cost ratios of less than 5%, 5–10% and 10–20% individually account for 31%, 37% and 23%. Another 6% have energy cost ratios of 20–50%. Similarly to the chemical sector, most steel companies have energy cost ratios below 20%. About 30% of steel companies have a ratio of below 5% and 10–20%, respectively; 25% of them have an energy cost ratio of 5–10%, and the remaining 12.5% of steel companies have an energy cost ratio of 20–50%.

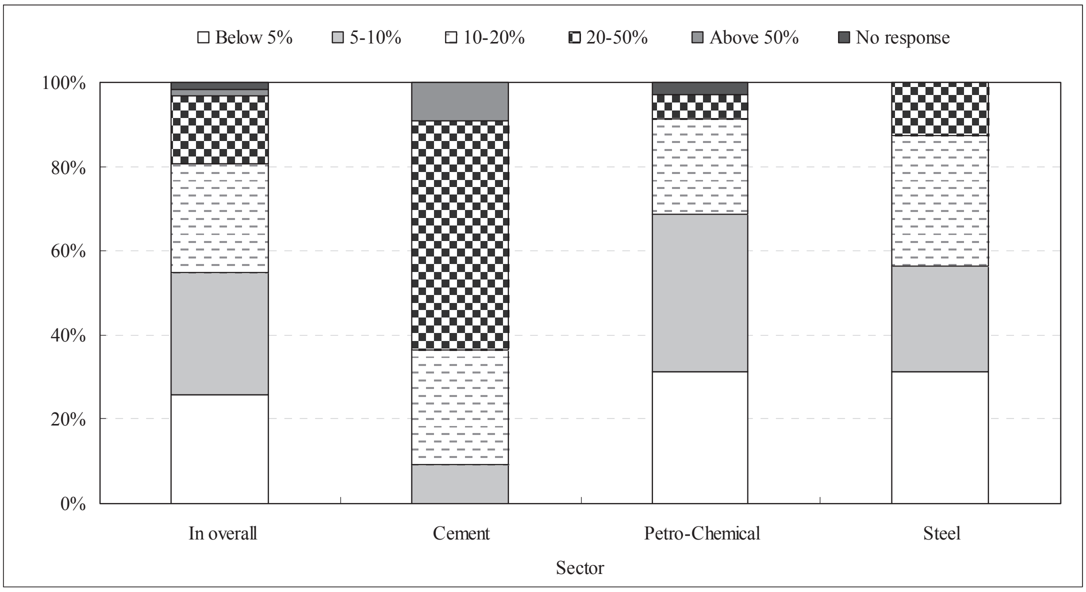

Figure 8.3 Distribution of energy cost shares in total sales by sector

5.2 Company viewpoints on GHG mitigation targets at national and sector levels

Korea's government pledged in 2009 to reduce its GHG emissions by 30% from the BAU scenario by 2020 compared with 2005 levels. In 2011, the national GHG reduction target was decomposed by sector, with the targets of iron & steel, petro-chemical and cement industries of respectively 6.5%, 7.5% and 8.5% compared with BAU levels. The respondents were requested to evaluate the impact of the national GHG mitigation goal on their businesses and the stringency of the targets at the sector level, as statistically summarised in fig.8.4 and fig.8.5.

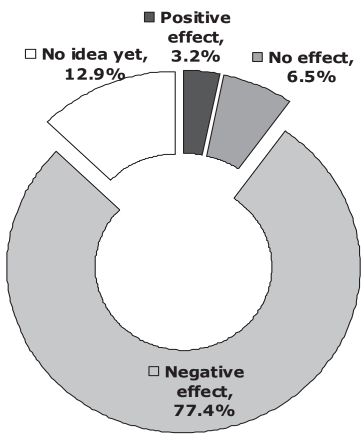

Figure 8.4 Company opinion on impact of nation GHG mitigation goal on their businesses (N=62)

As indicated in fig.8.4, most samples (77.4%) view that the national GHG mitigation target would bring negative impact to their businesses and only 3.2% express a positive attitude. Fig.8.5 shows that the targets by sector are strict for most of the surveyed companies. Some differences between the evaluations of companies, as follows. Comparatively, iron & steel companies are more resistant to the mitigation goal of their sector. Only 6% of the samples from the iron & steel industry think that the mitigation target is appropriate and the remaining 94% evaluate the target to be high. For petro-chemical companies, 20% of them view the mitigation target of their sector to be appropriate. It is clearly indicated that the three energy-intensive sectors in this survey oppose the GHG mitigation goals at the country and sector levels due to concern over its negative impact on their business and weakened market competitiveness.

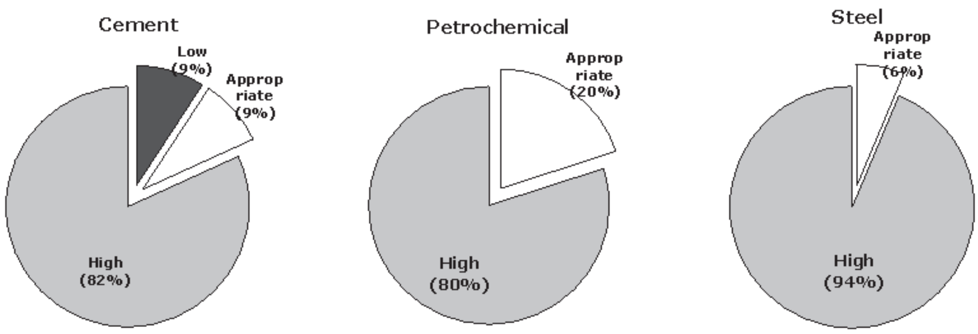

Figure 8.5 Company evaluations of GHG reduction goals at the sector level (N=62 in total)

5.3 Barriers for company investments in energy saving technologies

Investments in energy saving may enhance the competitiveness of companies (Karagozoglu and

Lindell, 2000). However, broad-ranging studies indicate that the cost-effective energy saving measures could not always be undertaken as expected (Rohdin et al., 2006). According to a report by KIET in 2009, the share of energy-saving investments in the manufacturing sector in Korea indicated a higher level in the late 1970s to early 1980s, shortly after the oil crisis. Since then the proportion of energy-saving investment has decreased and a downward trend has continued to the present despite the rise in oil price since 2000 (KIET, 2009). To clarify the barriers hindering a company's energy saving investment, this survey requested the companies to indicate the factors they perceived prevented them from corresponding investments. Fourteen barriers are listed in the questionnaire, which may be classified into three categories: 'general internal barriers'; 'financing constraints' and barriers related to 'uncertainties of technologies and timeliness'. A five-point scale is applied for the evaluations, with '5' = very important barrier; '4' = important; '3' = moderate importance; '2' = low importance; and, '1' = completely unimportant. The average scores are depicted in fig.8.6.

The result indicates that the most important impediment for the surveyed Korean companies is 'the lack of support at the national level government', with the highest score of 3.66 on average. This is consistent with the previous survey of Korean SMEs, which confirmed economic incentives to be useful for encouraging company energy saving practices (Suk et al., 2013). The Korean companies are concerned about 'production disruptions and economic losses during the new equipment replacement' and present this factor a mean of 3.58, a finding agreeing with that of Rohdin et al. (2006). As a financial barrier, 'internal constraint of the budget' is another obstacle with relatively high importance (averaged at 3.50).

The companies in this survey would prefer to pay the mild fines rather than invest huge sums of money in energy efficiency at the early stage of TMS and GHG ETS (averaged at 3.48). The ongoing TMS sets fines of up to 10 million KRW (around 9,000 USD) for companies failing to meet the reduction targets. The final proposal of GHG ETS documents that emissions exceeding the allocated allowances are subject to a penalty of three times the average market price but no more than 100 thousand KRW (around 90 USD) per tonne of CO_2. Korea Certified Emission Reductions (KCER) issued in July 2005 were purchased by the Korean government at an average price of 5,000 KRW/t-CO_2 (4.4 USD/t-CO_2) (Kim, 2008). Referring to the price of KCER and compared with the market price of EU-ETS in the first phase (approx. 12-32 USD/t-CO_2, 2005–2007), the penalties associated with TMS and GHG ETS in Korea are mild, which implies that more appropriate (severe) TMS and GHG ETS penalties would urge Korean companies to make energy saving investments.

The sampled companies presented low to moderate scores for all the other barriers, a result similar to the studies in China, which confirm low to moderate evaluations of Chinese companies to all the barriers (Liu et al., 2013a; Liu et al, 2013b). While Korean companies view national government support as important, the difficulty in external financing is identified as the most important barrier in Liu et al. (2013b). For Chinese SMEs, uncertainty over the quality of technologies is confirmed as the important factor (Liu et al., 2013a).

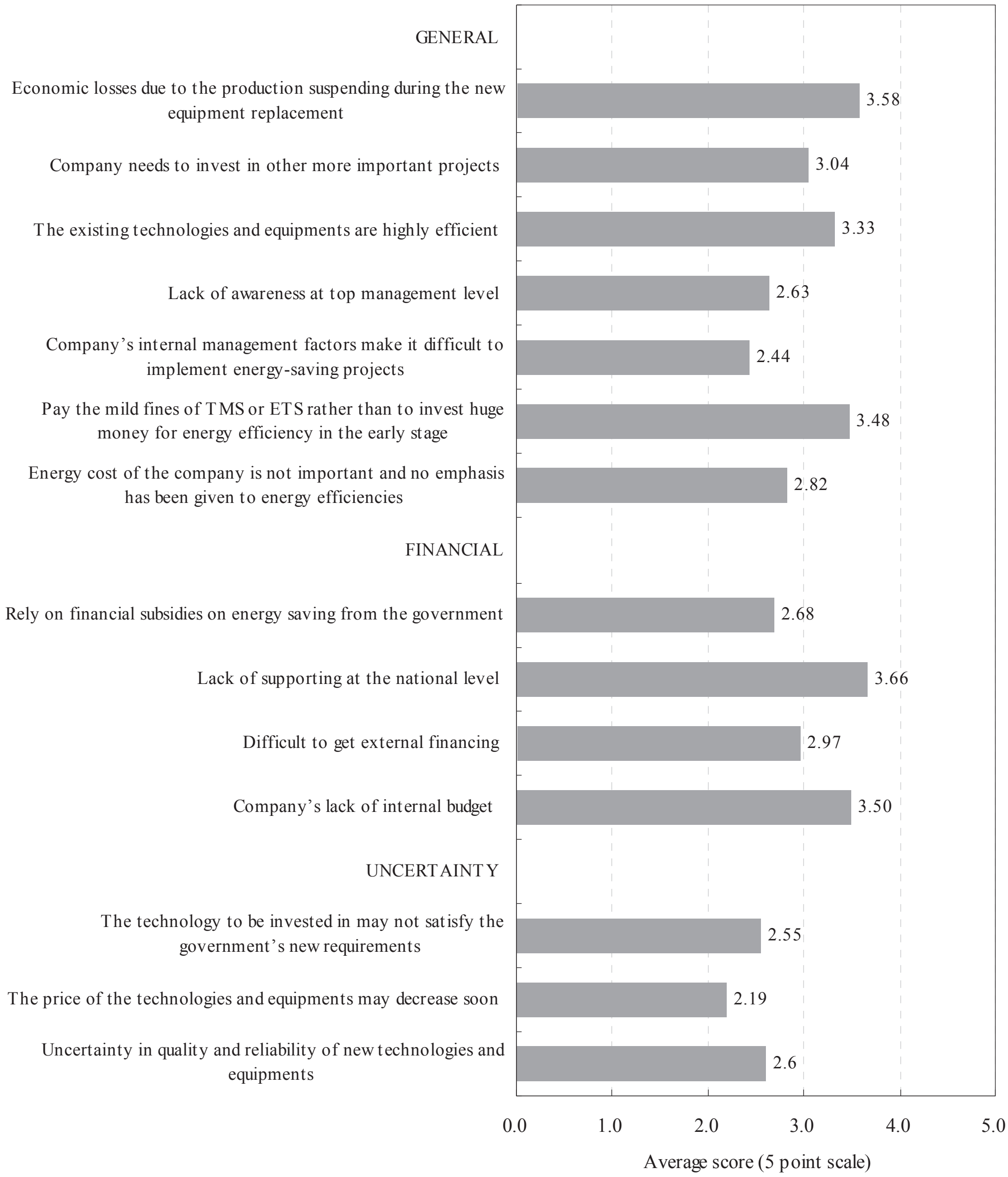

Figure 8.6 Barriers for companies to invest in energy saving technologies (N=62)

Payback time is usually used as the criteria for a company's decision-making regarding investments and Abadie et al. (2012) confirmed that payback time and initial cost are the main factors affecting investment in energy efficiency. We asked the companies to indicate their acceptable payback period in this survey, which produced a total of 62 answers, as depicted in fig.8.7.

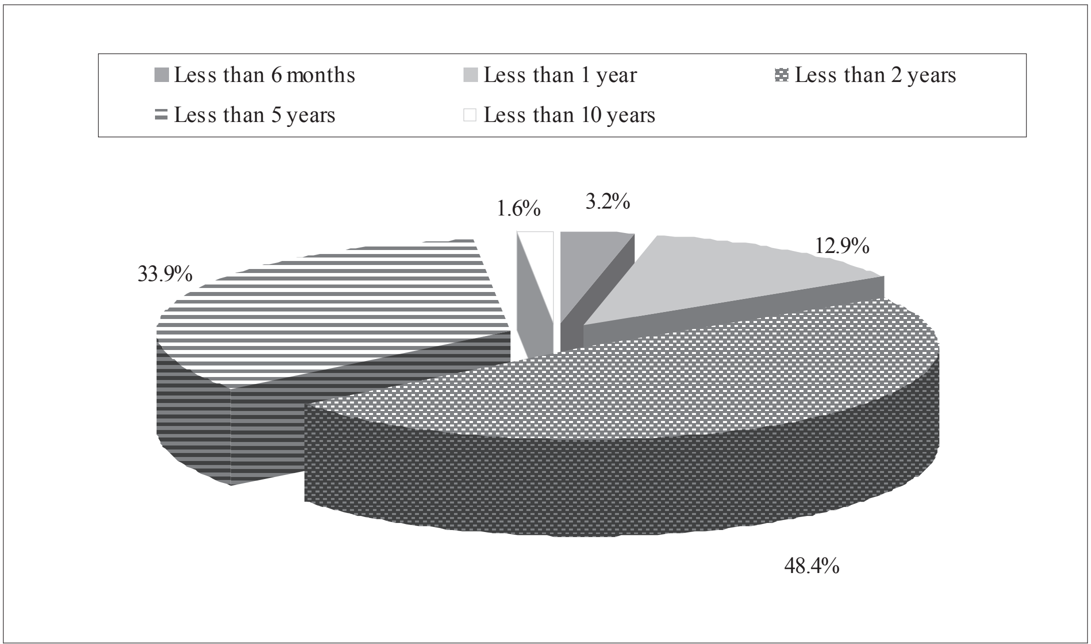

Figure 8.7 Distribution of samples by payback time of energy saving projects (N=62)

Nearly 65% of the samples would accept a payback time of within two years; 13% of them even expected to recoup the investment within one year. Nearly 34% could accept a payback period of from 2 to 5 years, which is similar to Thollander and Ottosson (2010) and Liu et al. (2013b), who confirm a high profitability expectation of the energy-intensive companies in Sweden and China. UK companies, on the other hand, would accept longer payback times of 3–5 years on average (Martin et al., 2012).

5.3 Statistics of the variables and correlation matrix

Table 8.4 summarises the statistics of company awareness of technologies, determinant factors as independent variables and the quantitative controls.

Table 8.4 Statistics of technology awareness, determinants and the quantitative controls

Variable		Obs.	Mean	Std. Dev.	Min.	Max.
Technology awareness	AWAREEXTTECH	62	2.89	0.96	1	5
	AWARENEWTECH	62	3.05	0.76	1	5
Determinant	COMPETITION	62	4.30	0.56	3	5
	ENPRICE	62	3.27	0.93	1	5
Control	SAVPOTENTIAL	61	1.86	0.61	1	4
	EDUCATION	62	3.24	0.92	1	5

The companies' understanding of energy saving technologies is moderate and the variables of

AWAREEXTTECH and AWARENEWTECH achieved means of 2.89 and 3.05 individually. Specifically, approximately 34% of the respondents are unclear about the energy saving technologies in use and 42% of them indicate a moderate understanding of the existing technologies. Nearly 20% of the samples have no knowledge of new energy saving technologies and two thirds selected the answer of moderate awareness. Less than 5% of the surveyed companies answered that they were fully aware of existing and new technologies, which reveals that the governments at various levels in Korea need to be more proactive in disseminating information on energy saving technologies, as it pertains to the public good (De Groot et al., 2001). Similarly, the information barrier was identified as a major obstacle restricting companies from adopting energy efficiency technologies in Europe (Kostas et al., 2011). Velthuijsen (1995) concludes that companies with more knowledge sources perform better than others in energy efficiency.

The companies feel strong pressures from competitors in the same sector and presented the highest scores to COMPETITION, with a mean of 4.30. In contrast with Chinese companies, which felt highly pressured by energy prices (Liu et al. 2013b), the surveyed companies in Korea give ENPRICE a moderate evaluation, with a mean of 3.27. This is consistent with Suk et al. (2013), confirming that energy price has no significant relationship with energy saving practices of Korean companies, despite the fact that energy price affects company energy efficiency (Prindle, 2010; Liu et al., 2012). Kang et al. (2012) confirms that the distorted electricity price in Korea imposes a very low price for the industry in comparison with other OECD countries. A mean of 1.86 for SAVPOTENTIAL reveals that the sampled companies perceive limited potentials for further energy saving. In a press release dated 19 June 2012 from the Federation of Korean Industries (FKI: the country's largest business association), the energy efficiency of key industries (such as chemicals, paper and iron & steel) were compared globally, which revealed that these sectors have already reached an advanced level of energy efficiency. This, FKI argued, was should be born in mind by the government when implementing climate change measures (FKI press, 2012).

The employees of companies have moderate education levels on average and the variable of EDUCATION achieved a mean of 3.24. The ratios of samples with ownerships of domestically private and foreign-funded are 88.7%, and 11.3%, respectively.

A pair-wise correlation was calculated to explore the relationships between the variables in table 8.4, the correlation matrix of which is listed in table 8.5. There is no indication for unacceptable multi-collinearity between the variables since the highest figure is 0.437 for AWARENEWTECH and AWAREEXTTECH at $P<0.01$. Harmful levels of multi-collinearity do not occur until the correlation coefficient reaches ± 0.9 (Farrar and Glauber, 1967). A negative and significant relationship exists between energy price and the awareness of new technologies.

Table 8.5 Correlation matrix of technology awareness, determinants and the quantitative controls

	AWA.EXT.	AWA.NEW.	COM.	ENP.	SAV.	EDU.
AWAREEXTTECH	1					
AWARENEWTECH	**0.437**[a]	1				
COMPETITION	0.187	-0.152	1			
ENPRICE	-0.131	**-0.230**[c]	-0.101	1		
SAVPOTENTIAL	-0.051	0.048	-0.088	**-0.359**[a]	1	
EDUCATION	0.050	0.026	0.004	-0.114	-0.141	1

[a] Significant at 1% level; [b] Significant at 5% level; [c] Significant at 10% level

5.4 Multivariate analysis with company awareness of technologies as the dependent variables

Multivariate regressions were performed to identify whether a company's awareness of energy saving technologies varies due to the external pressures and company characteristics. The analysis robustness was tested by adopting two models. Model 1 is the case of only including the independent variables and model 2 is the case of introducing all the variables listed in equation (1). The results are listed in table 8.6.

Table 8.6 Regression results with company technology awareness as the dependent variables

	Independent variables and controls	**Dependent: AWAREEXTTECH**		**Dependent: AWARENEWTECH**	
		Model 1	Model 2	Model 1	Model 2
Independent	COMPETITION	0.645	0.500	-0.532	-0.654
	EXPORT	-0.419	-0.270	**-1.163**[c]	**-1.806**[b]
	ENPRICE	-0.315	-0.284	**-0.815**[b]	**-1.057**[a]
Company's characteristics	SAVPOTENTIAL	-0.251	-0.181	-0.158	-0.437
	EDUCATION		0.767		-0.093
	STEEL		-1.136		0.856
	CHEMICAL		-0.906		1.384
	DOMESTIC		-0.439		0.671
	SMALL		-1.602		-2.610
	MEDIUM		-0.620		-0.616
	LMEDIUM		-0.667		**-1.661**[b]
	TMS		-0.182		1.187
	Obs.	61	61	61	61
	LR chi	3.77	7.26	**9.42**[b]	**22.16**[b]
	Pseudo R^2	0.0226	0.0435	0.0685	0.1612

[a] Significant at 1% level; [b] Significant at 5% level; [c] Significant at 10% level

The result indicates that companies with products mainly for the foreign market are less aware of new energy saving technologies than the companies with products destined for domestic markets. The pressure of energy prices is significantly but negatively associated with

AWARENEWTECH, which reaffirmed that the low level of energy prices for the industry in Korea cannot urge the companies to collect information on energy saving technologies, particularly the latest technologies. There exists a significant but negative relationship between a company's size and its knowledge of new technologies. Compared with the large companies, the large medium-sized ones indicate lower awareness of new energy saving technologies, a result consistent with that of De Groot et al. (2001) and Liu et al. (2013b), confirming that large companies have a better understanding of energy saving technologies than small ones.

5.5 Company awareness of MBIs and the determinant factors

5.5.1 Statistics of company's awareness of MBIs

The companies were requested to indicate their awareness of the nine items of MBIs, the statistics of which are shown in table 8.7.

Similarly with Liu et al. (2013a), the companies in Korea show moderate awareness of the pre-listed MBIs in general. Comparatively, the respondents have greater awareness of MBI06 (Soft loan for energy saving companies projects), with a mean of 3.60. This may be attributed to the implementation success of ESCO in Korea. The financial barrier is to be lifted for promoting energy efficiency investment and ESCO business (Lee et al., 2003). The following policies with relatively high awareness of the companies are MBI05 (Grant for high energy efficiency equipment, i.e., LEDs, transformers, freezers) and MBI09 (GHG ETS), with the same score of 3.31 on average. In spite of strong resistance from industry, recent discussions of GHG ETS in Korea have increased the focus on energy-intensive companies. The mean of awareness of most other MBIs is around 3.0. It is understandable for MBI08 (Carbon tax policy) to obtain a relatively low awareness since this is still being deliberated on within the government.

Table 8.7 Statistics of company awareness of MBIs

No.	Items of MBIs	Obs.	Mean	Std. Dev.	Min.	Max.
1	MBI01	62	3.21	1.01	1	5
2	MBI02	62	3.03	0.99	1	5
3	MBI03	62	3.11	0.94	1	5
4	MBI04	62	2.66	0.95	1	5
5	MBI05	62	3.31	0.86	1	5
6	MBI06	62	3.60	0.95	1	5
7	MBI07	62	3.27	1.03	1	5
8	MBI08	62	2.93	0.83	1	5
9	MBI09	62	3.31	0.74	2	5

5.5.2 Multivariate analysis with company policy awareness as dependent variables

Econometric regressions were performed to identify the determinant factors of company awareness of MBIs. The company's awareness degrees of MBIs, AWAREMBI, are an ordinal measurement and no abrupt changes in their cumulative probabilities are present. An ordered probit model is therefore a rational choice (Greene, 1997) and the results are listed in table 8.8.

The regression results of MBI02, MBI03, MBI04 and MBI07 are statistically significant. Differing from de Groot et al. (2001), suggesting that competition acts as a push for the companies to obtain strategic information, including that on policy issues, this analysis found no significant relationships between a company's awareness of MBIs and the external factors overall, with the exception of MBI04 (Soft loan for DSM investment programme). A significant but negative relationship was found between the awareness of this policy and COMPETITION. A company's size is significantly associated with company awareness of the four MBIs, with regressions statistically significant. The medium-sized companies indicate higher awareness of MBI02, MBI03, MBI04 and MBI07 than their large counterparts. This finding contrasts with Liu et al. (2013b) documenting that large Chinese companies have greater access to resources and have higher policy awareness than SMEs, and may be so since large Korean companies have less constraints on financing and the economic incentives are more meaningful for the medium-sized ones. This implies that companies may pay more attention to the policies with high relevance and selectively collect policy information related thereto. Another finding is that the TMS companies show lower awareness of MBI03 and MBI04 than the non-TMS ones.

Table 8.8 Multivariate regression results with the awareness of MBIs as dependent variables

Independent variables and controls		**Dependent variables: AWAREMBI**								
		MBI01	**MBI02**	**MBI03**	**MBI04**	**MBI05**	**MBI06**	**MBI07**	**MBI08**	**MBI09**
Independent	COMPETITION	0.050	-0.570	-0.428	**-0.881**[c]	0.726	0.245	-0.806	0.373	**0.851**[c]
	EXPORT	**-1.118**[c]	-0.406	0.085	-0.571	0.187	-0.667	-0.368	-0.710	**-1.262**[b]
	ENPRICE	0.260	-0.070	0.136	-0.305	0.538	-0.257	-0.431	-0.025	-0.449
Company's characteristics as controls	SAVPOTENTIAL	-0.600	-0.579	-0.711	0.067	-0.501	-0.563	0.090	0.418	-0.162
	EDUCATION	-0.164	0.111	-0.084	0.077	-0.158	-0.111	0.216	-0.037	0.086
	STEEL	0.394	0.035	0.144	0.023	0.801	0.843	0.532	0.560	0.731
	CHEMICAL	**1.441**[c]	0.749	1.138	0.285	**2.095**[b]	**2.433**[a]	1.185	**1.556**[c]	1.334
	DOMESTIC	0.434	0.574	0.466	-0.518	**1.510**[c]	0.372	1.269	0.253	-0.413
	SMALL	**3.159**[b]	-1.311	0.874	-2.726	1.593	1.339	-0.432	2.058	0.903
	MEDIUM	**1.335**[c]	**1.983**[a]	**1.558**[b]	**1.312**[c]	**2.362**[a]	0.627	**2.041**[a]	0.992	0.194
	LMEDIUM	0.380	0.473	-0.217	0.300	-0.539	-0.991	0.805	0.801	0.635
	TMS	-1.043	-1.054	**-2.679**[b]	**-2.900**[b]	-0.415	-0.559	-0.934	-1.566	-0.293
Obs.		61	61	61	61	61	61	61	61	61
LR chi		15.92	**19.90**[c]	**19.12**[c]	**19.37**[c]	25.59	16.93	**22.53**[b]	10.13	10.76
Pseudo R^2		0.0927	0.1171	0.1168	0.1177	0.1724	0.1057	0.1310	0.0681	0.0797

Note: [a] Significant at 1% level; [b] Significant at 5% level; [c] Significant at 10% level.

5.6 Company acceptability of energy saving policies and the determinant factors

5.6.1 Statistics of company acceptability of energy saving policies

In this survey, we asked the companies to show their subjective acceptability to all the policy tools listed in table 8.1. The average scores are depicted in fig.8.8.

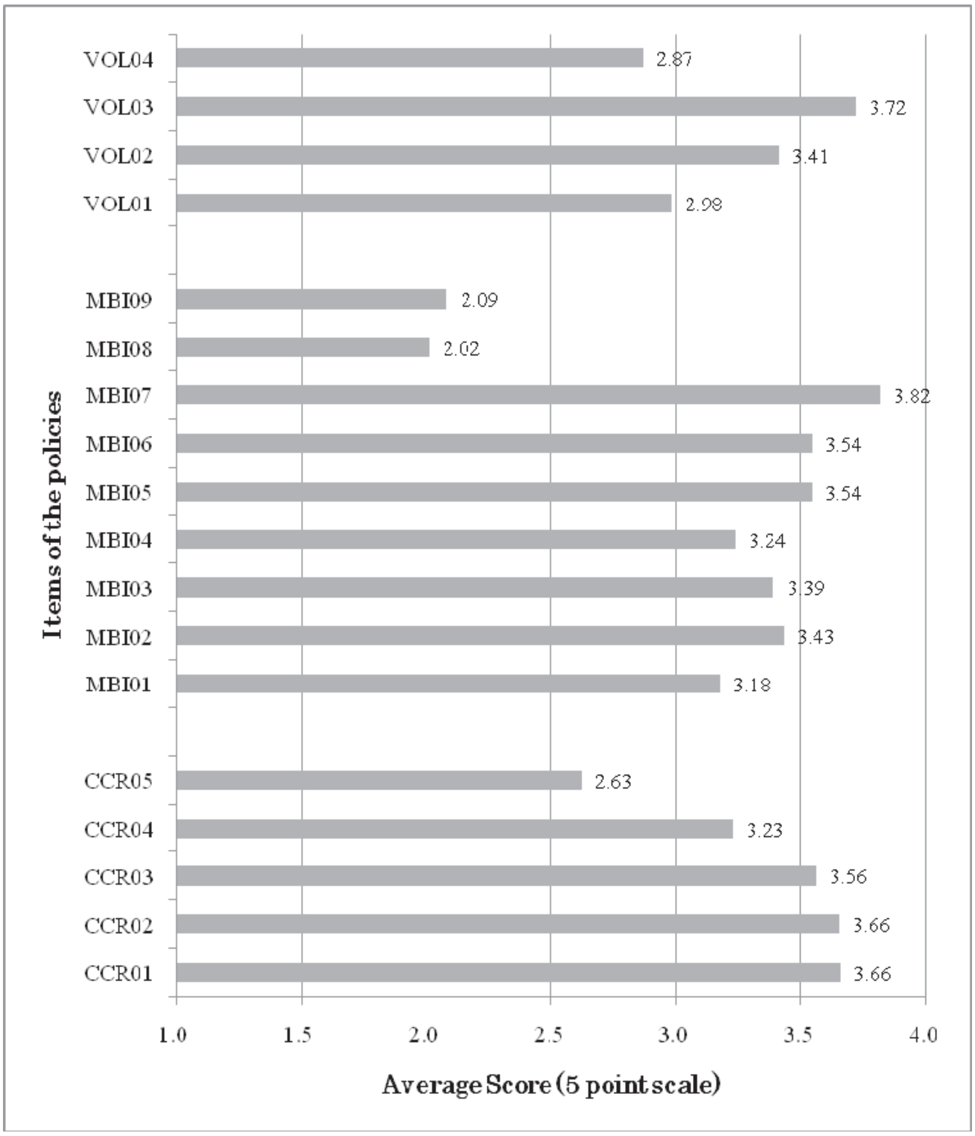

Figure 8.8 Company acceptability of energy saving policies (N=62)

As with Chinese companies (Liu et al., 2013a; 2013b), economic incentives are preferable and presented relatively higher scores. Particularly, MBI07 (Tax reduction for investment in energy-saving facilities) obtained the highest mean of 3.82. MBI02, MBI03, MBI05 and MBI06 received similar means of around 3.50. Conversely, carbon pricing policies, MBI08 (Carbon tax policy) and MBI09 (GHG ETS), are resisted by the companies in Korea, with both presenting means of around 2.00.

The survey confirms that certain voluntary approaches are appreciated. VOL03 (Training for energy managers) achieved a high mean of 3.72, showing the need of technological support for Korean companies. VOL02 (Voluntary agreement for energy saving) obtained a mean of 3.41, meaning that the companies intend to cope with the government energy saving requirements flexibly (Liu et al., 2013b). The samples indicate good acceptability to some regulative tools, such as CCR01 (GHG/energy target management system) to CCR03 (Energy audit requirement). These three regulative measures obtained similar means of around 3.60. Korean companies agree that the government needs to impose mandatory requirements as regards industrial energy saving (Klok et al., 2006; Liu et al., 2013b).

5.6.2 Multivariate analysis with company acceptability of MBIs as dependent variables

Multivariate regressions were performed to identify whether a company's acceptability of MBIs varies due to external pressures and company characteristics. An ordered probit model was applied, with the results being listed in table 8.9. The regression results of MBI01, MBI05, MBI08 and MBI09 are statistically significant and thus discussed.

Table 8.9 Multivariate regression results with acceptability of MBIs as dependent variables

Independent variables		Dependent variables: ACCETPMBI								
and controls		MBI01	MBI02	MBI03	MBI04	MBI05	MBI06	MBI07	MBI08	MBI09
Independent	COMPETITION	0.261	-0.072	0.326	0.404	**0.686**[b]	-0.255	0.104	0.290	0.416
	EXPORT	-0.073	-0.189	-0.224	**-0.888**[c]	-0.695	-0.240	-0.516	-0.522	-0.351
	ENPRICE	-0.235	-0.425	-0.060	-0.204	**-0.396**[c]	**-0.460**[b]	-0.054	0.141	0.178
Company's characteristics as controls	SAVPOTENTIAL	-0.142	**-0.591**[c]	-0.035	-0.290	-0.295	-0.306	-0.417	0.339	0.423
	EDUCATION	-0.247	0.195	0.045	-0.057	0.133	0.116	-0.190	-0.173	-0.236
	CEMENT	**1.083**[c]	0.563	0.835	0.284	0.857	0.155	-0.174	-0.549	0.262
	CHEMICAL	**1.019**[b]	-0.101	0.559	0.553	0.182	0.577	0.654	**0.665**[c]	**1.517**[a]
	FOREIGN	-0.766	-0.892	-0.750	**-1.159**[c]	-0.730	**-0.845**[c]	-0.860	0.496	0.066
	MEDIUM	-0.805	2.438	-0.996	-1.062	-0.250	1.648	-0.475	**1.785**[c]	-1.809
	LMEDIUM	-1.551	1.576	0.312	-0.851	-0.801	0.993	-0.644	-0.068	-2.028
	LARGE	-0.348	2.424	**-0.930**[c]	**-1.370**[b]	-0.175	1.308	-0.490	-0.146	-1.746
	TMS	0.338	1.020	0.142	0.119	**1.436**[c]	0.453	0.467	**-2.521**[a]	**-2.256**[a]
Obs.		50	50	50	45	56	56	59	60	58
LR chi		**19.79**[c]	17.70	16.22	15.02	**20.35**[c]	17.35	10.44	**21.80**[b]	**22.99**[b]
Pseudo R^2		0.138	0.171	0.132	0.146	0.162	0.122	0.077	0.149	0.153

Note: [a] Significant at 1% level; [b] Significant at 5% level; [c] Significant at 10% level

Differences in the acceptability of MBI01 (Subsidies for maintenance, improvement and replacement of energy saving facilities) exist between the sectors. Compared with the iron & steel sector, cement and chemical companies are more likely to accept MBI01. For MBI05 (Grant for high energy-efficiency products), the companies facing higher pressure from the market and the TMS target companies indicate higher acceptability; companies facing higher pressure from energy prices have lower acceptability of MBI05.

The acceptability of MBI08 (Carbon tax policy) and MBI09 (GHG ETS) is significantly associated with company characteristics. Compared with the iron & steel industry, chemical companies have better acceptability for these two carbon pricing policies, which is understandable since chemical companies are relatively less energy-intensive than the iron & steel industry. MBI08 and MBI09 would incur lower costs for chemical companies than for iron & steel. The TMS-target companies are more likely to resist MBI08 and MBI09 than the non-TMS companies. As TMS targets large energy-consuming entities in Korea, the companies at the top of the list of TMS targets would be the first to be impacted by GHG ETS. MBI08 (Carbon tax policy) would exert a heavier burden for TMS target companies than non-TMS ones, which may explain the difference in level of acceptability of MBI08 and MBI09 between the variously characterised companies.

5.7 Company behavioural responses to MBIs

It is a fact that a company's energy cost would increase if either of carbon taxes and GHG ETS were introduced. Aiming to monitor the possible responses of companies to these carbon pricing policies, we requested the companies to explore alternative actions that could be taken. A five-point scale was applied, where: '5' = very possible; '4' = relatively possible; '3' = moderate possibility; '2' = low possibility; and '1' = completely impossible. The statistics are shown in fig.8.9.

According to the results, the companies would avoid reactive actions (reducing levels of production; moving production to areas with looser policy; closing production facilities; taking no reaction by accepting the loss), as these four choices presented average scores of under 2.70. On the contrary, the companies indicated that they would prefer internal efforts to save energy to relieve the policy's negative impacts. Practicing managerial energy-saving activities is the most feasible option, with the highest mean of 3.82. To invest in energy efficient technologies, self-investment in R&D and use less carbon-intensive energies are responses with relatively higher possibilities. A meaningful finding from fig.8.9 is that the companies would not simply offload the policy burden onto their customers. The option of raising product prices for cost shifting achieved a moderate mean of 2.84, which differs from the finding of De Groot et al. (2001), who suggest that Dutch companies are more likely to pass on the additional costs to customers given an energy tax increase. The result in the present survey in Korea may be explained by the strict competition faced by Korean companies.

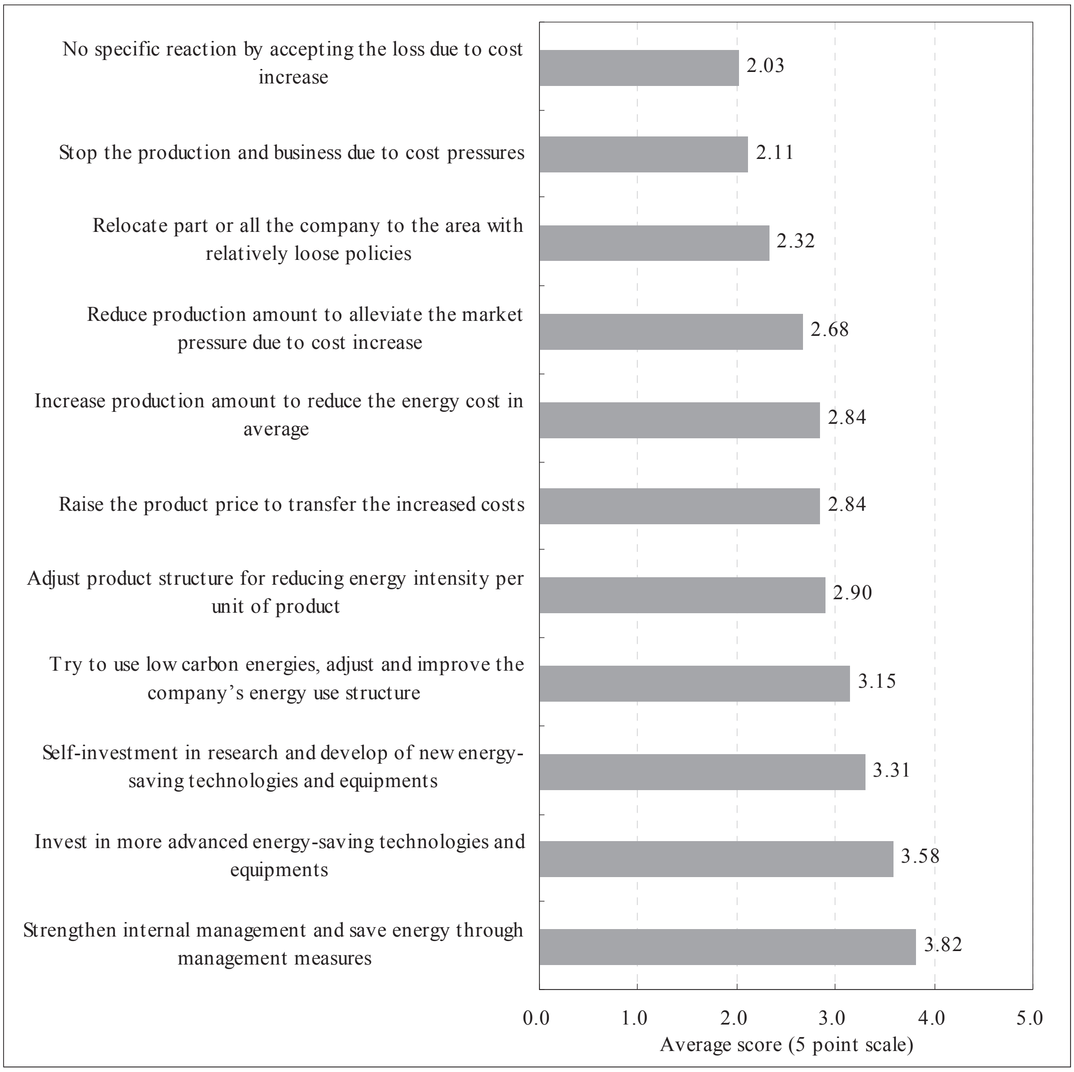

Figure 8.9 Company behavioral responses to MBIs (N=62)

6. Conclusions

This study measured company awareness and acceptability of MBIs via empirical analysis by targeting three energy-intensive sectors in Korea. Overall, the respondents indicate moderate awareness of the pre-listed nine MBIs. The companies exhibited more concern over policies closely associated with them and purposely collect policy information related thereto. They show good acceptability of industrial energy saving policies in general. The economic incentives and some voluntary approaches are appreciated. The companies agree with the usefulness of certain regulative requirements for industrial energy saving. However, the sampled Korean companies resist carbon pricing policies in the current phase. Therefore, to a certain extent, a company's policy acceptability is determined by its characteristics.

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Chapter 9:
Awareness and acceptability of Japanese companies on market-based instruments for energy saving: A survey in Hyogo, Japan*

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Chapter Highlights:

- This chapter gives an analysis of awareness and acceptability of Japanese companies on market-based climate policies using the data collected from 230 respondents based in Hyogo Prefecture.
- The survey result confirms a payback period of 3 to 5 years expected by the samples for energy saving investment projects.
- Overall, the surveyed companies have low awareness of the pre-listed MBIs. Nearly all the MBIs achieved low to moderate evaluations of awareness levels.
- Hyogo companies reveal moderate acceptability to the industrial energy saving policies in general. The samples presented low scores to their acceptability of carbon pricing tools.
- The companies would make internal efforts to alleviate the negative impacts of carbon pricing policies rather than simply transfer the burden onto their customers.

1. Introduction

The success of any energy efficiency policy is largely determined by the response it garners from the variously characterised companies it affects. A study in Europe of the efficacy of market-based instruments (MBIs) in promoting energy saving (Blok, 1993; De Groot et al., 2001; Klok et al., 2006), which identified certain success conditions of industrial energy efficiency policies, is of limited utility for the practice of MBIs in Asia, including Japan. The present study measures the awareness and acceptability of Japanese companies on MBIs with relevance to industrial energy saving. Hyogo prefecture is targeted as the study area.

Three main topics are discussed in this chapter: a) Company awareness and acceptability levels of the pre-listed MBIs for industrial energy saving, i.e., financial subsidies, energy and carbon taxes and GHG ETS; b) To what extent a company's policy awareness and acceptability are

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* The main content of this chapter was published as: Liu, X.B., Yamamoto, R., Suk, S.H., 2014. A survey of company's awareness and approval of market-based instruments for energy saving in Japan. Article in press, *Journal of Cleaner Production.*

influenced by the classified determinants, including the external pressures and internal factors; and, c) Company behavioral changes of energy management in response to implementation of the MBIs, particularly the carbon pricing policies. As an additional component, we also measured the barriers for the companies to invest in energy saving technologies and their expectations regarding the payback time for the investments.

The remainder of this chapter is structured as follows. Section 2 outlines the industrial energy saving and climate policies in Japan and lists the policy items targeted in this survey, section 3 describes the analytical framework used in this analysis, section 4 explains the methodologies, section 5 discusses the statistics of company policy awareness and acceptability, and the econometric regression results. Lastly, section 6 concludes the survey analysis.

2. Industrial energy saving and climate policies in Japan and the policies targeted in this survey

2.1 Industrial energy saving and climate policies in Japan

2.1.1 Command-and-control regulations

As a regulative measure, the 'Law Concerning the Promotion of the Measures to Cope with Global Warming' was firstly enacted in 1998 and was most recently amended in 2008. According to this law, the 'GHG Accounting and Reporting System' mandates large GHG emitters ('Specified Emitters') to calculate and report their emissions to the government every year. The Specified Emitters are those that consume more than 1,500 kl of crude oil equivalents and emit more than 3,000 t-CO_2 per year, and which have no less than 21 employees. The gathered information on GHG emissions is disclosed by the Ministry of the Environment, Japan (MOEJ) to the public. In 2009, over 11,000 businesses reported their GHG emissions under this system, accounting for about half of the total emissions of the country (Kauffmann et al., 2012).

2.1.2 Market-based instruments

Japan's government provides various economic incentives to support the efforts of industrial energy saving and carbon mitigation, including direct financial subsidies and tax credits. The energy saving and climate subsidies are mainly from governmental organisations such as METI (Ministry of Economy, Trade and Industry), MOEJ and NEDO (The New Energy and Industrial Technology Development Organisation).

METI provides financial support to projects related to energy diagnosis and installment of energy monitoring systems in small and medium-sized enterprises (SMEs). Companies under J-VETS (Japan's Voluntary Emissions Trading Scheme) may apply for the subsidy from MOEJ to achieve their reduction targets. The subsidy equates to one third of the facility investment and cannot exceed 200 million JPY for each project. The budget for the participants of J-VETS was 600 million JPY in 2011 (MOEJ, 2011a), and NEDO has subsidies available for the investment of leading-edge facilities and technologies. In terms of tax credits, ANRE (The Agency for Natural Resources and Energy) under METI oversees a preferential tax policy for improving the structures of energy supply and demand. Small businesses are eligible for a tax credit of 7% of the associated expenditure for acquiring energy saving equipment, which shall not exceed 20% of the corporation tax in the accounting period. Instead of tax credits, special depreciations to the value of a maximum of 30% of the reference purchase value may be received, in addition to the normal depreciation (ECCJ, 2009). The tax credit policy is amended every few years and applies for a list of eligible technologies (Tanaka, 2011).

Aside from the subsidies for energy saving technologies and facilities, economic incentives are available for energy efficient products in Japan. The consumers of eco-cars and certain categories of electronic home appliances have benefited from these policies. Automobile weight and acquisition taxes may be exempted or reduced by MLIT (Ministry of Land, Infrastructure, Transport and Tourism) for the purchase of an eco-car (MLIT, 2012). Further, METI has subsidies with a maximum of 250 thousand JPY available to purchasers of eco-cars. Both measures may apply if the requirements for eco-car tax reduction and subsidy are satisfied. The budget for eco-car tax reduction and subsidy was 540 billion JPY in 2009 and 440 billion JPY in 2010, which had corresponding impacts on real GDP growth of 0.56% and 0.45%, respectively. In terms of GHG emissions mitigation, however, the result was marginal as it only shaved off 0.1% from the country's 2020 total emissions target (Saruyama, 2010). The eco-car subsidies were revived in 2011 after the Great East Japan Earthquake and carried a total budget of 300 billion JPY, before being finally terminated in September 2012 owing to budget depletion (The Japan Times, 2012). Another representative subsidy for energy efficient products is the "eco-point" system for digital televisions, air conditioners and refrigerators, which carried a budget of 693 billion JPY. By the end of May 2011, around 45 million applications had been processed and points with a value of about 640 billion JPY issued. The eco-point policy was estimated to bump-up sales by about 2,600 billion JPY for the three types of appliance and create a mitigation capacity of about 2.7 Mt-CO_2 per year (MOEJ, METI and MICA, 2011).

Japan has also practiced certain policies exerting economic pressure for industry to save energy – energy-related taxes have been levied for many years, including automobile fuel taxes, aviation fuel tax, petroleum and coal tax and a tax for promoting the development of power. Such taxes vary considerably if the fuel is converted into carbon content, with the highest being 24,052 JPY/t-CO_2 for gasoline and the lowest 291 JPY/t-CO_2 for coal. Since the early 1990s carbon taxes have been discussed within the MOEJ, which, in the face of strong resistance from industry and lack of public support, has recommended a low-rate tax earmarked as specific funds for global warming. The 'Global Warming Countermeasure Tax' (or 'Environmental Tax') was intended to start on 1 October 2012 with tax rates of 289 JPY/t-CO_2 (equivalent to

760 JPY per kl of petroleum and oil products), 780 JPY per tonne of hydrocarbon gases and 670 JPY per tonne of coal. In the initial phase, one third of the rates quoted above are imposed for various fossil fuels, the second third was to be added commencing 1 April 2014 and the full levy was intended to apply from 1 April 2016. Overall, this new tax may be viewed as a positive improvement to existing energy taxes, as households will only need to pay around 100 JPY per month on average after the tax is fully levied and the expected reductions in total domestic GHG emissions by 2020 will range from 0.5 to 2.2% – equivalent to 6 to 24 Mt-CO_2 (MOEJ, 2012).

The Japanese government has also attempted to establish an integrated domestic market for GHG emissions. The experimental carbon market admits credits from various mechanisms, including J-VETS, domestic ETS on trial, Japan's verified emissions reduction (J-VER) and Kyoto mechanisms. MOEJ launched J-VETS in April 2005 by targeting SMEs not covered by the Keidanren Voluntary Action Plan (*Keidanren:* Japanese business federation). A total of 357 companies participated in J-VETS and successfully reduced their emissions by 947,670 t-CO_2 in 2009, equivalent to 28% of their base year emissions. The traded amount was 57,930 t-CO_2 at an average price of 750 JPY/t-CO_2 (MOEJ, 2011b). For the domestic GHG ETS on trial, the participating companies may voluntarily set their reduction targets in the form of absolute amounts or emission intensity. In 2009, 60 participants successfully realised their targets by self-reductions. The other 30 companies with insufficient self-reductions achieved their targets by borrowing future allowances or buying credits from the market (MOEJ, 2011b). J-VER, initiated in November 2008, permits large companies to provide technological or financial assistance to SMEs and thus receive VERs. The number of projects registered under J-VER was 106 as of May 2011, of which 63 were verified to receive VERs equal to 111,976 t-CO_2 (MOEJ, 2011b). Establishment of a domestic GHG ETS is recognised as one of the three policy pillars for climate change in Japan; however, this policy has been blocked in practice due to concerns over its excessive interference with business in emerging sectors (Reuters, 2010).

2.1.3 Voluntary approaches

A number of voluntary approaches have been practiced in Japan for industrial energy saving. As examples, the Keidanren Voluntary Action Plan on the Environment was firstly formulated in 1997, the overall goal of which was to reduce GHG emissions in 2010 below the 1990 levels for the member companies from industrial and energy conversion sectors (28 industries in 1997; increased to 34 sectors in 2010). The sub-industries declared their voluntary reduction targets in terms of absolute amounts or relative intensities. The GHG emissions of the participating industries accounted for nearly 83% of the total of the industrial and energy conversion sectors in 2010. An external committee was established by Keidanren in 2002 to regularly evaluate the state of implementation of this voluntary plan, and the latest report indicates that total emissions of the participating industries in 2010 were 443.47 Mt-CO_2, a decrease of 12.3% from the 1990 amount. This reduction includes 13.75 Mt-CO_2 of carbon credits acquired by market mechanisms (Keidanren, 2012). As a part of ongoing post-Kyoto efforts, Keidanren announced a commitment to a low carbon society in December 2009 (Keidanren, 2009), the basic principles and activities of which are specified in its new voluntary plan.

Japanese companies disclose their GHG-related information in environmental or sustainability reports or financial reports voluntarily, and such practice has gained popularity. MOEJ (2010) reported that 1,091 of the total 3,036 respondents in a ministry survey issued environmental reports in 2009. To establish a formal system for GHG information disclosure is under consideration of METI, MOEJ and the Japanese Institute of Certified Public Accountants (JICPA). METI has been developing the Carbon Footprint of Products (CFP) system since 2008 and launched a pilot project with other related ministries in June 2009 (METI, 2010). The CFP system calculates GHG emissions based on product lifecycle, allowing consumers to grasp the CO_2 emissions resulting from their purchases, which is intended to encourage production and consumption with lower emission intensities. As of 13 December 2012, 81 Product Category Rules (PCRs) had been issued and 631 products authorised with CFP labels (JEMAI, 2012).

2.2 Policies targeted in this survey

The descriptions and abbreviations of policies targeted in this survey are listed in table 9.1.

Table 9.1 Descriptions and abbreviations of policies in this survey

Category	Description	Abbreviation
Adm. Man. req. (AMR)	Reporting system of GHG emissions for companies with energy use or GHG emissions exceeding a certain amount	AMR01
Market-based instruments (MBIs)	Financial subsidies for the investments in energy saving technologies and projects:	MBI01:
	A: Subsidy by NEDO for introducing the most advanced facilities in SMEs	MBI01A
	B: Subsidy by METI for the investment of energy saving technologies in SMEs	MBI01B
	C: Subsidy by MOEJ for achieving mitigation targets of participants of J-VETS	MBI01C
	D: Interest subsidy by METI for the investment in large energy saving equipments	MBI01D
	Soft loan for the establishment of energy saving facilities	MBI02
	Subsidies to energy-efficient products, e.g., eco-car and eco-point for electronic appliances	MBI03
	Tax credit for energy saving products and technologies	MBI04
	Energy taxes including petroleum and coal taxes, gasoline tax and power promotion tax	MBI05
	Global warming countermeasure tax (Environment tax, started from 1 October 2012)	MBI06
	International emissions trading schemes under Kyoto Protocol, like CDM and JI	MBI07
	Integrative domestic carbon market, including J-VETS, ETS on trial and J-VER	MBI08
Voluntary approaches (VOLs)	Voluntary action plan of Nippon Keidanren (Japan Business Federation)	VOL01
	Voluntary disclosure of GHG emissions-related information of companies	VOL02
	Certification programme of product carbon footprint	VOL03

The eight policy items in table 9.1 are MBIs focused on in this analysis. They are MBI01 (Financial subsidies for the investments in energy saving technologies and projects) to MBI05 (Energy taxes, including petroleum and coal taxes, gasoline tax and power promotion tax), which have been implemented in Japan. MBI06 (Global warming countermeasure tax) is a new policy launched on 1 October 2012. MBI07 and MBI08 are two forms of GHG trading schemes – international and domestic. During the survey, MBI01 is further sub-categorised into MBI01A to MBI01D to represent the subsidies from various sources, such as NEDO, METI and MOEJ.

Two other types of policy are also listed in the questionnaire to compare them with MBIs in terms of level of company acceptability. One is the administrative management requirement (AMR) – which is similar to the reporting system of GHG emissions for companies with energy use or GHG emissions exceeding a certain amount (AMR01) – and the other is voluntary approaches (VOLs), including VOL01 (Voluntary action plan of Nippon Keidanren) to VOL03 (Certification programme of product carbon footprint). The policy descriptions in table 9.1 are listed in the survey document as-is so that the companies can attribute scores to their awareness and acceptability.

3. Analytical framework of this study

The analytical framework of this study is shown in fig.9.1 and is similar to that applied in our previous analyses of Chinese companies (Liu et al. 2013a; 2013b). This model follows the viewpoint of institutional theory, which addresses the usefulness of external pressures for enhancing a company's environmental performance and includes identifying its energy management problems and searching for energy efficiency related policies and technologies as a form of strategic information (Liu et al., 2010). A company's acceptability of a specific policy can be determined by how it evaluates the policy's impact, whether perceived or actual, on its comparative competitiveness.

There are two differences between the framework of this study and that in Liu et al. (2013a; 2013b). One is the selection of external pressures. Four factors – regulative pressure, normative pressure, competition pressure and energy price level – are classified as external pushes in this study. In Liu et al. (2013a; 2013b), the coercive and normative pressures were excluded since our earlier survey confirmed the weak roles of governmental requirements and industrial associations in determining the current energy saving practices of Chinese SMEs (Liu et al., 2012). The other is the selection of internal factors. Aiming to identify the difference in policy awareness and acceptability due to company characteristics, organisational size, industrial sector, learning capacity and energy saving potential are classified as control variables in this model. We excluded ownership since almost all the companies in this survey are domestic private ones.

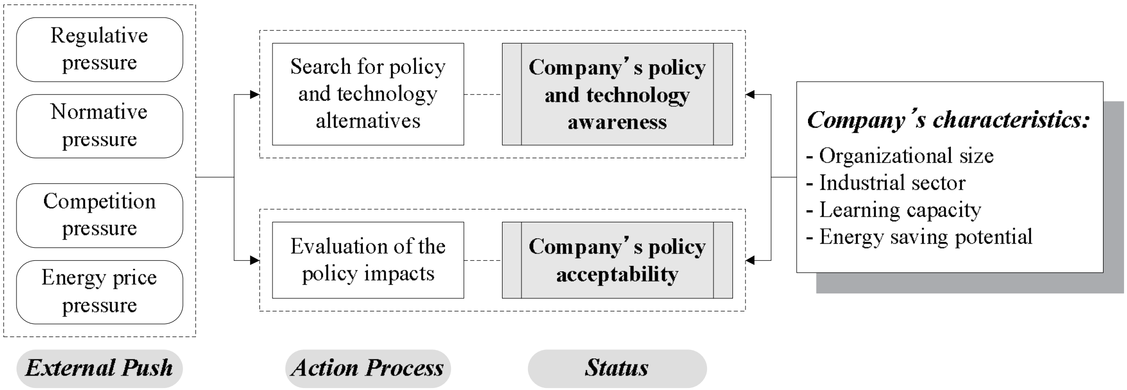

Figure 9.1 Analytical framework of this study

4. Methodologies

4.1 Outline of the survey and samples

The data for this analysis was obtained via a questionnaire survey conducted over July to October, 2012. A questionnaire was designed with the major objectives of identifying company energy saving activities, measuring awareness and acceptability of various energy saving policies and the affordability of energy cost increases due to introduction of the MBIs. The format consisted of six components related to the surveyed company: general information, energy use and management status, energy saving practices, barriers hindering investments in energy saving technologies, awareness and acceptability degrees of various energy saving policies, and degree of affordability of alternative energy cost increases. This chapter provides an analysis of company policy awareness and acceptability using part of the collected information.

We targeted energy managers positioned at the middle level in terms of company management structure as we believe they best represent the current situation and decisions within their companies. The survey was conducted with the support of two local organisations in order to obtain more complete responses from the companies – 'Hyogo Environmental Protection Management Association' and 'Division of Global Warming Countermeasures, the Government of Hyogo'. We posted the questionnaires to all 465 industrial companies with annual energy usages of over 1,500 kloe (kilolitres of oil equivalent) in Hyogo. Of these, 117 are environmental association members, which received a letter requesting cooperation along with the questionnaires. For the other 348 companies, the questionnaires were posted together with a letter from Hyogo government requesting their cooperation. As a result, 72 of the association members and 158 of the non-association group responded, giving a total of 230 valid respondents and a return rate of 49.5%. The distribution of useful samples by sector and organisational size is listed in table 9.2.

Table 9.2 Distribution of valid respondents by sector and size

Sector	Size			Number in total
	Small	Medium	Large	(%)
Food processing	0	32	10	42 (18.3)
Chemical	0	24	6	30 (13.0)
Iron & steel	0	12	8	20 (8.7)
Electronics	0	12	13	25 (10.9)
Other	4	84	25	113 (49.1)
Number in total (%)	4 (1.7)	164 (71.3)	62 (27.0)	230 (100.0)

The samples from the four major industries of Hyogo – food processing, chemicals, iron & steel and electronics – account for 50.1% of the total. The remaining 49.1% represent respondents from the other minor sectors. Of the 230 samples only four are small companies with a staff of less than 20; 62 are large companies with more than 300 employees and a registered capital of over 300 million JPY and the remaining 164 are medium-sized according to the 'Small and Medium-sized Enterprise Basic Act' of Japan.

4.2 Econometric approach

4.2.1 Valuation of the variables

The abbreviations, descriptions and valuation of the variables in this analysis are listed in table 9.3. The dependent variables of econometric regressions are a company's awareness of energy saving technologies and MBIs, and acceptability of MBIs. They are respectively abbreviated to AWAREEXTTECH, AWARENEWTECH, AWAREMBI and ACCEPTMBI. The companies are requested to evaluate their level of awareness of existing energy saving technologies and new technologies in their sector (the types of which weren't specified in the survey) for presenting scores to AWAREEXTTECH and AWARENEWTECH. A similar question was put to the companies to evaluate their understanding degree of each MBI item and acceptability level of all the policies listed in table 9.1. A five-likert point method was adopted for the valuation of dependent variables. The scores presented to the technology and MBIs awareness mean: '5' = 'very clear'; '4' = 'clear'; '3' = 'moderate understanding'; '2' = 'don't know well'; and, '1' = 'completely unknown'. The scales for the policy acceptability are: '5' = full acceptability; '4' = almost acceptability; '3' = moderate acceptability; '2' = low acceptability; and, '1' = completely unacceptable.

The four external pushes are defined as independent variables. A five-likert scale was applied to evaluate three of them, REGULATION, COMPETITION and ENPRICE, with '1' = very low; '2' = relatively low; '3' = moderate; '4' = relatively high; and, '5' = very high. The influence of industrial associations in the same sector, ASSOCIATION, is used as the proxy for normative pressure for a company. Five classifications were applied, with ‘5’ representing a major function of a company as the association member; ‘4’ meaning an active function; ‘3’ meaning a limited role; ‘2’ being not the association member but planning to join and ‘1’ for the case of not a member and no plans to join.

Table 9.3 Abbreviation, description and valuation of the variables

Category	**Abbreviation**	**Description**	**Valuation**				
			1	2	3	4	5
Dependent variables	AWAREEXTTECH	Company’s awareness of existing energy saving technologies					
	AWARENEWTECH	Company’s awareness of new energy saving technologies					
	AWAREMBI	Company’s awareness of market-based instruments					
	ACCEPTMBI	Company’s acceptability of market-based instruments					
Independent variables	REGULATION	Pressure from the government for energy saving					
	ASSOCIATION	Influence of industrial association of the same sector					
	COMPETITION	Competition degree of the company’s sales market					
	ENPRICE	Perception of domestic energy price levels					
Control variables	SAVPOTENTIAL	Energy saving potential of the company					
	TRAINING	Training of company’s employees for energy saving					
	SIZE	Company size					
	SECTOR	Industrial sector of the company					

Regarding the control variables, the company size, SIZE, is classified into two: small & medium-sized enterprises and large companies, respectively termed SME and LARGE. The company’s industrial sector, SECTOR, is divided into five: food processing, chemicals, iron & steel, electronics and other, which are notated as FOOD, CHEMICAL, STEEL, ELECTRONICS and OTHER. Internal training of employees for energy saving, TRAINING, was used as the proxy for a company’s learning capacity. Five classifications were applied, with ‘1’ = never arranged training for the employees; ‘2’ = 1 to 3 times per year; ‘3’ = 4 to 6 times per year; ‘4’ = 7 to 12 times per year; and, ‘5’ = over 12 times per year. A four-level point was presented to the company’s energy saving potential, SAVPOETNTIAL, with‘1’ = hardly for further saving; ‘2’ = limited potential; ‘3’ = relatively large potential; and, ‘4’ = very large potential.

4.2.2 Empirical models for the econometric analysis

The regression capturing the relationships between a company’s policy and technology awareness (AWAREMBI, AWAREEXTTECH and AWARENEWTECH) and the independent and control variables is shown as Eq. (1), where ε is the error term and β_0 is the constant.

$$AWAREMBI\ (AWAREEXTTECH\ or\ AWARENEWTECH) \\ = \beta_0 + \beta_1 REGULATION + \beta_2 ASSOCIATION + \beta_3 COMPETITION \\ + \beta_4 ENPRICE + \beta_5 SAVPOTENTIAL + \beta_6 TRAINING \\ + \beta_7 SIZE + \beta_8 SECTOR + \varepsilon \tag{1}$$

Similarly, the regression identifying the relationships between the company's policy acceptability, ACCEPTMBI, and the classified variables is established as Eq. (2), where ζ represents the error term and λ_0 is the constant.

$$ACCEPTMBI = \beta_0 + \beta_1 REGULATION + \beta_2 ASSOCIATION \\ + \beta_3 COMPETITION + \beta_4 ENPRICE + \beta_5 SAVPOTENTIAL \\ + \beta_6 TRAINING + \beta_7 SIZE + \beta_8 SECTOR + \varepsilon \tag{2}$$

All the dependent variables in equation (1) and (2) are measured in an ordinal method and there is no abrupt change in their cumulative probabilities. An ordered probit model was applied as a reasonable choice for this analysis (Greene, 1997). Some explanatory variables, such as SIZE and SECTOR, are categorical ones. Our analysis assumes that the influence of independent variables and other control variables is consistent across these variables. All the dummies are hypothesised to only change the intercept of regressions rather than the slope.

5. Results and discussions

5.1 Barriers to company investment in energy saving technologies

To clarify the barriers hindering a company to invest in energy saving technologies and equipment, we requested the samples to evaluate the factors preventing them from the corresponding investments. As with our earlier surveys in China (Liu et al., 2013a; 2013b), ten barriers are listed in the questionnaire allowing the companies in Hyogo to provide their individual ideas. The barriers are classified into three categories: general barriers, financing constraints, and barriers related to uncertainties of the technologies and regulations. A five-point scale is applied for the barrier evaluations, with '5' = very important barrier; '4' = important; '3' = moderate importance; '2' = low importance; and, '1' = completely unimportant. The average scores of the barriers are depicted in fig.9.2.

Hyogo companies presented low to moderate scores to the barriers. Comparatively, the most important barrier is the internal constraint of the required budget, with an average score of 3.67. The existence of other more promising investment opportunities, as a general barrier, is another obstacle with relatively high importance (averaged at 3.23). This result is consistent with the previous survey of Dutch companies (De Groot et al., 2001). Differing from our survey of the small companies in China (Liu et al., 2013a), the uncertainty of the quality of energy saving technologies is a minor issue hindering the investment decision of the sampled companies in Hyogo, with a mean of 2.81. Providing financial subsidies is supportive in leading a company's investment toward better energy efficiency. This survey indicates that the companies in Hyogo do not view waiting for the subsidies from governments as a choice, as only a low mean of 2.57 was noted. If an energy saving project was profitable, the companies would procure the necessary budget to invest in the project.

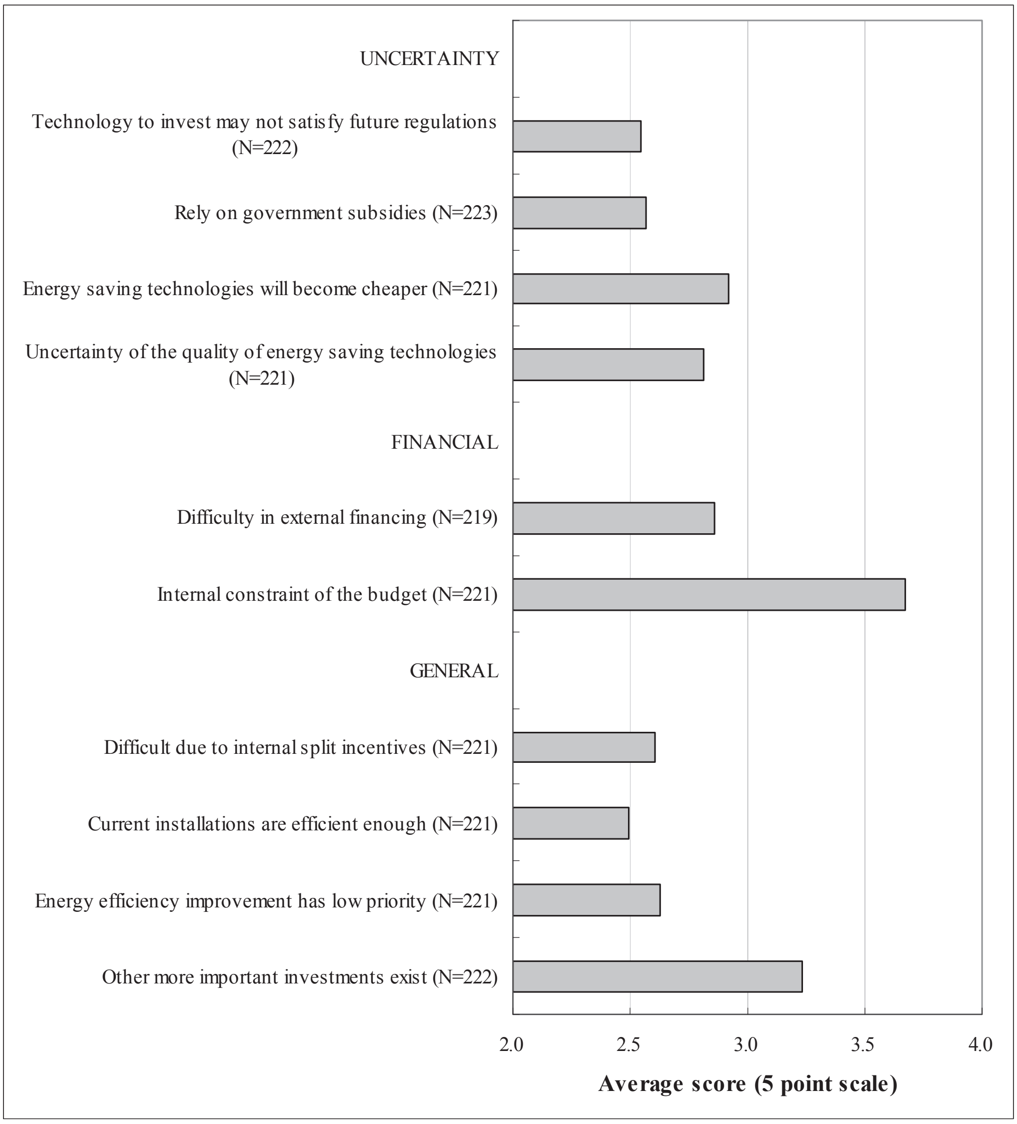

Figure 9.2 Barriers to companies investing in energy saving technologies

Energy saving projects reduce a company's energy cost and allow it to recoup the initial investment within a certain period, called the payback time, which is usually used as a criterion when making decisions on energy saving investments (Harris et al., 2000). We asked the Hyogo companies to indicate their acceptable payback time for energy saving investments, for which a total of 220 responses were received, the distribution of which is depicted in fig.9.3. Around 30% of the samples expect a payback time of less than three years and 41.4% of them request to recoup the investment between 3–5 years. Less than 2% of the samples could accept a payback period over 10 years. This result differs from that of Thollander and Ottosson (2010), who document that most Swedish energy-intensive companies require a payback criterion of three years or less for energy saving investments. Our survey in China confirmed a higher profitability expectation of Chinese companies to energy saving projects, with nearly 80% of them requiring payback times of below three years (Liu et al., 2013a; 2013b). However, the result of this survey is similar with that of Martin et al. (2012), confirming an average payback time of 3–5 years for UK companies.

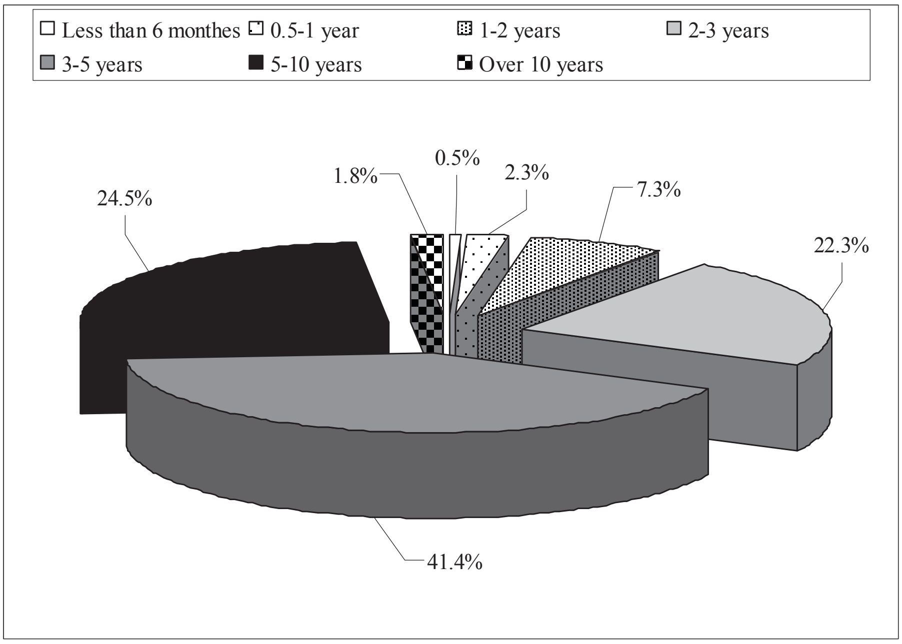

Figure 9.3 Distribution of the samples by payback time of energy saving investment (N=220)

5.2 Statistics of the variables and correlation matrix

The statistics of company policy awareness and acceptability will be explained in sections 5.4 and 5.5, respectively. Table 9.4 summarises the statistics of company awareness of technologies, external factors as independent variables and the quantitative control variables. It is readily apparent that company awareness of energy saving technologies is not high, as the variables of AWAREEXTTECH and AWARENEWTECH only achieved means of 2.87 and 2.69 individually. Specifically, around 28.4% of the respondents are unclear about energy saving technologies currently in use and half of them have a moderate understanding of the existing technologies. Nearly 40% of the samples have no knowledge of new energy saving technologies and nearly half selected the answer of moderate awareness. This result reveals the minor role of formal organisations of Japan, such as the governments and industrial associations, in providing technological information on energy saving for the companies. It is thus important for the governments at various levels to be more proactive in their dissemination of this kind of information, as it pertains to the public good, especially for specific categories of companies

(De Groot et al., 2001).

The surveyed companies face strong pressures from competitors in the same sector and domestic energy prices. They presented the highest mean of 4.25 to the variable of COMPETITION and a similar high score of 4.12 on average for ENPRICE. The respondents felt certain pressures from the government and the variable of REGULATION was given another relatively high mean of 3.86. This is probably since all the samples in this survey are large energy-consuming companies and mandated to measure and report their GHG emissions to the government. A mean of 2.23 for SAVPOTENTIAL indicates that the surveyed companies have limited potential for further improvements in energy efficiency. A mean of 2.04 for TRAINING indicates that the training of employees specific for energy saving is not frequently arranged in the companies, at about 1–3 times per year.

Table 9.4 Statistics of technology awareness, determinants and quantitative control variables

Variable		Obs.	Mean	Std. Dev.	Min.	Max.
Technology awareness	AWAREEXTTECH	229	2.87	0.80	1	5
	AWARENEWTECH	229	2.69	0.80	1	5
External factors	REGULATION	229	3.86	0.80	1	5
	ASSOCIATION	208	3.51	1.24	1	5
	COMPETITION	224	4.25	0.68	2	5
	ENPRICE	228	4.12	0.60	2	5
Control variables	SAVPOTENTIAL	227	2.23	0.53	1	4
	TRAINING	222	2.04	0.70	1	5

A pair-wise correlation was calculated to explore the relationships between the variables in table 9.4, as shown in table 9.5.

Table 9.5 Correlation matrix of technology awareness, determinants and the control variables

	AWA.EXT.	AWA.NEW.	REG.	ASSO.	COM.	ENP.	SAV.	TRA.
AWAREEXTTECH	1							
AWARENEWTECH	0.816[a]	1						
REGULATION	0.081	-0.002	1					
ASSOCIATION	0.060	0.084	-0.156[b]	1				
COMPETITION	0.076	0.029	0.200[a]	0.091	1			
ENPRICE	0.017	0.044	0.232[a]	0.042	0.278[a]	1		
SAVPOTENTIAL	0.042	0.056	-0.172[c]	0.135[c]	0.138[b]	0.139[b]	1	
TRAINING	0.098	0.077	-0.063	0.089	-0.026	-0.012	0.002	1

[a] Significant at 1% level; [b] Significant at 5% level; [c] Significant at 10% level

A significant and positive relationship exists between a company's awareness of existing energy saving technologies and new ones. The correlation coefficient is 0.816 for AWARENEWTECH and AWAREEXTTECH. However, there is no sign for an unacceptable level of multi-collinearity among the independent variables and control variables since the highest coefficient is 0.278 for COMPETITION (Competition degree of the company's sales market) and ENPRICE (Perception of domestic energy prices) at P<0.01. Harmful levels of multi-collinearity are not expected until the correlation coefficient reaches ±0.8 or ±0.9 (Farrar and Glauber, 1967).

5.3 Multivariate analysis with company technology awareness as the dependent variables

Ordered probit regressions were performed to identify whether a company's awareness of energy saving technologies varies due to the external pressures and company characteristics. The results are listed in table 9.6.

Table 9.6 Regression results with company technology awareness as dependent variables

Independent and control variables		Dependent variables	
		AWAREEXTTECH	AWARENEWTECH
Independent variables	REGULATION	0.078	-0.022
	ASSOCIATION	0.049	0.078
	COMPETITION	0.119	0.020
	ENPRICE	0.020	0.164
Company characteristics as control variables	SAVPOTENTIAL	0.116	0.078
	TRAINING	**0.239**[b]	0.167
	SME	-0.198	-0.298
	LARGE	-	-
	FOOD	**-0.708**[b]	**-0.929**[a]
	CHEMICAL	**-0.722**[b]	**-0.931**[a]
	STEEL	0.108	**-0.712**[b]
	ELECTRONICS	-	-
	OTHERS	**-0.482**[c]	**-0.796**[a]
Obs.		198	198
LR chi		**21.78**[b]	**23.13**[b]
Pseudo R^2		0.048	0.051

[a] Significant at 1% level; [b] Significant at 5% level; [c] Significant at 10% level

As with our survey in China (Liu et al., 2013b), all the external pushes, including REGULATION, ASSOCIATION, COMPETITION and ENPRICE, do not function significantly in driving Hyogo companies to assimilate technology related information for energy saving. However, the frequency of a company's training specific for energy saving, TRAINING, significantly and positively enhances its knowledge of existing technologies. This finding agrees with that of Liu et al. (2013b) and is in line with previous literature addressing the importance of organisational learning capacity in determining a company's ability for obtaining strategic information (De Groot et al., 2001). The awareness of energy saving technologies differs somewhat by industry. Comparatively, electronics companies indicate higher technological awareness than food processing, chemicals and the other sectors.

5.4 Company awareness of MBIs and the determinants

5.4.1 Statistics of company awareness of MBIs

As a core part of this survey, the companies were requested to indicate their awareness of MBIs. The statistics of company awareness of MBIs is shown in fig.9.4.

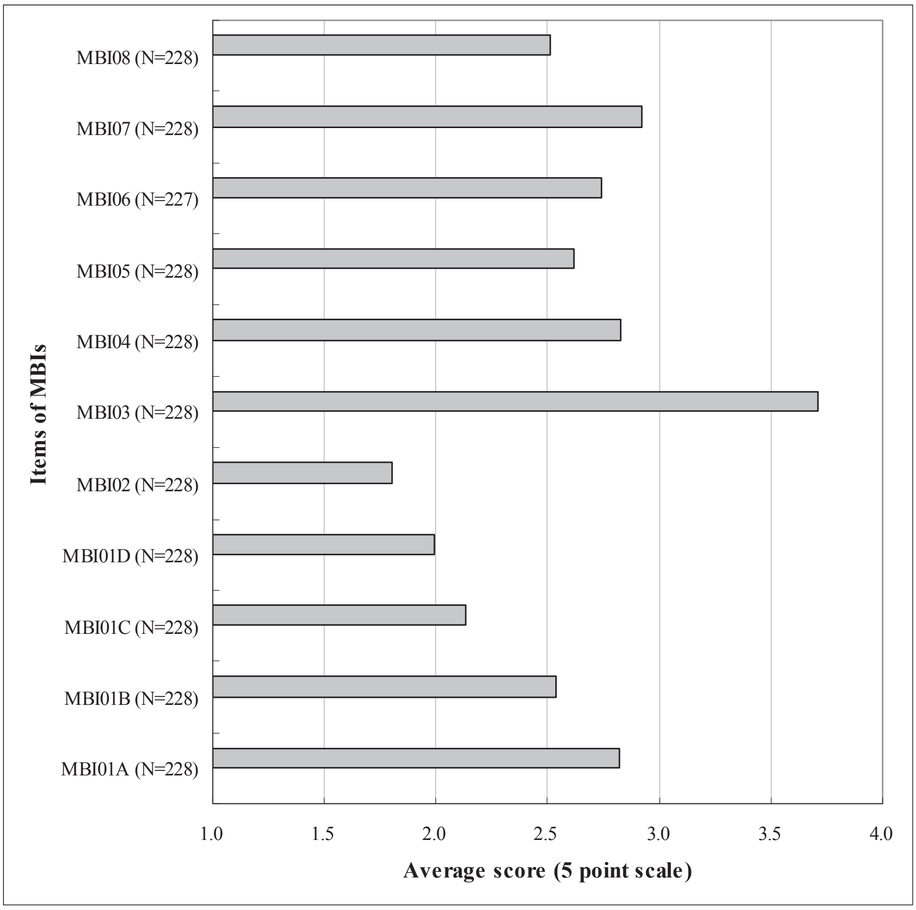

Figure 9.4 Statistics of company awareness of MBIs

Overall, the surveyed companies are not very conversant with the pre-listed MBIs as nearly all the MBI items achieved a mean of under 3.0 – the only exception being MBI03 (Subsidies to energy-efficient products, e.g., eco-car and eco-point for electronic appliances), which was presented the highest mean of 3.71. Several differences exist as regards company awareness of various MBIs. The policy with the lowest recognition for the samples companies is MBI02 (Soft loan for the establishment of energy saving facilities), with the lowest average score of 1.80. A further two policies with relatively low scores are MBI01C (Subsidy by MOEJ for achieving mitigation targets of participating companies of J-VETS) and MBI01D (Interest subsidy by

METI for the investment in large energy saving equipment), both of which achieved averages of around 2.0. The other MBI items presented similar means of 2.5–3.0.

5.4.2 Multivariate analysis with company MBI awareness as the dependent variables

Regressions were performed to identify the determinants of a company's awareness of MBIs. An ordered probit model was applied for this analysis. The regression results of six policy items, including MBI01C and MBI04 to MBI08, are statistically significant and listed in table 9.7.

Table 9.7 Ordered probit regression results with the awareness of MBIs as the dependents

Independent and control variables		Dependent variables: AWAREMBI					
		MBI01C	**MBI04**	**MBI05**	**MBI06**	**MBI07**	**MBI08**
Independent variables	REGULATION	0.173	0.103	**0.244**^{b}	0.010	0.157	0.152
	ASSOCIATION	0.079	-0.041	0.060	-0.006	**0.130**^{b}	**0.113**^{c}
	COMPETITION	**-0.256**^{b}	0.073	**-0.226**^{c}	**-0.205**^{c}	-0.163	**-0.311**^{a}
	ENPRICE	**0.259**^{c}	0.046	**0.342**^{b}	**0.311**^{b}	**0.270**^{c}	**0.273**^{c}
Company characteristics as control variables	SAVPOTENTIAL	-0.042	-0.079	-0.146	-0.127	-0.022	-0.066
	TRAINING	0.098	0.076	-0.147	0.089	-0.115	-0.027
	SME	**-0.301**^{c}	**-0.656**^{a}	**-0.456**^{b}	**-0.515**^{a}	**-0.430**^{b}	**-0.628**^{a}
	LARGE						
	FOOD	0.249	0.375	-0.266	-0.238	0.008	0.052
	CHEMICAL	-0.154	0.341	-0.087	-0.233	-0.064	-0.005
	STEEL	0.041	0.471	0.488		0.315	0.096
	ELECTRONICS				-0.165		
	OTHER	-0.026	0.280	-0.156	-0.258	-0.042	0.035
Obs.		197	197	197	196	197	197
LR chi		**17.58**^{c}	**19.60**^{c}	**33.88**^{a}	**18.45**^{c}	**22.34**^{b}	**27.29**^{a}
Pseudo R^2		0.034	0.035	0.059	0.032	0.041	0.05

^{a} Significant at 1% level; ^{b} Significant at 5% level; ^{c} Significant at 10% level

The following explanations are restricted to the sign and significance of the parameters due to the inherent difficulty of interpreting the coefficients of ordered probit estimations (Greene, 1997). In contrast with De Groot et al. (2001), who suggest that competitive pressure acts as a driver for the companies to obtain strategic information, this analysis found a significant but negative relationships between a company's awareness of MBI01C, MBI05, MBI06 and MBI08 and the variable of COMPETITION. This result differs from our survey in China, which confirmed the significant and positive relationship between a company's MBIs awareness and market competition (Liu et al., 2013a). However, the pressure of energy prices functions as a driver for the companies to collect information on climate policies, including the economic incentive of MBI01C and the pressure policies of MBI05 to MBI08. The other two external factors, REGULATION and ASSOCIATION, indicate significant and positive relationships with specific policy tools. As examples, the companies facing higher regulative pressure are more aware of MBI05. The companies with more active roles in their industrial associations have a deeper understanding of MBI07 and MBI08. The two quantitative control variables, SAVPOTENTIAL and TRAINING, indicate no significant influence on company awareness of the MBIs. Similarly to Liu et al. (2013b), the organisational size is significantly and positively associated with company awareness of all six MBIs with regressions statistically significant. The large companies have a better understanding of MBIs than their small and medium-sized counterparts, a result that agrees with the resource-based viewpoint that large companies have greater access to the resources necessary for proactive environmental practices (Aragón-Correa et al., 2008). There is no obvious gap in the policy awareness among the various sectors.

5.5 Company acceptability of energy saving policies and the determinants

5.5.1 Statistics of company acceptability of energy saving policies

In the survey, we asked the companies to subjectively evaluate their acceptability to each of the policy items listed in table 9.1. The average scores are depicted in fig.9.5.

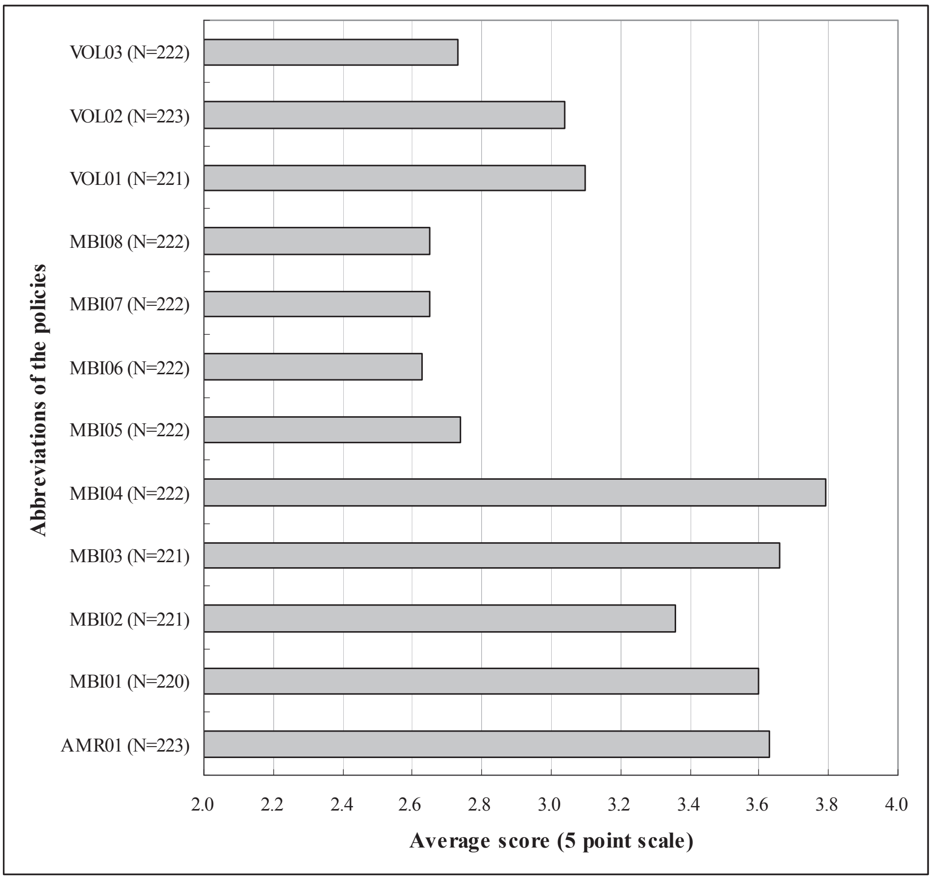

Figure 9.5 Company acceptability of industrial energy saving policies.

Differing from Liu et al. (2013a; 2013b), Hyogo companies indicate moderate acceptability to the pre-listed industrial energy saving policies in general. Naturally, economic incentives are more preferable and were presented relatively higher scores. Of these, MBI04 (Tax credit for energy saving products and technologies) obtained the highest mean of 3.79. MBI01 (Direct subsidies for the investment in energy saving technologies and projects) and MBI03 (Direct subsidies to energy-efficient products) had similar means of around 3.60. In contrast, companies are reluctant to accept policies that would incur economic burden for them. The four carbon pricing tools, MBI05 (Energy taxes including petroleum and coal taxes, gasoline tax, etc.) to MBI08 (Integrative domestic carbon market, including J-VETS, ETS on trial and domestic credit), achieved similar but low means of around 2.60. The voluntary approaches achieved moderate acceptability for the surveyed companies in this study. VOL01 and VOL02 presented similar means of around 3.0, a result that differs from our surveys in China, confirming that Chinese companies prefer voluntary policies to maximise the freedom to satisfy the governmental requirements of energy saving (Liu et al., 2013a; 2013b). The survey in Hyogo indicates that the administrative management requirement is acceptable for the companies. AMR01 (Reporting system of GHG emissions for companies with energy use or GHG emissions exceeding certain amounts) obtained a higher mean of 3.63, implying that the respondents recognise that some mandatory requirements are necessary (Klok et al., 2006).

5.5.2 Multivariate analysis with company acceptability of MBIs as the dependent variables

Multivariate regressions were carried out to identify the determinant factors for a company's acceptability of MBIs. The ordered probit model was applied and the regression coefficients are listed in table 9.8.

Excluding MBI03, the regression results of all seven other MBIs are statistically significant. ENPRICE, the pressure of domestic energy price, is significantly and negatively associated with company acceptability of MBI06, which confirms that a company would be reluctant to accept further energy cost increase originating from the newly launched global warming countermeasure tax if it felt the energy prices were already high. Similarly, higher competition pressure makes the economic incentive of MBI04 more preferable but reduces a company's preference to MBI07 and MBI08, which may represent economic burdens for the companies. The variable REGULATION indicates a significant but negative relationship with company acceptability of incentive policies, MBI01. This is probably because companies facing higher regulation pressures have less chance to successfully obtain the subsidies for energy saving from the governments. Significant and positive relationships were found between the variable ASSOCIATION and the acceptability of MBI04, MBI07 and MBI08.

In terms of company characteristics, the acceptability of MBI01, MBI02 and MBI04 is significantly and positively associated with the organisational size, a finding agreeing with that of our survey by sector in China (Liu et al., 2013b). Usually, large companies have more resources for energy saving investments and therefore are more likely to enjoy these preferential policies than their small and medium-sized counterparts. A difference in the acceptability of MBI01, MBI02, MBI05 and MBI06 was observed between various sectors. Compared with the electronics sector, it is more likely for iron & steel and chemical companies and the companies from the other sectors to accept MBI01 and MBI02. For MBI05 and MBI06, steel companies indicate lower acceptability compared with the other sectors, which may be due to the differentiated impacts of these policies on various industries.

Table 9.8 Ordered probit regression results with acceptability of MBIs as dependent variables.

Independent and control variables		Dependent variables: ACCEPTMBI							
		MBI01	**MBI02**	MBI03	**MBI04**	**MBI05**	**MBI06**	**MBI07**	**MBI08**
Independent variables	REGULATION	**-0.252^{b}**	-0.149	0.011	0.156	0.122	-0.152	-0.081	-0.018
	ASSOCIATION	-0.016	-0.011	-0.030	**0.142^{b}**	0.042	0.083	**0.118^{c}**	**0.145^{b}**
	COMPETITION	-0.006	-0.096	0.174	**0.308^{a}**	-0.196	-0.102	**-0.238^{c}**	**-0.288^{b}**
	ENPRICE	0.014	-0.063	-0.027	-0.060	-0.212	**-0.239^{c}**	-0.068	0.116
Company characteristics	SAVPOTENTIAL	0.033	0.114	-0.225	-0.075	0.086	0.070	0.062	-0.018
	TRAINING	-0.058	-0.129	-0.226^{b}	-0.047	0.078	0.126	0.161	0.050
	SME		**-0.503^{a}**						
	LARGE	**0.645^{a}**		0.456^{b}	**0.329^{c}**	-0.173	0.089	0.268	0.161
	FOOD	0.324	0.024	0.340	0.003	**0.713^{b}**	**0.804^{b}**	0.339	0.344
	CHEMICAL	**0.825^{a}**	**0.587^{c}**	0.076	0.064	**1.111^{a}**	**0.989^{a}**	0.411	0.393
	STEEL	**0.819^{b}**	**0.860^{b}**	0.612^{c}					
	ELECTRONICS				0.048	**0.964^{a}**	**0.898^{b}**	-0.077	-0.010
	OTHER	**0.464^{c}**	**0.570^{b}**	0.311	0.199	**0.921^{a}**	**0.903^{a}**	0.484	0.443
Obs.		190	191	191	192	192	192	192	192
LR chi		**22.84^{b}**	**21.37^{b}**	16.99	**19.09^{c}**	**20.15^{b}**	**25.00^{a}**	**23.01^{b}**	**17.43^{c}**
Pseudo R^2		0.047	0.043	0.035	0.040	0.043	0.054	0.049	0.038

^{a} Significant at 1% level; ^{b} Significant at 5% level; ^{c} Significant at 10% level

5.6 Company behavioral responses to energy cost increases due to MBIs

A company's energy cost would naturally increase upon introduction of a carbon tax policy or GHG ETS. To measure the possible responses of companies to these two carbon pricing policies, which have been partly practiced in Japan, we requested the companies to consider the feasibility of other options. A five-point scale was applied with '5' = very possible; '4' = relatively possible; '3' = moderate possibility; '2' = low possibility; and '1' = completely impossible. The statistical results are shown in fig.9.6 and reveal that the companies would avoid knee-jerk reactions such as reducing levels of production, moving production bases to areas with looser policies, shutting down production facilities and taking no action and accepting losses as these four choices presented average scores of less than or around 2.0. On the contrary, the companies would take internal efforts in energy saving to relieve the policy's negative impacts. Practicing managerial energy-saving activities is the most possible response, with a mean of 4.03. To invest in energy efficient technologies was given a moderate possibility (averaged at 3.21). The other three choices – the use of less carbon-intensive energies, adopting to a less energy-intensive product structure and investing in R&D of advanced energy-efficient technologies – are responses with lower possibilities. A meaningful finding is that the respondents would not simply offload the costs of carbon pricing policies onto their customers, as the option of raising product prices for cost shifting only achieved a minor mean of 2.24. This result differs from that of De Groot et al. (2001), who confirm that Dutch companies are more likely to charge their customers with additional costs given an energy tax. Our finding may be attributed to the strict competition faced by the surveyed Hyogo companies, who may be concerned over loss of market presence due to increased product prices.

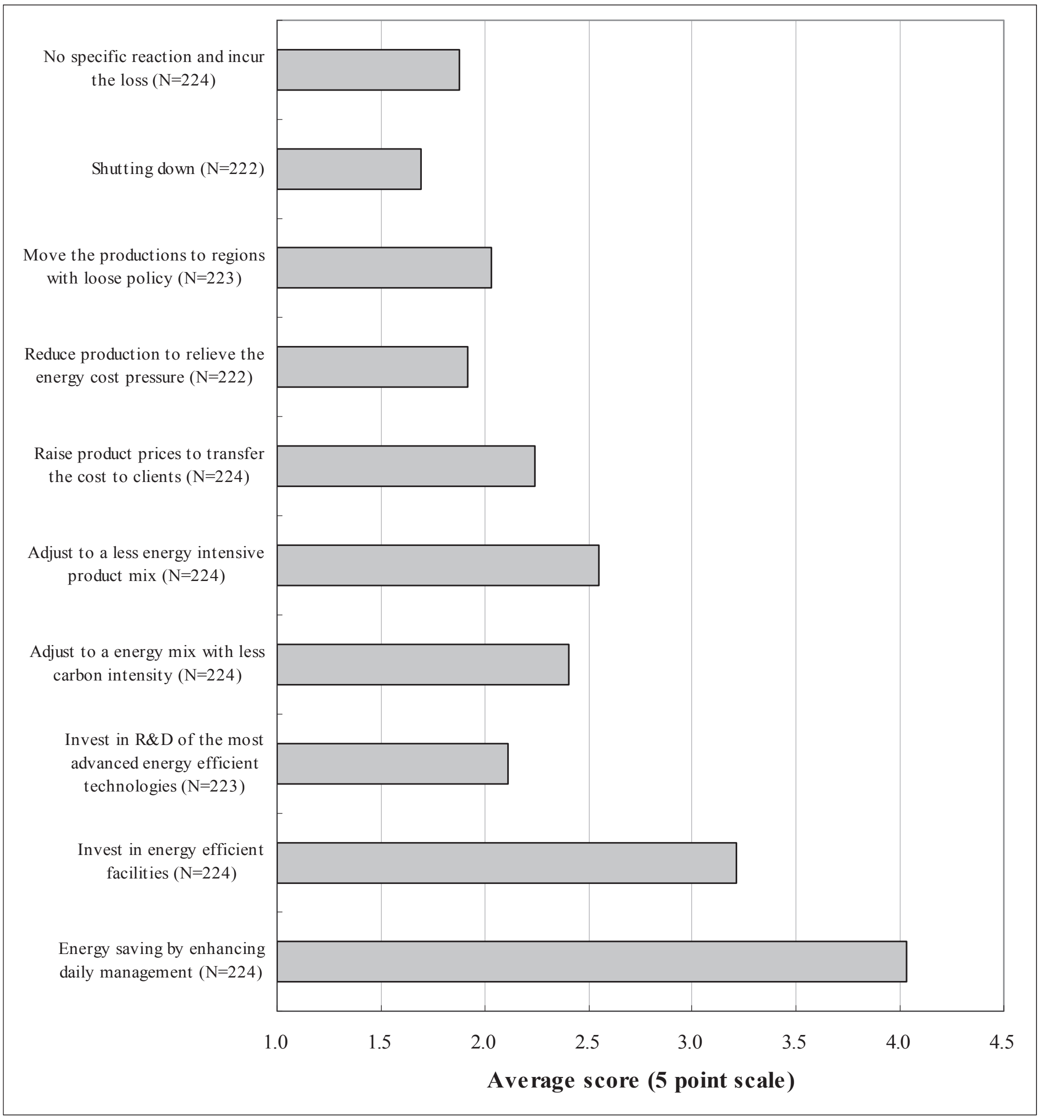

Figure 9.6 Company behavioral responses to MBIs

6. Conclusions

This chapter measured company awareness and acceptability of MBIs by a survey in Hyogo, Japan. The pre-classified determinants are partly confirmed by econometric regressions. The organisational size is identified as a determinant for companies to obtain information on energy saving policies. Large companies indicate a higher awareness of policies than their small and medium-sized counterparts. The surveyed companies reveal moderate acceptability of industrial energy saving policies in general. The economic incentives are appreciated for the respondents while carbon pricing tools achieve low acceptability. To a certain extent it could be said that a company's policy acceptability would be determined by its perception of policy impact and comparative advantages. In the case of introducing carbon pricing policies such as carbon taxes or GHG ETS, the surveyed companies would make internal efforts in energy saving to relieve the policy negative impacts rather than simply transferring the burden onto their customers.

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PART V:

AFFORDABILITY OF COMPANIES ON CARBON PRICES

Chapter 10:

Affordability of companies on increased energy costs due to climate policies: A survey by sector in China*

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Chapter Highlights:

- Using data collected from 170 respondents and the willingness-to-pay (WTP) model, this chapter estimates energy cost increases acceptable for Chinese companies due to the introduction of market-based climate policies.
- A mean climate policy-originated energy cost increase of 8.8% would be acceptable for the samples overall; that for chemical companies is slightly higher at 9.9% and for cement companies is lower, at 7.7%.
- Acceptable energy cost increases affordable for the companies based on the above means equate to a carbon price of 6−12 USD/t-CO_2.
- The result provides a referendum for setting prices for carbon emissions from the business viewpoint, and could aid in the development of carbon tax policy and GHG ETS in China.

1. Introduction

The adoption of MBIs for improving energy efficiency and mitigating CO_2 emissions has been much slower in Northeast Asia, including China (Liu et al., 2011). Discussions have been emerging on the roadmap for China to introduce carbon tax among experts at the research institutes under related ministries (Li, 2010; Wang et al., 2009); however, the expected policy efficacy would be marginal since the proposed tax rates are very conservative, at about 1.5 USD/t-CO_2 for the initial phase (Su et al., 2009). Establishing an integrated domestic carbon market was first mentioned in an official central government document in 2010 but no specific decisions on the means of determining emission caps or timetabling for formal introduction of a domestic carbon ETS have been made (Liu, 2010). Nevertheless, a number of local environmental exchange institutes were consecutively set up across the country in preparation

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* The main content of this chapter was published as: Liu, X.B., Wang, C., Zhang, W.S., Suk, S.H., Sudo, K., 2013. Company affordability of increased energy costs due to climate policies: A survey by sector in China, *Energy Economics* 36 (2013): 419-430.

for establishment of a regular carbon market – for example, the 'China Beijing Environmental Exchange' and 'Shanghai Environment and Energy Exchange' – which have carried out some trading of voluntary emission reductions (VERs) (Zhang and Li, 2010). The market for VERs is obviously limited as in the current phase Chinese companies have no motivation to offset their CO_2 emissions voluntarily.

China therefore needs to be able to make use of MBIs for enhancing industrial energy efficiency in a cost-effective way. In practice, the acceptance of companies as major policy targets is essential in determining the progress and actual success of new GHG ETS and carbon tax policies. Company acceptance of governmental policy is mainly affected by the cost, for them, resulting from introduction of such policy, therefore to gauge just what is acceptable for industry as a whole this research estimates the affordability of companies with regards to energy cost increases based on a phase-in approach. Three energy-intensive sectors, iron & steel, cement and chemical industries, were targeted. This chapter covers two main topics – the estimation of policy cost affordability of companies in the three target sectors as expressed by energy cost increase ratios, and identification of the determinant factors affecting the estimated cost affordability.

The remainder of this chapter is structured as follows: Section 2 presents a review of related literature and the contribution of this research, section 3 explains the methodologies, including the models for estimating the cost affordability of companies by multiple-bounded discrete choice (MBDC) data, and the analytical framework for identifying the determinants of the estimated cost affordability, section 4 outlines the distribution of samples by sector and organisational size, section 5 discusses the results of affordability estimations and econometric analysis and section 6 concludes the research findings.

2. Literature review and contributions of this research

Broad analyses have discussed policy measures for enhancing industrial energy efficiency (Schleich, 2009). Industrial energy programmes such as energy audits and long-term agreements (LTAs) are often applied for promoting energy efficiency in industry (Thollander and Dotzauer, 2010). Rietbergen et al. (2002) concluded that a large portion of energy savings in Dutch manufacturers can be attributed to LTAs. Social mechanisms, establishing via regional or local learning networks of companies, are useful to motivate improvements in energy efficiency in Switzerland and Germany, as substantial progress was confirmed in energy efficiency of the network participating companies (Jochem and Gruber, 2007). Klok et al. (2006) found an overall preference of Danish companies for voluntary approaches, such as energy efficiency labeling, rather than command and control regulations, and that the surveyed companies agreed on the necessity of certain mandatory requirements. The empirical evidence is mixed on the effectiveness of subsidy policies. Unlike carbon taxes and GHG ETS, which raise prices of energy and related CO_2 emissions, financial subsidies do not provide incentives for the companies to cease use of the polluting technologies (Jaffe et al., 2005). Kounetas and Tsekouras (2008) examined the adoption of energy efficient technologies by Greek companies and found that companies that were granted greater capital subsidies and whose production is energy-intensive are more likely to adopt energy-saving technologies. Smaller or financially constrained companies are more susceptible to capital incentives than their larger or less constrained counterparts (Skuras et al., 2006). In practice, the success of policies for improving energy efficiency and lowering carbon intensity mainly hinges on the ability of policymakers to predict industry's response to the various policy measures (Martin et al., 2012). Effective policies should provide incentives for not only short-term improvements in energy efficiency but also technology research and development leading to sustainable efficiency growth over the long term. From the viewpoint of individual companies, raising energy costs functions as an important driver for them to improve energy efficiency, especially for the energy-intensive industries (Bunse et al., 2011). Only a small number of industries would bear a disproportional burden of a carbon tax or similar policy (Morgenstern et al., 2004). Therefore, carbon tax policy should be aimed changing the emitter's behavior rather than simply raising government revenue. Some companies view taxation as an effective instrument if combined with sector agreements and minimum efficiency requirements (Klok et al., 2006).

Employing a set of panel data of China's most energy-intensive and large and medium-sized companies from 1997 to 1999, Fisher-Vanden et al. (2004) identified rising energy prices as a principal driver of their declining energy intensities. Andrews-Speed (2009) examined the context of nearly 30 years of measures for the enhancement of energy efficiency in China and addressed a number of constraints, including the reluctance to use economic instruments. China has been involved in the international carbon market through the project-based Clean Development Mechanism (CDM), but critics claim that the scale of CO_2 emissions reductions of CDM projects is insufficient and that the project-based crediting process is inefficient (Lewis, 2010). On the other hand, levying a carbon tax is viewed as not only an economic means to combat global warming but also an important strategy for energy saving and sustainable development of China (Wei et al., 2011). Based on a review of empirical analyses of carbon and energy taxes, Zhang and Baranzini (2004) concluded that competitive losses and distributive impacts are usually less severe than previously thought. Considering the difficulty of tax collection, the carbon tax proposals of Chinese experts include levying taxes on fuel-containing carbon emissions. Concerning the negative impacts of carbon tax on the economy and industrial competitiveness, the proposed carbon tax rates are quite low (Liu et al., 2011). Further, although China's economy is still accelerating and the country's GHG emissions will inevitably increase in the long term, China's government is reluctant to set specific caps on its overall carbon emissions in the near future. Attaching limitations to CO_2 emissions could lead to a drop in labour demand in energy-intensive industries and increased unemployment, concomitant with the workforce being replaced by more advanced production lines (Cai et al., 2009).

Therefore, clarification of the opinions of various stakeholders is necessary to facilitate the ongoing discussions on carbon pricing policies in China. As mentioned above, whether these politically uncomfortable but effective measures are actually introduced is determined by the acceptability of industry as a whole as regards the key policy targets. A previous policy overview and comparative analysis of Northeast Asia conducted by the authors confirmed that strong resistance from industry has been the chief obstacle to carbon tax policies in Japan, thus Chinese companies would also likely feel the same (Liu et al., 2011). Although literature simulating the impacts of carbon taxes on economic growth and carbon mitigation in China using macro-economic models does exist (e.g. Liang et al., 2007; Su et al., 2009; Cao et al., 2012), it is of limited scope with respect to the viewpoints of actual companies affected. Literature also exists covering policy acceptability from the perspective of individuals (Bristow et al.; 2010; Wang et al., 2012); however, to the best of our knowledge the present survey conducted by the authors is the first attempt to estimate the affordability of companies regarding the costs originating from market-based climate policies. In terms of methodological contribution, this study is a novel extension of the MBDC format – a contingent valuation (CV) method frequently applied for the quantification of personal willingness-to-pay (WTP) for environmental improvements – to the company level. In spite of the inherent logistical and other difficulties involved in arranging the survey, responses from the three main target sectors were sufficient to satisfy the simulations and statistical analyses.

3. Methodologies

3.1 Estimating affordability of energy cost increases for companies

3.1.1 Multiple-bounded discrete choice questionnaire

The CV method has been widely used to estimate a person's willingness-to-accept (WTA) environmental improvements as compensation for ecological damage and pollution. Wang (1997) argued that uncertainty is actually inherently based on an individual's valuation of commodities or services and thus could only be represented by a distribution, rather than a number. The uncertainty of the CV method can be handled using two strategies. One is to lengthen the dimensions of bidding prices to narrow down the actual interval of respondent valuations by increased information quantity and the other is to request the respondents to express the quality of their choices concerning the proposed price levels (Wang and He, 2010). Double-bounded dichotomous choice (DC) (Cameron and Quiggin, 1994) and payment card questionnaires (Ryan et al., 2004) are typical examples of the first strategy, which both raise the level of information quantity by multiple bidding propositions. As an example of the second approach, Li and Mattsson (1995) asked respondents to value their confidence in the CV answers and used this information to measure the preference uncertainty. As a method developed for CV estimation, the 'return potential' format, used by sociologists to measure the strength of social norms, has been adapted for use in the MBDC questionnaire (Welsh and Bishop, 1993). The MBDC format allows respondents to vote on a wide range of referendums and express voting certainty for each referendum and therefore reinforces the quantity and quality of data.

The introduction and implementation of carbon taxes and GHG ETS increase the costs of energy use of companies by attributing prices to the related CO_2 emissions. The affordability of a company on the part of energy cost increases, attributed to the climate policies, can be viewed as the company's WTP for the externality of CO_2 emissions. Inspired by the research on personal WTP, an MBDC questionnaire was applied in this survey to estimate the affordability of companies for energy costs increases due to the economic climate policies. Referring to Welsh and Poe (1998), the question and format prepared for the surveyed companies and an example response from a cement company are shown in fig.10.1.

Question: The energy prices would be increased due to the introduction and implementation of market-based climate polices, such as imposing energy taxes or carbon taxes in the sector of energy production and transition. Accordingly, the industrial company's energy consumption cost would be increased. We would like to understand the viewpoint of your company to the energy cost increases due to the climate policy interventions. Please circle one letter to each increase ratio to indicate the affordability degree of your company.

Energy cost increase ratio (%)	Your company's choice				
	Very low; Easily acceptable	Not high; Acceptable	Moderate; Barely acceptable	High; Rejection	Very high; Strong rejection
0.1	Ⓐ	B	C	D	E
0.3	Ⓐ	B	C	D	E
0.5	A	Ⓑ	C	D	E
0.7	A	Ⓑ	C	D	E
1.0	A	Ⓑ	C	D	E
3.0	A	B	Ⓒ	D	E
5.0	A	B	Ⓒ	D	E
7.0	A	B	Ⓒ	D	E
10.0	A	B	Ⓒ	D	E
15.0	A	B	C	Ⓓ	E
20.0	A	B	C	Ⓓ	E
30.0	A	B	C	Ⓓ	E
50.0	A	B	C	D	Ⓔ
70.0	A	B	C	D	Ⓔ
100.0	A	B	C	D	Ⓔ

Figure 10.1 Question and example response in MBDC format used in this study

The companies are presented with an ordered and ascending sequence of energy cost increase thresholds but instead of circling a single value or interval, the companies are given multiple choice options: 'easily acceptable', 'acceptable', 'barely acceptable', 'rejection' and 'strong rejection'.

3.1.2 Estimation models for the affordability of companies

Various models have been proposed for estimation of likelihood matrix gathered by the MBDC format, the most prominent of which were developed by Welsh and Poe (1998) and Alberini et al. (2003). Welsh and Poe's model is straightforward and is founded on the assumption that all respondents share the same valuation distribution. Alberini et al. extended the random valuation threshold model and constructed a log-likelihood function to retain all the responses reflecting the different preference certainties of each respondent. This extended model permits the threshold to be individualised and enables the uncertainty of each individual to be measured.

The present study applied the approach proposed by Wang and He (2010). The subjective verbal likelihoods circled by the respondent companies are encoded into numerical data for estimations. Assuming the policy-caused energy cost increase ratio affordable for a company i is V_i, which is a random variable with a cumulative distribution function F(r), the mean value of V_i is expressed as μ_i and the standard variance is ε_i. In this analysis, μ_i may be interpreted as company i's WTP for its CO_2 emissions currently, which is represented by the company's affordability of energy cost increases due to climate policies. Such cost affordability model can be expressed as:

$$V_i = \mu_i + \varepsilon_i \qquad (1)$$

where, ε_i is a random term with a mean of zero. Given an energy cost increase threshold of r_{ij}, the probability for the company to accept this ratio will be:

$$P_{ij} = \Pr(V_i \rangle r_{ij}) = 1 - F(r_{ij}) \qquad (2)$$

Once P_{ij}, the probability for company i to agree with the increase ratio r_{ij}, is known by assigning numerical values to the verbal MBDC answers, equation (2) can be estimated for each company. The estimation model can be written as:

$$P_{ij} = 1 - F(r_{ij}) + \lambda_i \qquad (3)$$

where, λ_i is an error term with a mean of zero and a standard variance of δ_i, P_{ij} is the dependent variable with values between 0 to 1, which can be achieved from the uncertainty answer given by the company i at the ratio of r_{ij}. Assuming a specific function for $F(r_{ij})$, such as a normal accumulative distribution with a mean of μ_i and a standard variance of σ_i, equation (3) becomes:

$$P_{ij} = 1 - \Phi\left(\frac{r_{ij} - \mu_i}{\sigma_i}\right) + \lambda_i \qquad (4)$$

Next, μ_i and σ_i can be estimated for each company using equation (4). After obtaining each company's mean affordability and the standard variance, a multivariate regression model can be constructed to analyse the determinant factors of the affordability. A linear model can be expressed as:

$$\mu_i = \beta_0 + \beta X_i + \varepsilon \qquad (5)$$

where, X_i is a vector of determinant factors including the company's specific characteristics, β is a vector of coefficients to be estimated and ε is the random error.

3.2 Econometric analysis of the determinants of affordability for companies

3.2.1 Analytical framework and the determinants

An econometric analysis was carried out to identify the relationships between the estimated affordability of companies on energy cost increases with the determinant factors, including company characteristics. The analytical framework is depicted in fig.10.2.

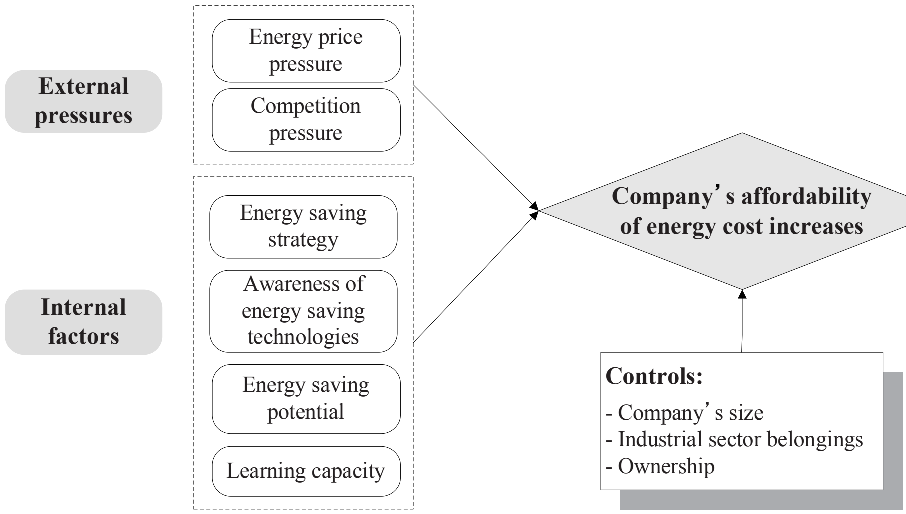

Figure 10.2 Analytical framework for the econometric analysis

We classified the determinants of affordability of companies on energy cost increases into external pressures and internal factors (Liu et al., 2010). The existing governmental requirements on industrial energy efficiency still do not regulate small and medium-sized enterprises (SMEs) in China, and industrial associations are weak overall. Liu et al. (2012) confirmed that there is no significant relationship between coercive and normative pressures and a company's energy saving practices. However, Chinese companies are sensitive to the energy management performance of their competitors, thus the current energy price level significantly and positively influences their energy saving efforts. Two external pressures were defined. One is energy price pressure felt by the companies, in which if a company felt energy prices to be already high it would be harder for it to accept additional increases in energy costs. The other is the strength of market competition, in which a company would be reluctant to take on additional burden to avoid the loss of competitiveness if competition in its sector was fierce. Four internal factors were classified accordingly. One is the energy saving strategy of companies, indicating willingness to improve energy management; a company could more easily afford an energy cost increase if it had greater intentions for better energy efficiency. The second is awareness of companies on energy saving technologies; knowledge of technology alternatives would help the company to more accurately evaluate measures for dealing with business risks due to energy cost increases. Energy saving potential is categorised as the third internal factor. Companies with higher saving potential could more flexibly alleviate the energy cost by self-reduction efforts. The last internal factor is the learning capacity of companies. The educational level of employees is the basis of a company's learning capacity and used as the proxy for this factor.

Regarding company characteristics, we selected size, sector belongings and ownership as controls. Usually, energy-intensive sectors are more sensitive to changes in energy costs, which is why carbon tax and GHG ETS proposals often recommend relief measures for energy-intensive sectors, in order to avoid resistance from such sectors (Liu et al., 2011).

3.2.2 Valuation of the variables

The dependent variable for the econometric analysis is the estimated mean of affordability for companies based on equation (4). The abbreviation, description and valuation of determinant factors as independent variables and company characteristics as controls are listed in table 10.1.

Table 10.1 Abbreviation, description and valuation of independent variables and controls

Category	Abbreviation	Description	Valuation
External pressures	ENPRICE	Perception of domestic energy price levels	Five-point scale applied: 1: very low; 2: relatively low; 3: moderate; 4: relatively high; 5: very high
	COMPETITION	Competition degree of the company's sales market	
Internal factors	EXISTINGTECH	Company awareness of existing energy saving technologies	
	NEWTECH	Company awareness of new energy saving technologies	
	ENSTRATEGY	The status of energy saving target setting	Five-level classification used
	SAVPOTENTIAL	The level of energy saving potential of the company	Four-level point applied
	AVGEDU	Average education level of the company's employees	Classified into five categories
Controls	SIZE	Organisational size	Categorised into three types
	SECTOR	Industrial sector to which the company belongs	Categorised into five types
	OWNERSHIP	The company's ownership status	Categorised into three types

A five-point scale was applied to evaluate the two external pressures, ENPRICE and COMPETITION, and company awareness of energy saving technologies (EXISTINGTECH and NEWTECH), with ‘1’ = very low; ‘2’ = relatively low; ‘3’ = moderate; ‘4’ = relatively high; and, ‘5’ = very high. A four-level point was applied to the level of energy saving potential, SAVPOTENTIAL, with ‘1’ = further energy saving very difficult; ‘2’ = limited potential; ‘3’ = relatively large potential; and, ‘4’ = very high potential. The status of energy saving target settings shows a company’s energy management strategy, ENSTRATEGY. A five-level classification was applied for this variable, with ‘5’ referring to a company that has clear annual and internally decomposed energy saving targets; ‘4’ as one having a specific annual target; ‘3’ as one having short or medium-term targets of 3 to 5 years; ‘2’ as one only having a rough target in the long run, and ‘1’ as one not having any quantitative target. The average educational level of employees, AVGEDU, was used to indicate the company’s learning capacity. Five categories were applied, with ‘1’ = the ratio of employees with educations from college and above being less than 10%; ‘2’ = 10–20%; ‘3’ = 20–30%; ‘4’ = 30–50%; and, ‘5’ = over 50%.

For the controls, company size is classified into three types: small, medium-sized and large, and respectively abbreviated as SMALL, MEDIUM and LARGE. Company sectors are categorised into five types: iron & steel, cement, chemicals, paper and other. We purposely targeted the three sectors as mentioned earlier. However, the actual survey included a few samples from paper and some other industries. They are individually named as STEEL, CEMENT, CHEMICAL, PAPER and OTHER in the analysis. Ownership consists of three types: state-owned, domestically private and foreign-funded, including fully foreign funded and joint ventures, abbreviated as STATEOWNED, DOMPRIVATE and FOREIGN.

3.2.3 Econometric model

The model capturing the relationship between the company’s mean affordability, abbreviated as *MEANAFFORD* and the identified variables can be developed from equation (5) and written as equation (6), where ε is the error term and β_0 is the constant.

$$\begin{aligned} MEANAFFORD = \beta_0 &+ \beta_1 ENPRICE + \beta_2 COMPETITION + \beta_3 ENSTRATEGY \\ &+ \beta_4 EXISTINGTECH + \beta_5 NEWTECH + \beta_6 SAVPOTENTIAL \\ &+ \beta_7 AVGEDU + \beta_8 SIZE + \beta_9 SECTOR + \beta_{10} OWNERSHIP + \varepsilon \end{aligned} \tag{6}$$

4. Outline of the survey and samples

The questionnaire for this analysis was designed with the main objective of measuring the affordability of companies for energy cost increases due to the introduction of MBIs, and to identify the corresponding determinants. The format consists of four major components: general information of the company; company energy use and management status; acceptability degrees to various ratios of energy cost increases; and external pressures felt by the company and the company's internal factors. The implementation of the survey was described in chapter 7 and thus omitted here. As a result, a total of 170 respondents were confirmed to be useful for this analysis. The distribution of valid samples by sector and size is listed in table 10.2.

Table 10.2 Distribution of usable respondents by sector and size

Sector \ Size	Number of samples					Percentage
	Small	Medium	Large	Unclear	In total	
Iron & steel	14	27	10	1	52	30.6
Cement	24	7	1	1	33	19.4
Chemical	12	21	4	1	38	22.4
Paper	1	8	6	0	15	8.8
Other	19	12	1	0	32	18.8
Total	70	75	22	3	170	100.0

The samples from iron & steel, cement and chemical industries individually account for 30.6%, 19.4% and 22.4% of the total. Paper companies have a share of 8.8% and the remaining 18.8% is the respondents from other sectors. Three companies did not provide full information on the scale of employee numbers, registered capital or annual sales for clarifying the company's size. Of the other 167 samples, 70 are small companies, having less than 300 staff or an annual turnover of below 30 million Yuan or a registered capital of less than 40 million Yuan. Twenty two companies are large, with more than 2,000 employees, an annual turnover of more than 300 million Yuan and a registered capital of over 400 million Yuan. The remaining 75 are medium-sized companies.

5. Results and discussions

5.1 Affordability of energy cost increases for companies

The affordability of energy cost increases for companies was monitored using the MBDC format. A total of 15 energy cost increase ratio thresholds are listed – the acceptability of each of which could be selected by the companies. The reliability of this measurement was tested by Cronbach's alpha, which produced an alpha for answers of all the samples of 0.9424. The alphas for the two sample groups, collected by the students and the institutes of the two provinces, are 0.9244 and 0.9463, respectively. All the values are over 0.70 as the criteria recommended by Nunnally and Bernstein (1994), which confirmed the reliability of the survey data construct.

5.1.1 Statistics of cost affordability of the samples overall

Table 10.3 lists the statistics of affordability of all the respondents to each energy cost increase ratio in the MBDC format.

Table 10.3 Statistics of affordability responses of all samples (N=111)

Energy Cost Increase Ratio (%)	Strong Rejection (%)	Rejection (%)	Barely Acceptable (%)	Acceptable (%)	Easily Acceptable (%)	Total (%)
0.1	0.0	0.0	1.8	33.3	**64.9**	100.0
0.3	0.0	0.0	5.4	45.1	**49.6**	100.0
0.5	0.0	0.9	14.4	**50.5**	**34.2**	100.0
0.7	0.0	4.5	17.1	**50.5**	**27.9**	100.0
1.0	1.8	8.1	**37.8**	**35.1**	**17.1**	100.0
3.0	6.3	14.4	**43.2**	**27.9**	8.1	100.0
5.0	7.2	18.9	**46.9**	**21.6**	5.4	100.0
7.0	11.7	29.7	**42.3**	**12.6**	3.6	100.0
10.0	**19.8**	**42.3**	29.7	6.3	1.8	100.0
15.0	**31.5**	**41.4**	24.3	2.7	0.0	100.0
20.0	**46.0**	**41.4**	10.8	1.8	0.0	100.0
30.0	**55.9**	**37.8**	5.4	0.9	0.0	100.0
50.0	**75.7**	21.6	2.7	0.0	0.0	100.0
70.0	**84.7**	15.3	0.0	0.0	0.0	100.0
100.0	**87.4**	12.6	0.0	0.0	0.0	100.0

A total of 111 companies provided fully-circled answers, which were used to generate the statistics. At the lowest energy cost increase ratio of 0.1%, 64.9% of companies indicated this increase to be very low and easily acceptable and 33.3% expressed 'no problem'; only 1.8% selected 'barely acceptable' for this ratio. In summary, all the respondents could afford this increase. The share of companies with acceptance degrees of barely acceptable and beyond dropped to 90.1% at an increase ratio of 1.0%, 73.9% at a ratio of 5.0%, and 58.6% at a ratio of 7.0%. Less than 40% of the companies indicated that they could accept an increase ratio of 10.0%. The ratios of companies with affordability degrees of 'barely acceptable" and over continue to drop with rising energy cost − more than 70% of the companies viewed an increase of 15.0% to be high and circled the answers of rejection and strong rejection; around 75% of the surveyed companies would strongly reject an energy cost increase of 50.0%.

Figure 10.3 depicts the results of aggregated data listed in table 10.3 and the simulation curves. Two groups of data, 'easily acceptable' and 'acceptable', and 'barely acceptable' and beyond, are shown in the figure because they are meaningful for observing the rough range of energy cost increase ratios acceptable for the sampled companies. A cumulative normal distribution model was applied for the regressions with the aggregative shares of samples as the dependent variable and the energy cost ratios as the independent variable. The R-squared figures for the regressions of the two sets of data are 0.9404 and 0.9795, respectively, indicating a good fit between the observed data and regression curves. Affordability on the part of 50% of the samples corresponds to energy cost increase ratios of 2.8% and 9.3% on the two curves. The mean of energy cost increase ratios affordable for the samples is 2.8–9.3%.

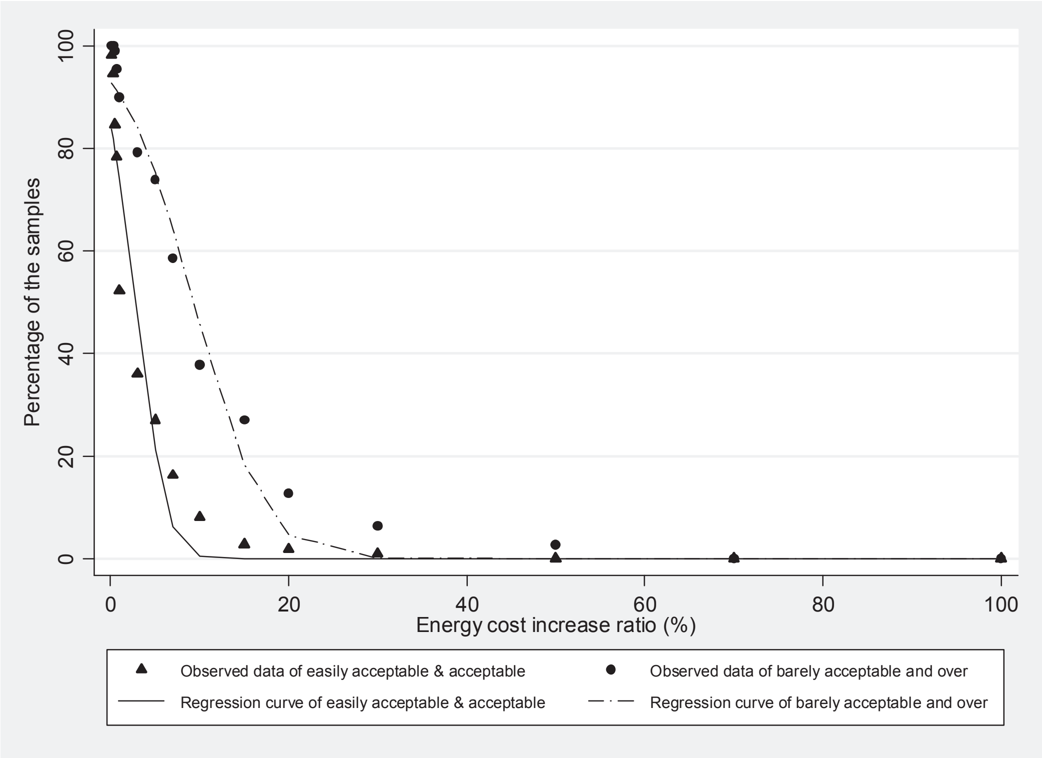

Figure 10.3 Affordability of energy cost increases of all samples (N=111)

5.1.2 Statistical summary of the affordability for iron & steel companies

Table 10.4 lists the statistics of affordability for samples from the iron & steel industry. At the lowest ratio of 0.1%, 61.8% of respondents indicated the increase to be too low and easily acceptable and 38.2% of the companies thought it no problem to accept the increase. All the respondents could accept this ratio. The share of samples with selections of barely acceptable and beyond dropped to 88.3% when energy cost increased by a ratio of 1.0%; 70.6% at the ratio of 5.0%; and 55.9% at the ratio of 7.0%. Less than 35% of the companies thought they could accept an increase ratio of 10.0%. The affordability continues to decrease with the rise in energy cost. More than 85% of iron & steel companies viewed an increase of 20.0% to be high and selected the answers of rejection and strong rejection. Nearly 75% of them would strongly reject an energy cost increase of 50.0%.

Figure 10.4 presents the aggregated results of observed data listed in table 10.4 and the regression curves. The R-squared figures for the regressions of the two sets of data are 0.9240 and 0.9661, respectively, confirming that the simulations are appropriate. The affordability of 50% corresponds to an energy cost increase ratio of 2.6% and 9.3% on the two curves. This shows almost the same affordability range for the iron & steel sector as that of all the samples.

Table 10.4 Statistics of affordability responses of iron & steel companies (N=34)

Energy Cost Increase Ratio (%)	Strong Rejection (%)	Rejection (%)	Barely Acceptable (%)	Acceptable (%)	Easily Acceptable (%)	Total (%)
0.1	0.0	0.0	0.0	38.2	**61.8**	100.0
0.3	0.0	0.0	5.9	44.1	**50.0**	100.0
0.5	0.0	2.9	17.7	**47.1**	**32.4**	100.0
0.7	0.0	5.9	17.7	**52.9**	**23.5**	100.0
1.0	2.9	8.8	**41.2**	**32.4**	**14.7**	100.0
3.0	8.8	20.6	**35.3**	**26.5**	8.8	100.0
5.0	8.8	20.6	**44.1**	**20.6**	5.9	100.0
7.0	14.7	29.4	**41.2**	**11.8**	2.9	100.0
10.0	**20.6**	**47.1**	23.5	5.9	2.9	100.0
15.0	**29.4**	**41.2**	26.5	2.9	0.0	100.0
20.0	**47.1**	**38.2**	11.8	2.9	0.0	100.0
30.0	**52.9**	**44.1**	0.0	2.9	0.0	100.0
50.0	**73.5**	23.5	2.9	0.0	0.0	100.0
70.0	**79.4**	20.6	0.0	0.0	0.0	100.0
100.0	**82.4**	17.7	0.0	0.0	0.0	100.0

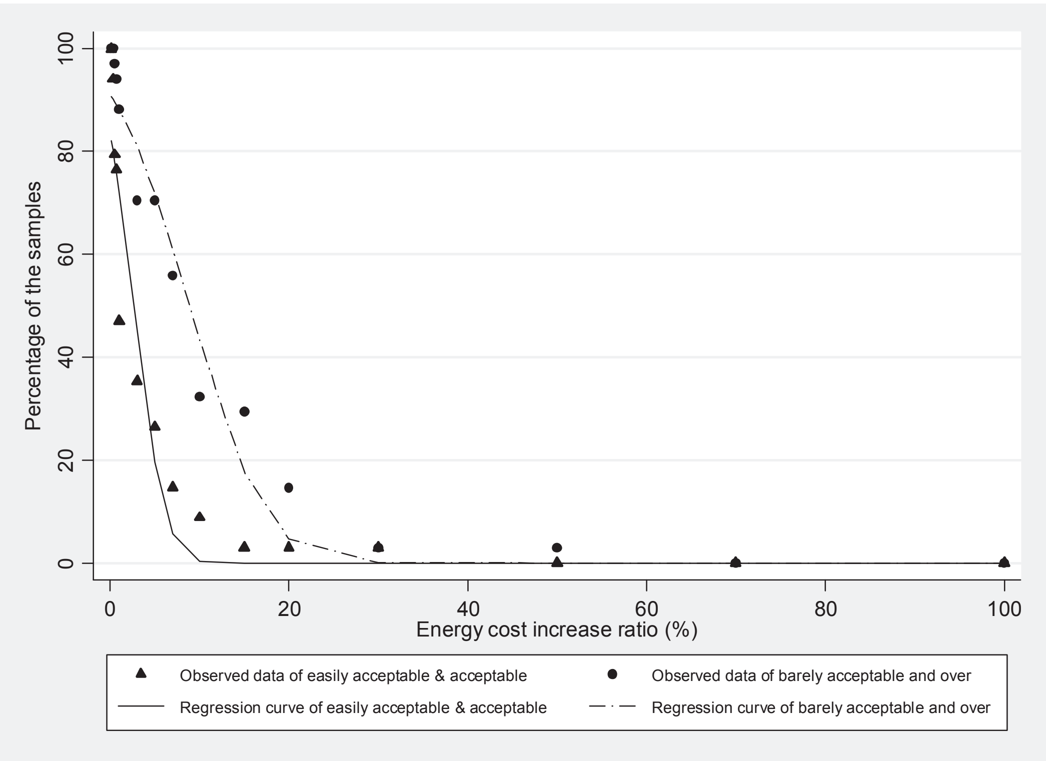

Figure 10.4 Affordability of energy cost increases for the iron & steel industry (N=34).

5.1.3 Statistical summary of the affordability for cement companies

Table 10.5 shows the statistics of affordability for samples from the cement industry to energy cost increases. The number of usable respondents in this sector is 17. At the lowest ratio of 0.1%, 76.5% of the respondents indicated the increase to be too low and easily acceptable and 23.5% of the companies indicated it to be no problem for them to afford the increase. This confirms full acceptance of the respondents for this ratio. The share of the samples with selections of barely acceptable and beyond dropped to 82.3% at the increase ratio of 5.0%, and quickly to 58.8% at the ratios of 7.0%. Only 35% of cement companies believed that they could accept an increase ratio of 10.0%. The affordability continues to decrease as the energy cost rises. More than 75% of the cement companies viewed an increase of 15.0% to be high and selected the answers of rejection and strong rejection. Nearly half of the surveyed companies would strongly reject an energy cost increase of 20.0%.

Figure 10.5 presents the aggregated results of observed data listed in table 10.5 and the regression curves in the same way. The R-squared figures for the two regressions are 0.9696 and 0.9867, respectively, indicating the suitability of simulations. An affordability of 50% corresponds to respective energy cost increase ratios of 2.6% and 9.0% on the two curves.

Table 10.5 Statistics of affordability responses of cement companies (N=17)

Energy Cost Increase Ratio (%)	Strong Rejection (%)	Rejection (%)	Barely Acceptable (%)	Acceptable (%)	Easily Acceptable (%)	Total (%)
0.1	0.0	0.0	0.0	23.5	**76.5**	100.0
0.3	0.0	0.0	0.0	35.3	**64.7**	100.0
0.5	0.0	0.0	0.0	**58.8**	**41.2**	100.0
0.7	0.0	0.0	5.9	**58.8**	**35.3**	100.0
1.0	0.0	0.0	**35.3**	**41.2**	**23.5**	100.0
3.0	0.0	11.8	**52.9**	**29.4**	5.9	100.0
5.0	0.0	17.7	**64.7**	**17.7**	0.0	100.0
7.0	0.0	41.2	**52.9**	**5.9**	0.0	100.0
10.0	**17.7**	**47.1**	29.4	5.9	0.0	100.0
15.0	**23.5**	**52.9**	23.5	0.0	0.0	100.0
20.0	**47.1**	**47.1**	5.9	0.0	0.0	100.0
30.0	**64.7**	35.3	0.0	0.0	0.0	100.0
50.0	**82.4**	17.7	0.0	0.0	0.0	100.0
70.0	**94.1**	5.9	0.0	0.0	0.0	100.0
100.0	**94.1**	5.9	0.0	0.0	0.0	100.0

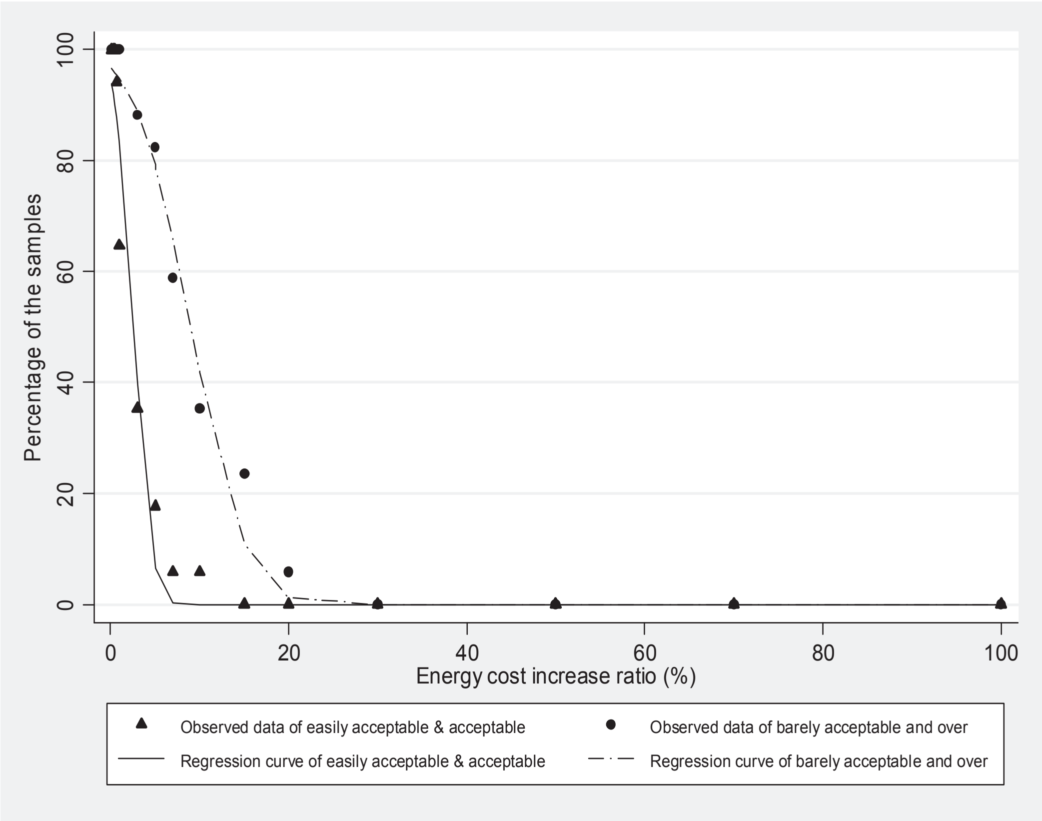

Figure 10.5 Affordability of energy cost increases for the cement industry (N=17).

5.1.4 Statistical summary of the affordability for chemical companies

Table 10.6 shows the statistics of affordability for samples from the chemical industry to energy cost increases. The number of usable respondents in this sector is 27. At the lowest ratio of 0.1%, 59.3% of the respondents indicated the increase to be too low and easily acceptable and 40.7% of the companies indicated it to be no problem for them to afford the increase. This also indicates full acceptance of the respondents for this ratio. The share of the samples with selections of barely acceptable and beyond dropped to 88.6% at the increase ratio of 1.0%, and 70.2% at the ratio of 5.0%. Less than 35% of the chemical companies believed that they could accept an increase ratio of 10.0%. The affordability continues to decrease as the energy cost rises. More than 75% of the cement companies viewed an increase of 15.0% to be high and selected the answer of rejection and strong rejection. More than half of the surveyed companies would strongly reject an energy cost increase of 20.0%.

Figure 10.6 presents the aggregation results of observed data listed in table 6 and the regression curves in the same way. The R-squared figures for the two regressions are 0.9156 and 0.9479 respectively, indicating that the simulations were suitable. An affordability of 50% corresponds to respective energy cost increase ratios of 3.0% and 8.5% on the two curves.

Table 10.6 Statistics of affordability responses of chemical companies (N=27)

Energy Cost Increase Ratio (%)	Strong Rejection (%)	Rejection (%)	Barely Acceptable (%)	Acceptable (%)	Easily Acceptable (%)	Total (%)
0.1	0.0	0.0	0.0	40.7	**59.3**	100.0
0.3	0.0	0.0	3.7	51.9	**44.4**	100.0
0.5	0.0	0.0	11.1	59.3	**29.6**	100.0
0.7	0.0	3.7	14.8	55.6	**25.9**	100.0
1.0	3.7	7.4	**37.0**	**37.0**	**14.8**	100.0
3.0	7.4	11.1	**48.2**	**29.6**	3.7	100.0
5.0	7.4	22.2	**40.7**	**25.9**	3.7	100.0
7.0	11.1	37.0	**29.6**	**18.5**	3.7	100.0
10.0	**14.8**	**51.9**	22.2	11.1	0.0	100.0
15.0	**44.4**	**33.3**	14.8	7.4	0.0	100.0
20.0	**55.6**	**22.2**	18.5	3.7	0.0	100.0
30.0	**66.7**	14.8	18.5	0.0	0.0	100.0
50.0	**74.1**	22.2	3.7	0.0	0.0	100.0
70.0	**88.9**	11.1	0.0	0.0	0.0	100.0
100.0	**88.9**	11.1	0.0	0.0	0.0	100.0

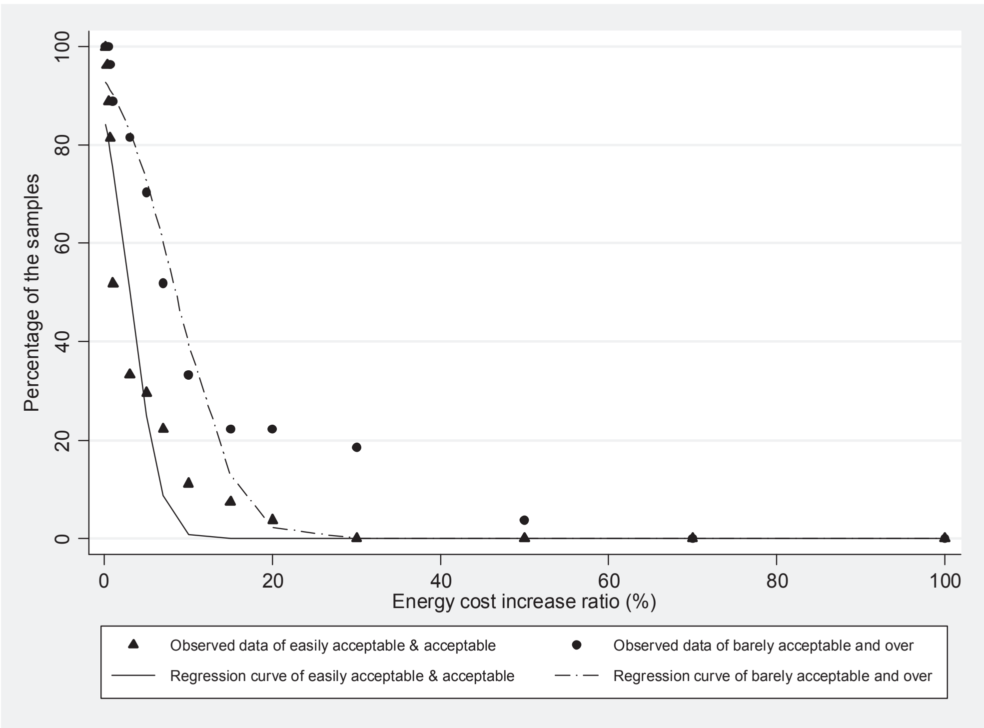

Figure 10.6 Affordability of energy cost increases for the chemical industry (N=27)

5.2 Estimation results of cost affordability for individual companies

The mean and standard variance of affordability of individual companies for energy cost increases were estimated using equation (4). In this study, a 'strong rejection' was given a probability value of 0.1% since a value of zero would generate infinity in the model simulation. A simple 'rejection' was given a value of 25%, 'barely acceptable' 50% and 'acceptable' 75%. An 'easily acceptable' was presented a value of 99.9% to avoid infinity in the calculation. A one-way ANOVA (analysis of variance) was conducted to find whether differences exist between the means of affordable energy cost increases for the two groups of samples, respectively collected by the students and arranged by the local government-affiliated organisations. The ANOVA result produces an F value of 0.01. There are no statistically significant differences between the two sample groups. Table 10.7 lists the mean values and percentiles of all the samples and the respondents from the three industries.

Table 10.7 Distribution of estimated individual company's cost affordability

Variable	Percentile	Centile (%)	95% Conf. Interval (%)	
Panel A: All the samples (N=111)				
Mean of μ: **8.8%** The std. dev. of μ: 9.0%	10	0.7	0.5	1.9
	30	4.0	2.6	5.1
	50	**6.6**	5.2	7.0
	70	10.2	7.1	12.9
	90	18.5	13.8	28.9
Panel B: Samples from iron & steel sector (N=34)				
Mean of μ: **8.8%** The std. dev. of μ: 9.9%	10	0.6	0.3	1.7*
	30	3.4	1.0	6.7
	50	**6.7**	4.4	10.4
	70	11.2	6.8	16.0
	90	17.9	13.1	52.6*
Panel B: Samples from cement sector (N=17)				
Mean of μ: **7.7%** The std. dev. of μ: 4.4%	10	2.2	1.9	5.1*
	30	5.2	2.3	6.8
	50	**6.8**	5.1	10.2
	70	9.8	6.5	13.1
	90	14.3	10.2	19.1*
Panel B: Samples from chemical sector (N=27)				
Mean of μ: **9.9%** The std. dev. of μ: 11.2%	10	0.8	0.5	3.2*
	30	3.7	1.6	5.2
	50	**5.2**	3.6	9.1
	70	8.3	5.2	25.7
	90	29.6	11.1	44.1*

* Lower (upper) confidence limit held at minimum (maximum) of sample

The mean of energy cost increase ratios affordable for all the surveyed companies is 8.8%, which drops in the range of affordability, 2.8% to 9.3%, preliminarily observed from fig.10.5. The sample's standard variance is 9.0%. The medium value of affordability for companies of energy cost increases is 6.6%. Comparatively, the companies from the chemicals sector have a slightly higher mean (9.9%) of energy cost increase affordability than that of the total samples. The mean for cement companies is 7.7%, slightly lower than that of all the samples. The standard deviation of energy cost increase affordability for companies of chemical and cement sectors is 11.2% and 4.4%, respectively. As described earlier, the iron & steel sector has almost the same energy cost increase affordability mean as the surveyed companies overall.

5.3 Statistics of the determinant factors and controls

Table 10.8 summarises the statistics of determinants as independent variables. The surveyed companies presented higher scores to ENPRICE (the level of domestic energy prices), with an average of 4.12. COMPETITION achieved another higher mean of 4.07. This indicates that the companies felt strong pressure from energy prices and market competitors in the same sector. An average score of 3.72 given to ENSTRATEGY implies that companies have a certain motivation to set targets for energy-saving. However, the companies tend to behave reactively in response to energy-saving requirements from the government and hesitate to clarify internally decomposed energy-saving targets over the short and medium terms. The understanding of companies on energy-saving technologies is not optimistic, with EXISTINGTECH and NEWTECH averaged at 3.57 and 3.19 respectively. A mean of 2.62 for the variable of SAVPOTENTIAL reveals that the surveyed companies are using manufacturing technologies at the domestically average level and have relatively large potentials for energy efficiency improvements. A mean of 2.62 for AVGEDU indicates that the level of education of employees at the companies is not high; more than half of the sampled companies only have a share of less than 20% of employees with an education level of college and above.

Table 10.8 Statistical summary of the determinant factors

variable	Obs.	Mean	Std. dev.	Min.	Max.
ENPRICE	162	4.12	0.70	1	5
COMPETITION	162	4.07	0.83	1	5
ENSTRATEGY	163	3.72	1.44	1	5
EXISTINGTECH	159	3.57	0.81	1	5
NEWTECH	159	3.19	0.77	2	5
SAVPOTENTIAL	160	2.62	0.63	1	4
AVGEDU	162	2.62	1.36	1	5

The distribution of samples by sector and size was described in section 4. The ratios of samples with an ownership of state-owned, domestically private and foreign-funded are 31.5%, 63% and

5.5%, respectively.

5.4 Correlation matrix and bi-variable results

Pair-wise correlation was calculated to preliminarily explore the relationships between the estimated cost affordability, *MEANAFFORD*, and the independent variables. The correlation matrix is shown in table 10.9. There is no indication for an unacceptable level of multi-collinearity between the independent variables as the highest correlation coefficient is 0.601 for NEWTECH (Awareness of new energy saving technologies) and EXISTINGTECH (Awareness of existing energy saving technologies). Harmful levels of multi-collinearity are not expected until the correlation coefficient reaches ±0.8 or ±0.9 (Farrar and Glauber, 1967). This confirms that the independent variables are mutually exclusive in this analysis. The correlation result indicates that COMPETITION (Competition degree of the company's sales market) is significantly but negatively associated with *MEANAFFORD* at $P<0.1$. The other variables have no significant correlations with *MEANAFFORD*.

Table 10.9 Correlation matrix of estimated affordability and determinants

	MEAN.	ENP.	COM.	ENS.	EXI.	NEW.	SAV.	AVG.
MEANAFFORD	1							
ENPRICE	-0.026	1						
COMPETITION	-0.158[c]	0.145[c]	1					
ENSTRATEGY	-0.014	-0.102	-0.055	1				
EXISTINGTECH	0.096	-0.032	-0.092	0.254[a]	1			
NEWTECH	-0.021	-0.030	-0.062	0.195[b]	0.601[a]	1		
SAVPOTENTIAL	-0.016	0.013	-0.122	-0.234[a]	-0.157[b]	-0.208[a]	1	
AVGEDU	0.084	-0.080	-0.057	0.104	0.291[a]	0.130	-0.295[a]	1

[a] Significant at 1% level; [b] Significant at 5% level; [c] Significant at 10% level

5.5 Multivariate regression results of the estimated affordability

Table 10.10 presents the econometric analysis results of the determinants for estimated affordability. This analysis may test the validity and quality of the affordability estimations for individual companies to some degree, since the estimated results follow an underlying economic rationale and intuitive reasoning. The econometric analysis could also check the ordering effects of matrix design in the MBDC approach. As a referendum method, there may be an anchoring effect of the cost increase presentation sequence in the MBDC format; however, considering the difficulty in requesting cooperation from companies, this survey could only adopt an identical MBDC matrix starting from the lowest ratio with all the other ratio options ascending. Therefore, anchoring effects cannot be tested in this study.

The robustness of the analysis results was tested by repeating the regression with the gradual introduction of independent variables and controls. Three models were adopted: Model 1 is the case of only importing external pressures as independents, model 2 adds the internal factors, and model 3 includes all the independent variables and controls. There are no obvious changes in the determinants showing significant relationships with the estimated affordability. It is indicated that COMPETITION is significantly but negatively associated with affordability, a result that could be expected since if a company feels high competition pressure from the market it would be unwilling to accept additional economic burdens (such as energy cost increases due to climate policies). Another finding of this analysis is that cost affordability is significantly and positively associated with company size; large companies have higher cost affordability than small ones. Other controls, including the company's sector position and ownership, indicate no significant effect on the estimated cost affordability.

Table 10.10 Multivariate regression results of cost affordability for companies

Independent variables and controls		Coefficients with mean affordability as the dependent		
		Model 1	Model 2	Model 3
ENPRICE		-0.0018	-0.0032	0.0021
COMPETITION		-0.0164*	-0.0174*	-0.0178*
ENSTRATEGY			-0.0030	-0.0042
EXISTINGTECH			0.0185	0.0148
NEWTECH			-0.0173	-0.0194
SAVPOTENTIAL			-0.0050	-0.0084
AVGEDU			0.0034	0.0023
SIZE	SMALL			--
	MEDIUM			0.0311
	LARGE			0.0519*
SECTOR	STEEL			--
	CEMENT			0.0107
	CHEMICAL			0.0080
	PAPER			-0.0190
	OTHER			0.0216
OWNERSHIP	STATEOWNED			--
	DOMPRIVATE			0.0089
	FOREIGN			-0.0336
Obs.		111	111	111
R Squared		0.025	0.051	0.092

* Significant at 10%

5.6 Carbon prices affordable for the companies by sector

The energy cost increase affordable for a company or a sector on average, *MEANAFFORD*, is the equivalent of its affordable carbon price in response to the introduction of climate policies. The relationship between *MEANAFFORD* and affordable carbon price can be expressed as equation (7), where *i* indicates the energy type.

$$MEANAFFORD = \frac{\sum_i Emission\ factor_i \times Use\ amount_i \times Affordable\ carbon\ price}{\sum_i Energy\ price_i \times Use\ amount_i} = \frac{\sum_i Emission\ factor_i \times Energy\ ratio_i \times Affordable\ carbon\ price}{\sum_i Energy\ price_i \times Energy\ ratio_i} \quad (7)$$

Equation (7) can be converted to the following equation (8). Using the mean of affordable ratios of energy cost increases (*MEANAFFORD*), the surveyed ratios of energy uses of the companies by type, carbon prices affordable for the respondents can be calculated by equation (8).

$$Affordable\ carbon\ price = MEANAFFORD \times \frac{\sum_i Energy\ price_i \times Energy\ ratio_i}{\sum_i Emission\ factor_i \times Energy\ ratio_i} \quad (8)$$

The data sources and calculation results of the three sectors are listed in table 10.11. Five major types of energy – electricity, coal, oil, natural gas and steam – are covered since they account for about 95% of the total energy used in the surveyed companies. An assumption for this calculation is that price increases of the secondary energies, including electricity and steam here, due to the climate policies are fully transferred to the final energy users.

Table 10.11 Estimations of affordable carbon prices by sector

Energy type	Energy use ratios (%)			Current energy price [a]	Emission factor [b]
	Iron & steel	Cement	Chemical		
Electricity	27.9	31.2	18.6	0.618 Yuan/KWh	0.8592 t-CO_2/MWh
Coal	61.8	61.7	32.1	746 Yuan/t	1.9383 t-CO_2/t
Fuel oil	0.6	2.4	34.9	4450 Yuan/t	3.0358 t-CO_2/t
Natural gas	1.0	0.0	2.0	2.78 Yuan/m^3	2.1731 t-CO_2/1,000 m^3
Steam	0.7	0.0	6.5	230 Yuan/t	0.3231 t-CO_2/t
MEANAFFORD	8.8%	7.7%	9.9%	**Data source:** [a] www.askci.com; www.cngold.org; [b] (Su et al., 2009); (NDRC, 2010).	
Affordable carbon price (Yuan/t-CO_2)	**42.7**	**38.6**	**83.7**		

Large differences exist in affordable carbon prices among the three sectors. A carbon price of 83.7 Yuan/t-CO_2 (about 12 USD/t-CO_2, 1 USD=6.80 Yuan in 2010) would be acceptable for the chemical industry. The affordable carbon price for iron & steel and cement sectors is much lower, at around 40.0 Yuan/t-CO_2 (about 6 USD/t-CO_2). According to the results in section 6.3, the mean of affordable energy cost increase ratios for the chemical sector is only slightly higher than that of iron & steel and cement industries. Overall, such large variation in affordable carbon prices may be mainly attributed to the different compositions of energy uses. Iron & steel and cement companies both heavily rely on coal, whose carbon content is higher than that of other types of energy, thus the same carbon price would lead to higher energy cost increases for the iron & steel and cement sectors compared to the chemical industry.

The affordable carbon prices calculated by sector have meaningful policy implications and may support ongoing discussions on carbon taxes and GHG ETS from the industrial perspective in China. Liang et al. (2007) established a CGE (Computable General Equilibrium) model for simulating carbon tax policy in China. Under the preferable scheme with the tax completely exempted for the five most energy-intensive sectors (iron & steel, building materials, chemicals, non-ferrous metals and paper industries), while being identical for all the other sectors, a tax rate of 348 Yuan/t-C (94.9 Yuan/t-CO_2, or about 11.5 USD/t-CO_2 at the 2002 constant price) would be necessary to achieve a 10% reduction target in comparison with the assumed baseline scenario. Cao et al. (2012) modeled the carbon tax as a direct unit tax proportional to the carbon content of fossil fuels. The authors confirmed that carbon tax at a low rate of 100 Yuan/t-C (about 27 Yuan/t-CO_2) would lead to a very slight fall in the national GDP if the tax revenue was recycled in a lump sum back to households to maintain government spending. Experts from the Ministry of Finance (MOF) of China came to a similar conclusion as regards carbon tax policy in their CGE modeling (Su et al., 2009) – they proposed to phase-in carbon tax policy from a very low rate of 10 Yuan/t-CO_2 in China and then raise the rate to 40 Yuan/t-CO_2 from the second phase, set to start from 2020. Regarding the current market of VERs in China, the first VER deal conducted by the 'China Beijing Environment Exchange' was completed on 5 August 2009, with an average price of 35 Yuan/t-CO_2 (CBEEX, 2009). An interview by the authors at another environmental exchange institute in Shanghai confirmed that the transaction price of the limited VERs is around 20 Yuan/t-CO_2. Referring to the analysis of carbon tax policy in existing literature and the estimation results of this study, giving a carbon price of 10–40 Yuan/t-CO_2 would be feasible and appropriate in the current Chinese context. However, considering the disparity in affordable carbon prices among different sectors, relief measures or subsidies should be provided to certain energy-intensive sectors in order to alleviate the policy's negative impacts (Liang et al., 2007).

6. Conclusions

This study extended the application of the MBDC technique to a new field. It estimated the affordability of companies from three energy-intensive sectors for energy cost increases due to possible introduction of market-based climate policies in China. The results indicate that an energy cost increase with a mean of 8.8% would be acceptable for the respondents as a whole. The chemical sector expressed a slightly higher affordability, with a mean of 9.9%, while the cement sector's is lower, at 7.7%. Econometric analysis identified the market competition level as a significant determinant negatively affecting the affordability for companies. The calculation results of the affordable carbon prices for companies in the target industries indicate useful referendums for the development of carbon tax policy and the establishment of a domestic GHG ETS in China.

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Chapter 11:
Affordability of energy cost increases for Korean companies due to market-based climate policies: A survey by sector*

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Chapter Highlights:

- This chapter estimates energy cost increases acceptable for Korean companies using the data collected from 62 respondents from iron & steel, cement and petro-chemical industries.
- A mean policy-originated energy cost increase of 2.6.8% would be acceptable for the samples as a whole.
- Acceptable energy cost increases affordable for the companies based on the above means equate to a carbon price of 2,500–4,000 KRW/t-CO_2 (about 2.3–3.5 USD/t-CO_2) would be affordable for the surveyed companies.
- This research confirms that the latest carbon tax proposal of Korea, particularly in terms of tax rate, would be acceptable from the business perspective.

1. Introduction

The subject of reducing GHG emissions via market-based instruments (MBIs), particularly the GHG emissions trading scheme (GHG ETS) and carbon taxes, has been under governmental discussion in Korea for some time. Its GHG ETS bill was approved on 2 May 2012 and will come into force on 1 January 2015. Introduction of a carbon tax has also been reviewed as a possible measure for GHG mitigation in recent years. The Korea Institute for Public Finance (KIPF) studied green fiscal reform by addressing the negative externalities of the existing taxation system and suggested a carbon tax be introduced from 2013 to replace the transportation-energy-environment tax scheduled to end in 2012 (Kim and Kim 2010). However, based on consideration of acceptance of the policy and the need to minimise its impact on the economy, a recent KIPF report suggested a lower tax rate be imposed for the early stage (at a level 1/8 the initial proposal) to realise a tax revenue equal to 2% of Korea's GDP (Kim and Kim 2010).

* The main content of this chapter appears in the Journal of Cleaner Production as: Suk, S.H., Liu, X.B., Lee, S.Y., Go, S.J., Sudo, K., 2014. Affordability of energy cost increases for Korean companies due to market-based climate policies: A survey study by sector, *Journal of Cleaner Production* 67(2014): 208–219.

In spite of the emerging policy progresses in recent years, our previous study found that Korean companies were still at an early stage in response to governmental climate change and energy saving measures (Suk et al., 2012). Based on the export-oriented nature of Korea's economy, which is dominated by energy-intensive industries, carbon pricing policies face a huge wall of resistance, as industry as a whole is hypersensitive to any factors that could increase its energy costs, which could in turn impact on Korea's international competitiveness (Liu et al., 2011).

Many researches have focused on the above issue (Kang et al, 2011; Kim et al., 2010; Kim, 2009a; Kim, 2009b; Kim et al., 2008); however, few studies test the affordability of energy cost increases due to the introduction of MBIs from the perspective of individual companies in Korea. Therefore, this research set out to estimate the affordability of Korean companies for energy cost increases due to the phase-in of market-based climate policies. Three energy-intensive sectors, iron & steel, cement and chemical industries, were selected as the survey targets. Two topics are discussed in this chapter: One is the estimation of affordability for companies in the target sectors regarding energy cost increases, and the other is the identification of determinants to clarify the relationships between affordability and company characteristics.

The remainder of this chapter is structured as follows: Section 2 explains the methodologies, including the models for estimating affordability of companies on energy cost increases by multiple-bounded discrete choice (MBDC) data, and the analytical framework for identifying the determinants of the estimated affordability, section 3 outlines the distribution of samples, section 4 discusses the results of affordability estimations and econometric analysis, and section 5 concludes the research findings.

2. Methodologies

2.1 The MBDC format and the analytical framework in this study

The methodology for this analysis is almost the same as that used for Chinese companies explained in chapter 10. The question format prepared for the companies in Korea and an example response from a cement company are shown in fig.11.1. The companies are presented with an ordered and ascending sequence of 10 energy cost increase thresholds, but instead of circling a single value or interval, the companies are given multiple choice options: 'easily acceptable', 'acceptable', 'barely acceptable', 'rejection' and 'strong rejection'. The models used for the estimations of company affordability of energy cost increases are explained in chapter 10.

We also carried out an econometric analysis to identify the relationships between the estimated affordability of energy cost increases of companies with the determinant factors, including company characteristics. The analytical framework is depicted in fig.11.2, which is similar to the previous analysis of Chinese companies (Liu et al., 2013). The determinant factors are described as follows.

Q: Direct rise of energy prices and/or government's levying of energy tax or carbon tax in energy production and conversion sector will bring a rise in energy prices and therefore increase the company's energy costs. We would like to know your company's opinion on the possible rise of energy costs due to above factors. Please evaluate and make your choice according to the willingness level of your company to accept the optional increasing rates of energy costs.

Rise rate of energy cost (%)	Your choice				
	Too low; Very easy to accept	Not high; Accept	Moderate; Moderately accept	High; Reject	Too high; Strongly reject
0.1	✓	☐	☐	☐	☐
0.5	✓	☐	☐	☐	☐
1.0	☐	✓	☐	☐	☐
3.0	☐	✓	☐	☐	☐
5.0	☐	☐	✓	☐	☐
7.0	☐	☐	✓	☐	☐
10.0	☐	☐	☐	✓	☐
20.0	☐	☐	☐	✓	☐
30.0	☐	☐	☐	☐	✓
50.0	☐	☐	☐	☐	✓

Figure 11.1 Question and example response of MBDC format used in this study

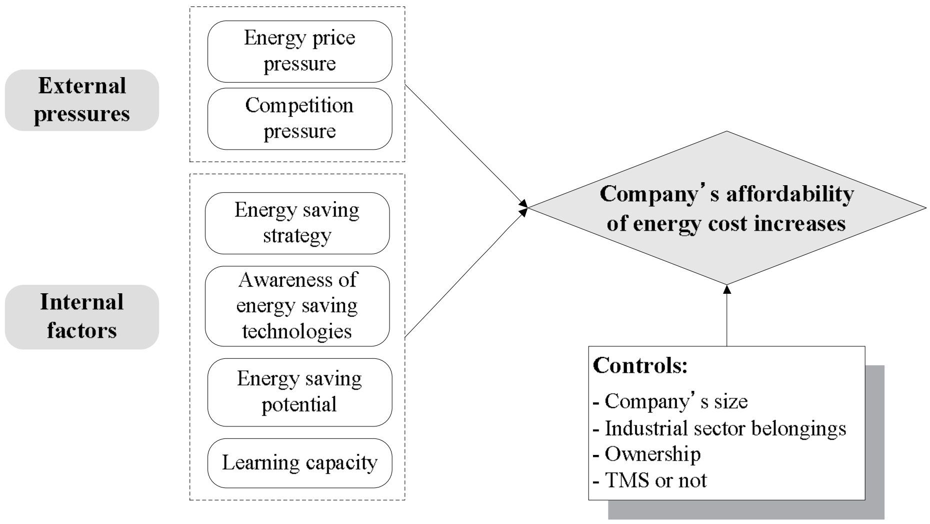

Figure 11.2 Analytical framework for econometric analysis

We classified the determinants of affordability of companies on energy cost increases into external pressures and internal factors. Two external pressures were defined: One is the energy price pressure felt by the companies and the other is the strength of market competition. Four internal factors were classified, accordingly: One is the energy saving strategy of companies, indicating willingness to improve energy management. The second is awareness of companies on energy saving technologies; energy saving potential is categorised as the third internal factor. As regards this, companies with higher energy saving potential can more flexibly accommodate the energy cost burden by self-reduction efforts. The last internal factor is the learning capacity of a company, which is represented by the educational level of its employees as a proxy for this factor. Regarding the company's characteristics, size, industrial sector belongings and ownership were selected. The involvement status of TMS was added as another control for this analysis.

2.2 Valuation of the variables

The dependent variable for the econometric analysis is the estimated mean of affordability for companies. The abbreviation, description and valuation of determinant factors as independent variables and company characteristics as controls are listed in table 11.1.

Table 11.1 Abbreviation, description and valuation of independent variables and controls

Category	**Abbreviation**	**Description**	**Valuation**					
			0	**1**	**2**	**3**	**4**	**5**
External pressures	ENPRICE	Perception of domestic energy price levels						
	COMPETITION	Competition degree of the company's sales market						
Internal factors	ENSTRATEGY	The status of energy saving target setting						
	EXISTINGTECH	Company's awareness of existing energy saving technologies						
	NEWTECH	Company's awareness of new energy saving technologies						
	SAVPOTENTIAL	The level of energy saving potential of the company						
	AVGEDU	Average education level of the company's employees						
Controls	SIZE	The organisational size						
	SECTOR	Industrial sector to which the company belongs						
	OWNERSHIP	The company's ownership status						
	TMS	Involvement status of TMS						

A five-point scale was applied to evaluate the two external pressures, ENPRICE and COMPETITION, and company awareness of energy saving technologies, EXISTINGTECH and NEWTECH, with '1' = very low; '2' = relatively low; '3' = moderate; '4' = relatively high; and, '5' = very high. A four-level point was applied to the level of energy saving potential, SAVPOTENTIAL, with '1' = further energy saving very difficult; '2' = limited potential; '3' = relatively large potential; and, '4' = very high potential. The status of energy saving target setting was used to represent a company's energy management strategy, ENSTRATEGY. For this a five-level classification was applied, with '5' referring to a company that has clear annual and internally decomposed energy saving targets; '4' as one having a specific annual target; '3' as one having short and medium-term targets of 3 to 5 years; '2' as one having only a rough target in the long run, and '1' as one having no quantitative target. The average educational level of employees, AVGEDU, was used to indicate a company's learning capacity, for which five categories were used: ‘1’ = the ratio of employees with education level of college and above being less than 10%; ‘2’ = 10–20%; ‘3’ = 20–30%; ‘4’ = 30–50%; and, ‘5’ = over 50%.

For the controls, company size is classified into four types – small, medium-sized, large medium and large – abbreviated as SMALL, MEDIUM, MLARGE and LARGE. Company sectors are categorised into three types: iron & steel, cement, and chemical industries, named as STEEL, CEMENT, and CHEMICAL. Ownership consists of two types, domestically private and foreign-funded, abbreviated as DOMPRIVATE and FOREIGN. The respondents are sorted into TMS or non-TMS targets.

2.3 Econometric model

The model capturing the relationship between a company’s mean affordability, abbreviated as *MEANAFFORD*, and the identified variables can be developed as in the following equation, where ε is the error term and β_0 is the constant.

$$\begin{aligned} MEANAFFORD = \beta_0 + \beta_1 ENPRICE + \beta_2 COMPETITION + \beta_3 ENSTRATEGY \\ + \beta_4 EXISTINGTECH + \beta_5 NEWTECH + \beta_6 SAVPOTENTIAL \\ + \beta_7 AVGEDU + \beta_8 SIZE + \beta_9 SECTOR + \beta_{10} OWNERSHIP + \beta_{11} TMS + \varepsilon \end{aligned}$$

3. Outline of the survey and samples

Based on our understanding of Korea’s situation, a questionnaire was designed with the main objective of measuring the affordability of companies for energy cost increases due to the introduction of carbon pricing policies, through identifying the determinants thereof. The questionnaire format consists of four major components related to companies: general information on the company; energy use and management status; acceptability degrees to various ratios of energy cost increases due to economic climate policies; and, external pressures felt by the company and the company’s internal factors.

The data was obtained by the same questionnaire survey as that in chapter 8 over a period from 25 January to 10 February 2012. Questionnaires were faxed or emailed to a total of 205 companies, including 137 TMS target companies and 68 non-TMS companies. Of these, answers from 62 companies were collected and confirmed to be valid. The distribution of the usable samples by company characteristics is summarised in table 11.2.

The respondents from cement, iron & steel and chemical sectors individually account for 17.7%, 25.8% and 56.5 % of the total. According to the classification criteria of the ‘Minor Enterprises Act’ of Korea, which is based solely on the number of employees, 27 are medium-sized companies with a staff of more than 50 but less than 300 and an annual turnover of less than 8 billion KRW; two are small companies, with a staff of less than 50; 13 are large ones with more than 1,000 employees, an annual turnover of more than 150 billion KRW and a registered capital of over 50 billion KRW; and the remaining 20 are large medium-sized, which is a size between large and medium-size. Of the total 62 samples, 58 respondents are TMS targets.

Table 11.2 Distribution of usable respondents by company characteristics

Company characteristics		Number of samples				Number in total (%)
		Small	Medium	Large Medium	Large	
Number in total (%)		2 (3.2)	27 (43.5)	20 (32.2)	13 (21.0)	62 (100.0)
Sector	Cement	2	6	2	1	11 (17.7)
	Steel	-	8	5	3	16 (25.8)
	Petro-chemical	-	13	13	9	35 (56.5)
TMS	TMS	2	26	17	13	58 (93.5)
	Non-TMS	-	1	3	-	4 (6.5)

4. Results and discussions

4.1 Affordability of energy cost increases for companies

The affordability of energy cost increases for companies was monitored by the MBDC format. Ten thresholds of energy cost increase ratios are provided. The reliability of this measurement was tested by Cronbach's alpha, and the alpha of answers of all the samples is 0.9075, which is above 0.70, the criteria recommended by Nunnally and Bernstein (1994), confirming the reliability of the survey data construct.

4.1.1 Statistics of cost affordability of the samples overall

Table 11.3 lists the statistics of affordability of all the valid respondents to each energy cost increase ratio presented in the MBDC format.

Table 11.3 Statistics of affordability responses of all the samples (N=36)

Energy Cost Increase Ratio (%)	Strong Rejection (%)	Rejection (%)	Barely Acceptable (%)	Acceptable (%)	Easily Acceptable (%)	Total (%)
0.1	0.0	0.0	22.2	55.6	22.2	100.0
0.5	0.0	5.6	25.0	63.9	5.6	100.0
1.0	8.3	11.1	61.1	16.7	2.8	100.0
3.0	25.0	44.4	19.4	8.3	2.8	100.0
5.0	41.7	41.7	8.3	8.3	0.0	100.0
7.0	72.2	16.7	11.1	0.0	0.0	100.0
10.0	83.3	8.3	8.3	0.0	0.0	100.0
20.0	86.1	13.9	0.0	0.0	0.0	100.0
30.0	88.9	11.1	0.0	0.0	0.0	100.0
50.0	91.7	8.3	0.0	0.0	0.0	100.0

A total of 36 companies provided fully-circled answers, which were used to generate statistics. At the lowest energy cost increase option of 0.1%, 22.2% of companies indicated this increase to be very low and easily acceptable for them; 55.6% of the respondents expressed that it is no problem for them to afford this increase; the remaining 22.2% selected ‘barely acceptable’ for this increase ratio. In summary, all the respondents could afford this increase. The share of the companies with acceptance degrees of barely acceptable and beyond dropped to 94.4% at the increase ratio of 0.5%, 80.6% at the ratio of 1.0%, and 30.5% at the ratio of 3.0%. The ratios of companies with affordability degrees of ‘barely acceptable’ and over continue to decrease with the rise in energy cost. More than 91.6% of the companies viewed an increase of 10.0% to be high and circled the answers of rejection and strong rejection. An energy cost increase ratio of 20% and over was rejected or strongly rejected by all the samples. Figure 11.3 depicts the results of the aggregated data listed in table 11.3 and the simulation curves.

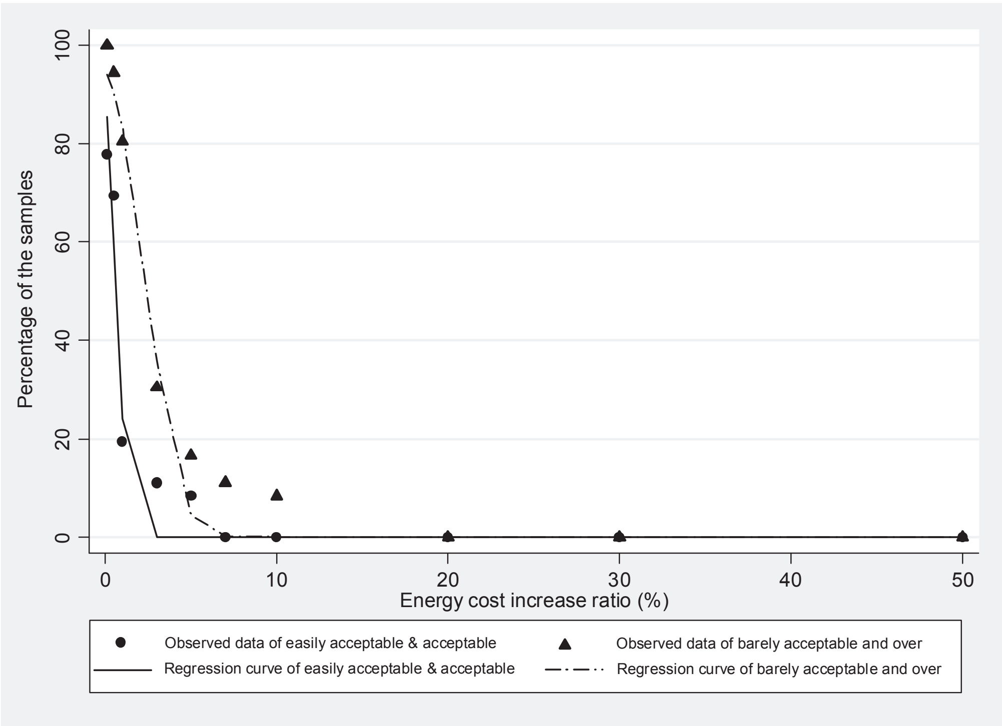

Figure 11.3 Affordability of energy cost increases of all the samples (N=36)

Two groups of data – easily acceptable and acceptable, and barely acceptable and beyond – are shown in the figure because they indicate the rough range of energy cost increase ratios acceptable for the sampled companies. A cumulative normal distribution model was applied for the regressions, with the aggregative shares of the samples as the dependent variable and the energy cost ratios as the independent variable. The R-squared figures for regressions of the two sets of data are 0.9565 and 0.9721, respectively, indicating a good fit between the observed data and regression curves. Affordability on the part of 50% of the samples corresponds to energy cost increase ratios of 0.6% and 2.3% on the two curves. The mean of energy cost increase ratios affordable for the samples may be between 0.6% and 2.3%.

4.1.2 Statistical summary of the affordability for iron & steel companies

Table 11.4 lists the statistics of affordability for samples from the iron & steel industry. At the lowest cost increase ratio of 0.1%, 36.4% of respondents indicated this increase to be too low and easily acceptable, and 45.5% of the companies thought it no problem to accept this increase. Another 18.2% selected 'barely acceptable' for this increase ratio. Therefore, all the respondents could accept this ratio. The share of samples with selections of barely acceptable and beyond dropped to 90.9% when energy cost increased to a ratio of 1.0%. This number drastically fell to 18.2% at the ratio of 3.0%, and 9.1% at the ratio of 7.0%. Less than 10% of the companies thought they could accept an increase ratio of 10.0%. All the surveyed companies rejected the energy cost increase ratio of 20% and over.

Table 11.4 Statistics of affordability responses of iron & steel companies (N=11)

Energy Cost Increase Ratio (%)	Strong Rejection (%)	Rejection (%)	Barely Acceptable (%)	Acceptable (%)	Easily Acceptable (%)	Total (%)
0.1	0.0	0.0	18.2	45.5	36.4	100.0
0.5	0.0	0.0	18.2	81.8	0.0	100.0
1.0	0.0	9.1	81.8	9.1	0.0	100.0
3.0	27.3	54.5	9.1	9.1	0.0	100.0
5.0	54.5	27.3	9.1	9.1	0.0	100.0
7.0	72.7	18.2	9.1	0.0	0.0	100.0
10.0	81.8	9.1	9.1	0.0	0.0	100.0
20.0	81.8	18.2	0.0	0.0	0.0	100.0
30.0	81.8	18.2	0.0	0.0	0.0	100.0
50.0	81.8	18.2	0.0	0.0	0.0	100.0

Figure 11.4 presents the aggregation results of observed data listed in table 11.4 and their regression curves. The R-squared figures for the regressions of two sets of data are 0.9523 and 0.9708, respectively, confirming that the simulations are appropriate. The affordability of 50% corresponds to an energy cost increase ratio of 0.7% and 2.2% on the two curves. This shows a similar affordability range for the iron & steel sector compared with that of all the samples.

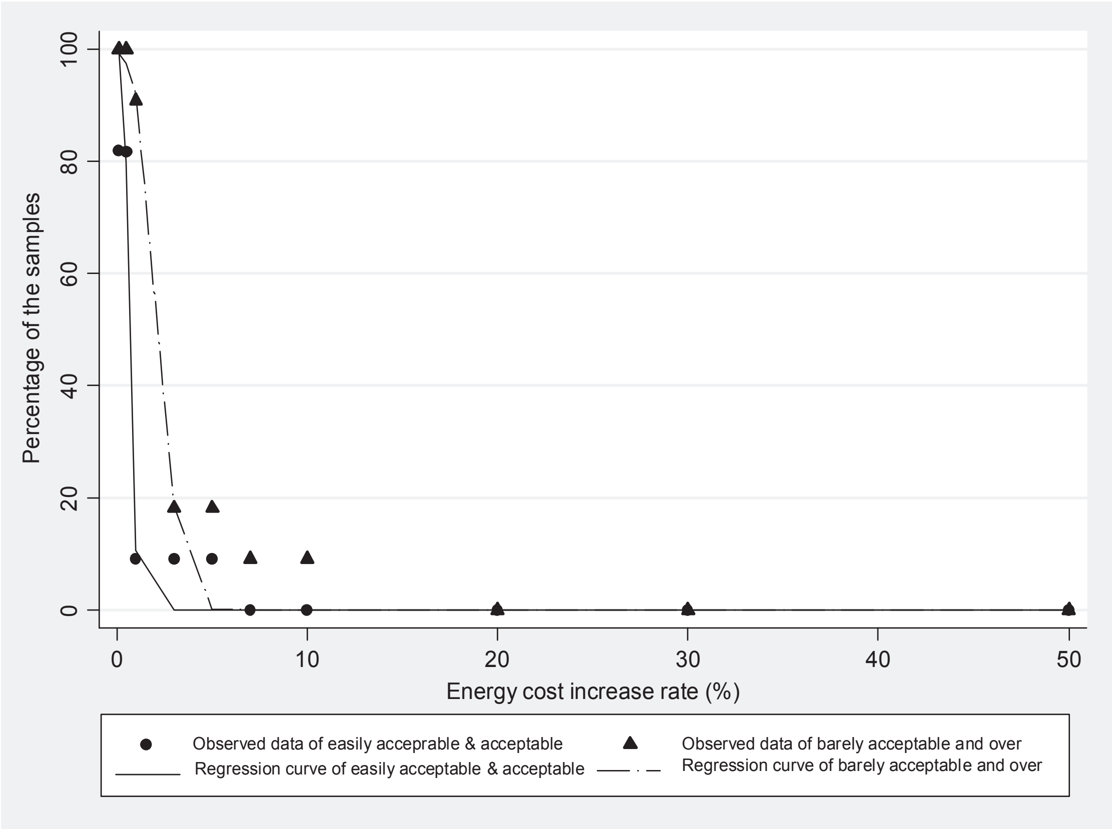

Figure 11.4 Affordability of energy cost increases for the iron & steel industry (N=11)

4.1.3 Statistical summary of the affordability for chemical companies

Table 11.5 shows the statistics of affordability for energy cost increases for samples from the chemical industry. The number of usable respondents in this sector is 20. At the lowest ratio of 0.1%, 15.0% of the respondents indicated the increase to be too low and easily acceptable and 65.0% of the companies indicated it to be no problem for them to afford the increase. Another 20.0% selected 'barely acceptable' for this increase ratio. This result confirms full acceptance of the respondents to this ratio. The share of the samples with selections of barely acceptable and beyond dropped to 75.0% at the increase ratio of 1.0%, and 35.0% at the ratio of 3.0%. The affordability continues to decrease as the energy cost rises. Of the chemical companies, 5% could barely accept an increase ratio of 10.0%; all of them viewed an increase of 20.0% and over to be high and selected the answers of rejection and strong rejection.

Figure 11.5 presents the aggregation results of observed data listed in table 11.5 and their regression curves in the same way. The-R squared for the two regressions is 0.9700 and 0.9775, respectively, indicating the suitability of simulations. The affordability of 50% corresponds to an energy cost increase ratio of 0.7% and 2.5% respectively on the two curves, which is almost the same as that of all the samples in the iron & steel sector.

Table 11.5 Statistics of affordability responses of chemical companies (N=20)

Energy Cost Increase Ratio (%)	Strong Rejection (%)	Rejection (%)	Barely Acceptable (%)	Acceptable (%)	Easily Acceptable (%)	Total (%)
0.1	0.0	0.0	20.0	65.0	15.0	100.0
0.5	0.0	5.0	30.0	55.0	10.0	100.0
1.0	10.0	15.0	50.0	20.0	5.0	100.0
3.0	20.0	45.0	25.0	5.0	5.0	100.0
5.0	35.0	50.0	5.0	10.0	0.0	100.0
7.0	70.0	20.0	10.0	0.0	0.0	100.0
10.0	85.0	10.0	5.0	0.0	0.0	100.0
20.0	90.0	10.0	0.0	0.0	0.0	100.0
30.0	90.0	10.0	0.0	0.0	0.0	100.0
50.0	95.0	5.0	0.0	0.0	0.0	100.0

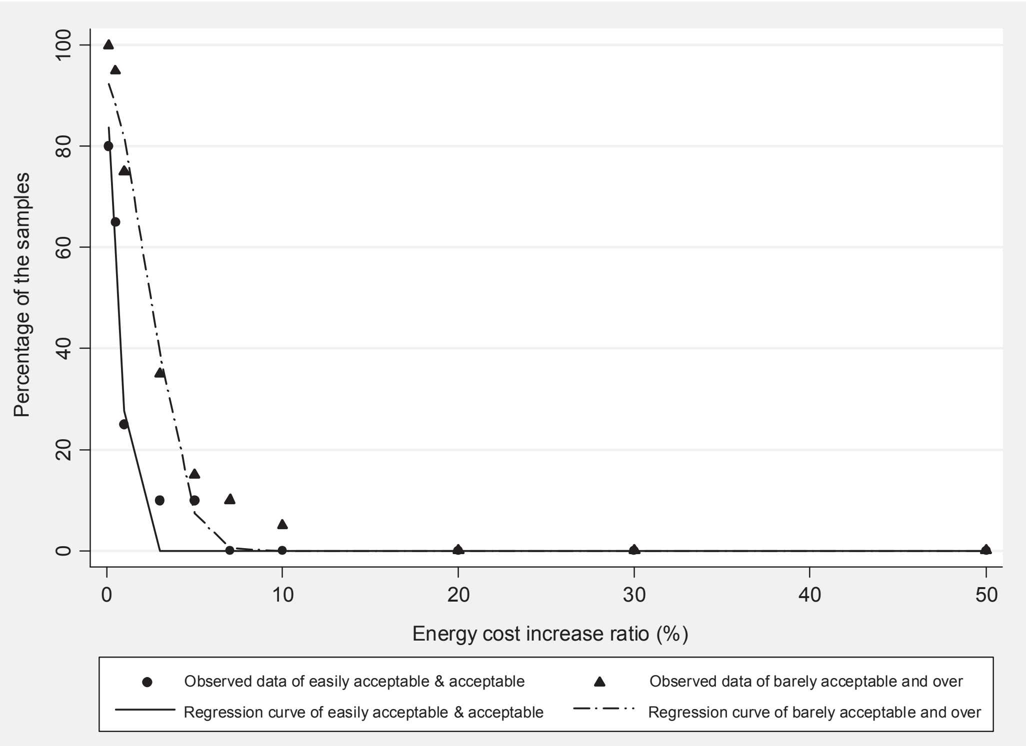

Figure 11.5 Affordability of energy cost increases for the chemical industry (N=20)

4.2 Estimation results of cost affordability for individual companies

The mean and standard variance of affordability of individual companies for energy cost increases was estimated. In this study, a 'strong rejection' was given a probability value of 0.1% since a value of zero would generate infinity in the model estimation. A simple 'rejection' was given a value of 25%, 'barely acceptable' 50% and 'acceptable' 75%. An 'easily acceptable' was presented a value of 99.9% to avoid infinity in the calculation. Table 11.6 lists the mean values and percentiles of all the samples and the respondents from the three target industries.

The mean of energy cost increase ratios affordable for all the surveyed companies is 2.6%, which drops near the range of affordability, 0.6−2.3%, preliminarily observed from fig.11.5. The sample's standard deviation is 3.9%, the medium value of affordability for the companies on energy cost increases is 1.6%, the mean of energy cost increase ratios affordable for chemical companies is 2.6% and the mean for steel companies is 2.5%. The medium values of energy cost increase affordability for companies of chemical and steel sectors are both 1.6%, which is almost the same as that of all the samples. The mean and medium values of energy cost increases affordability for the cement sector are 2.8% and 1.8%, respectively. In comparison with the study conducted in China (Liu et al., 2013), which indicates that a mean of 8.8% in energy cost increase would be acceptable for all the sampled Chinese companies, the affordability of Korean companies is much lower. This may be attributed to perception of Korean companies in their limited energy saving potential, particularly for the energy-intensive industries in this survey.

Table 11.6 Distribution of estimated individual company cost affordability

Variable	Percentile	Centile (%)	95% Conf. Interval (%)	
Panel A: All the samples (N=36)				
	10	0.4	0.1	0.5
Mean of μ: **2.6%**	30	0.7	0.5	1.4
The std. dev. of μ: 3.9%	50	**1.6**	0.9	2.3
	70	2.6	1.7	3.6
	90	9.2	2.8	13.2
Panel B: Samples from iron & steel sector (N=11)				
	10	0.5	0.5	1.0
Mean of μ: **2.5%**	30	0.9	0.5	1.6
The std. dev. of μ: 3.8%	50	**1.6**	0.6	2.4
	70	1.8	1.4	12.7
	90	11.4	1.7	13.3
Panel C: Samples from cement sector (N=5)				
	10	0.1	0.1	1.5
Mean of μ: **2.8%**	30	4.1	0.1	3.9
The std. dev. of μ: 4.3%	50	**1.8**	0.1	8.8
	70	3.9	4.1	8.8
	90	8.8	20.2	8.8
Panel D: Samples from chemical sector (N=20)				
	10	0.3	0.1	0.6
Mean of μ: **2.6%**	30	0.7	0.4	1.6
The std. dev. of μ: 3.8 %	50	**1.6**	0.7	2.7
	70	2.7	1.5	6.7
	90	9.6	2.7	11.3

* Lower (upper) confidence limit held at minimum (maximum) of sample

4.3 Statistics of the determinant factors and controls

Table 11.7 summarises the statistics of determinants as independent variables. The surveyed companies presented moderate scores to ENPRICE (the level of domestic energy prices), with an average of 3.27. COMPETITION achieved a high mean of 4.31, which indicates that the surveyed companies felt strong pressures from market competitors in the same sector. An average score of 3.27 given to ENSTRATEGY implies that companies have moderate motivation to set targets for energy saving. The understanding of companies on energy saving technologies, existing and new, is not optimistic, with EXISTINGTECH and NEWTECH giving means of 2.89 and 3.05, respectively. A mean of 1.89 for the variable of SAVPOTENTIAL reveals that the surveyed companies are using manufacturing technologies at the domestically advanced level and have limited potential for further improvement in energy efficiency. A mean of 2.43 for AVGEDU indicates that the employee education level of the companies is not so high; around 50% of the employees in 30% of the sampled companies have education levels of college and above.

Table 11.7 Statistical summary of the determinant factors

Variable	Obs.	Mean	Std. dev.	Min.	Max.
ENPRICE	62	3.27	0.70	1	5
COMPETITION	62	4.31	0.83	3	5
ENSTRATEGY	62	3.27	1.44	1	5
EXISTINGTECH	62	2.89	0.96	1	5
NEWTECH	62	3.05	0.77	2	5
SAVPOTENTIAL	61	1.89	0.63	1	4
AVGEDU	62	2.43	0.69	1	5

Regarding the characteristics of companies, the distribution of samples by sector and size was described in section 3. The ratios of samples that are domestically private and foreign-funded are 88.7% and 11.3%, respectively.

4.4 Correlation matrix and bi-variable results

Pair-wise correlation was calculated to explore the relationships between the estimated cost affordability, *MEANAFFORD*, and the independent variables. The correlation matrix is shown in table 11.8.

There is no indication for an unacceptable level of multi-collinearity between these variables as the highest correlation coefficient is 0.437 for NEWTECH (Awareness of new energy saving technologies) and EXISTINGTECH (Awareness of existing energy saving technologies). Harmful levels of multi-collinearity are not expected until the correlation coefficient reaches ±0.8 or ±0.9 (Farrar and Glauber, 1967). The correlation result indicates that AVGEDU (Average education level of the company's employees) is significantly but negatively associated with MEANAFFORD at $P<0.1$. The other variables have no significant correlations with the estimated MEANAFFORD.

Table 11.8 Correlation matrix of estimated affordability and the determinants

	MEAN.	ENP.	COM.	ENS.	EXI.	NEW.	SAV.	AVG.
MEANAFFORD	1.000							
ENPRICE	-0.106	1.000						
COMPETITION	0.026	-0.101	1.000					
ENSTRATEGY	-0.081	0.099	0.080	1.000				
EXISTINGTECH	-0.029	-0.131	0.187	0.106	1.000			
NEWTECH	-0.213	-0.230[c]	-0.152	0.257[b]	0.437[a]	1.000		
SAVPOTENTIAL	0.034	-0.359[a]	-0.088	0.019	-0.051	0.048	1.000	
AVGEDU	-0.294[c]	-0.114	0.004	0.072	0.050	0.026	-0.141	1.000

[a] Significant at 1% level; [b] Significant at 5% level; [c] Significant at 10% level

4.5 Multivariate regression results of the estimated affordability

Table 11.9 presents the results of econometric analysis of the estimated affordability of the companies.

Table 11.9 Multivariate regression results of cost affordability for companies

Independent variables and controls		Coefficients with mean affordability as the dependent: Model 1	Model 2	Model 3
ENPRICE		-0.003	-0.009	-0.013*
COMPETITION		-0.001	-0.009	-0.011
ENSTRATEGY			0.001	0.001
EXISTINGTECH			0.002	0.004
NEWTECH			-0.015	-0.017
SAVPOTENTIAL			-0.003	-0.010
AVGEDU			-0.009*	-0.008
SIZE	MEDIUM			0.009
	MLARGE			0.019
	LARGE			0.015
SECTOR	CEMENT			-0.013
	CHEMICAL			-0.009
OWNERSHIP	FOREIGN			0.033*
	TMS			0.026
Obs.		36	35	35
R Squared		0.011	0.192	0.349

* Significant at 10%

The robustness of the analysis results was tested by repeating the regression with gradual introduction of the independent variables and controls. It is indicated that the energy price level and company ownership are significantly associated with affordability. Compared with the domestically private companies, the foreign-funded ones have a higher affordability for energy cost increases. All the other determinant factors and controls, including the company's sector belongings and size, have no significant effect on the estimated cost affordability.

4.6 Carbon prices affordable for the companies by sector

Using the mean of affordable ratios of energy cost increases, *MEANAFFORD*, the surveyed ratios of energy uses of the companies by type, carbon prices affordable for the respondents can be calculated by the below equation.

$$Affordable\ carbon\ price = MEANAFFORD \times \frac{\sum_i Energy\ price_i \times Energy\ ratio_i}{\sum_i Emission\ factor_i \times Energy\ ratio_i}$$

The data sources and calculation results are listed in table 11.10. The calculation results reveal that a carbon price of 2,500 to 4,000 KRW/t-CO_2 (about 2.3 to 3.5 USD/t-CO_2; 1 USD = 1,131 KRW as of March of 2012) would be acceptable for the surveyed companies. This figure is much lower than the carbon tax rate previously proposed in the study of Kwon and Heo (2010), who suggested a carbon tax equivalent to 36,545 KRW/t-CO_2 (about 31 USD/t-CO_2) for achieving the medium-term mitigation target of Korea. On the other hand, a recent report from KIPF recommended that the carbon tax be introduced at a lower rate in the early stage considering its short-term negative impact on industrial competitiveness and company acceptance (Kim and Kim, 2010). Kim and Kim (2010) suggested a carbon tax rate at the level of 1/8 that first proposed by KIPF (Kim et al., 2008), which was 25 EURO/t-CO_2 (equivalent to 31,328 KRW/t-CO_2). The estimated carbon price affordable for the companies in this study is similar to the tax rate proposed by KIPF, which confirms that the latest carbon tax proposal of KIPF, particularly in terms of the tax rate, would be acceptable for the Korean companies.

Table 11.10 Estimations of affordable carbon prices by sector

Energy type	Energy use ratios (%)			Current energy price[*1]	Emission factor[*3]
	Iron & steel	Cement	Chemical		
Electricity	64.0	29.3	51.3	73.69 KRW/KWh	1.428 t-C/toe[*4]
Coal	3.6	36.9	0.5	113,138 KRW/t	1.059 t-C/toe
Fuel oil	5.2	1.6	10.0	612,352 KRW/t	0.875 t-C/toe
Gas	24.8	8.2	15.5	552 KRW/m^3	0.637 t-C/toe
Steam	0.2	0	15.7	30,000 KRW/t[*2]	0.3231 t-C/toe
MEANAFFORD	2.5%	2.8%	2.6%	Data sources:	
Affordable carbon price (KRW/t-CO_2)	3,770	2,600	3,950	[*1] IEA (2010); [*2] International Journal; [*3] IPCC; [*4] Kim (2006).	

5. Conclusions

This study extended application of the MBDC technique to estimate the affordability of Korean companies from energy-intensive industries for energy cost increases due to possible introduction of market-based climate policies. The results indicate that a mean energy cost increase of 2.6% would be acceptable for the respondents as a whole. Further, the affordability of the companies is roughly equal across all three sectors, with the range of acceptable energy cost increase being 2.6–2.8%. The econometric analysis confirms the energy price level and ownership as the determinants significantly affecting the cost affordability for the companies. These calculation results for the affordable carbon prices for companies may be used as a referendum to develop a carbon tax policy and establish domestic ETS in Korea.

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Chapter 12:

Affordability of energy cost increases for Japanese companies due to climate policies: A survey in Hyogo, Japan

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Chapter Highlights:

- This chapter provides an analysis of acceptability of Japanese companies on energy cost increases originated from economic climate policies using the data collected from 230 respondents based in Hyogo Prefecture.
- A mean climate policy-originated energy cost increase of 2.3% would be acceptable for the samples overall; that for chemical companies is slightly higher at 3.1% while that for the iron and steel industry is lower, at 1.5%.
- Acceptable energy cost increases affordable for the companies based on the above means equate to a carbon price of 5–13 USD/t-CO_2.
- This survey analysis confirms that the pricing of carbon emissions has been practiced in Japan within the affordability of the surveyed companies.

1. Introduction

As an economic policy, energy-related taxes have been levied in Japan for many years. The decision to put the 'Global Warming Countermeasure Tax' (or the 'Environmental Tax') into motion starting 1 October 2012 was encouraging, with a tax rate of 289 JPY/t-CO_2. This tax was designed to be introduced in three phases. Initially, one-third of the rate described above is levied for various fuels, the second third will be added on 1 April 2014, and the taxes will be fully imposed on 1 April 2016. At the household level, this will mean an approx. 100 JPY per month increase on average after full introduction of the tax. This tax is expected to realise a 0.5–2.2% reduction in the country's 2020 GHG emissions from the 1990 levels, equivalent to 6–24 million tonnes of CO_2 (Mt-CO_2) (MOEJ, 2012).

Japan's national government has attempted to establish a domestic market for GHG emissions on trial. The experimental market admits credits from various mechanisms, including Japan's Voluntary Emissions Trading Scheme (J-VETS), domestic ETS on trial, Japan's Verified Emission Reduction (J-VER) and the Kyoto mechanisms (Liu et al., 2012). A total of 357 companies joined J-VETS, which successfully led to a 947,670 t-CO_2 reduction in 2009, equivalent to 28% of their base year emissions. The traded amount was 57,930 t-CO_2 at an average price of 750 JPY/t-CO_2 (MOEJ, 2011). For the domestic GHG ETS on trial, the participating companies may voluntarily set their reduction targets in terms of absolute amount or emissions intensity. In 2009, 60 participants successfully realised their targets by self-reductions; another 30 companies with insufficient self-reductions achieved their targets by borrowing future allowances or buying credits from the market. These companies opted for Kyoto credits and 10 of them purchased 52.28 Mt-CO_2 (83.5% of the total insufficient amount) from Kyoto mechanisms (MOEJ, 2011). J-VER, initiated in November 2008, permits large companies to provide technological or financial assistance to SMEs and receive the VERs to offset their emissions. As of May 2011, 106 companies had registered in this scheme, 63 projects of which were verified with a total of 111,976 t-CO_2 (MOEJ, 2011) of VERs. Establishing a domestic GHG ETS is recognised as one of the three bulwarks against global warming in Japan; however, this policy has been blocked in practice (Reuters, 2010).

Aiming to support further progress in carbon taxes and GHG ETS in Japan, this research estimates the affordability of companies on energy cost increases due to the pricing of GHG emissions. Hyogo prefecture, the base of our research centre, was selected as the study area. This chapter covers two main topics: one is the estimation of policy cost affordability of companies in form of energy cost increase ratios and the other is identifying the determinant factors affecting the estimated cost affordability.

The remainder of this chapter is structured as follows: Section 2 explains the methodologies, including the models for estimating the company's cost affordability by multiple-bounded discrete choice (MBDC) data and the analytical framework for identifying the determinants of the cost affordability, section 3 outlines the distribution of samples, section 4 discusses the results of estimations and econometric analysis and section 5 concludes the research findings.

2. Methodologies

2.1 MBDC format and the analytical framework in this study

Similarly with our earlier study of Chinese companies in chapter 10, an MBDC questionnaire was applied to estimate affordability of Japanese companies for energy costs increases due to the pricing of carbon emissions (Liu et al., 2013a; 2013b). The question and format prepared for the surveyed companies and an example response are shown in fig.12.1. The companies are presented with an ascending sequence of 12 thresholds of energy cost increases, but instead of circling a single value or interval, they are presented with multiple choice options: 'easily acceptable', 'acceptable', 'barely acceptable', 'rejection' and 'strong rejection'. The models for estimating company affordability of energy cost increases are the same as in chapter 10.

An econometric analysis was carried out to identify the relationships between the estimated affordability of companies on energy cost increases with the determinant factors, including company characteristics. The analytical framework for this analysis is depicted in fig.12.2. Two external pressures were selected. One is the energy price pressure felt by the companies, and the other is the strength of market competition. Four internal factors were identified. One is the energy saving strategy of companies, indicating the awareness of and willingness to improve in energy management. The second is the awareness of companies of energy saving technologies, existing and new. Energy saving potential is categorised as the third internal factor. The last internal factor is a company's learning capacity – the proxy for this factor being the training of employees specific for energy saving. Regarding the company's characteristics, we selected organisational size and sector belongings.

Question: The energy prices would be increased in the case of introducing and implementing market-based climate polices, such as imposing a tax as anti-measure for globe warming or establishing a domestic GHG emissions trading scheme. Accordingly, the industrial company's energy consumption cost would be increased. We would like to understand the viewpoint of your company to energy cost increases due to the intervention of carbon pricing policies. Please circle one letter for each increase ratio in the following table to indicate the affordability degree of your company.

Energy cost increase ratio (%)	Your company's choice				
	Very low; Easily acceptable	Not high; Acceptable	Moderate; Barely acceptable	High; Rejection	Very high; Strongly rejection
0.1	Ⓐ	B	C	D	E
0.3	Ⓐ	B	C	D	E
0.5	Ⓐ	B	C	D	E
0.7	A	Ⓑ	C	D	E
1.0	A	B	Ⓒ	D	E
3.0	A	B	C	Ⓓ	E
5.0	A	B	C	D	Ⓔ
7.0	A	B	C	D	Ⓔ
10.0	A	B	C	D	Ⓔ
20.0	A	B	C	D	Ⓔ
30.0	A	B	C	D	Ⓔ
50.0	A	B	C	D	Ⓔ

Figure 12.1 Question and example response of MBDC format in this survey

2.2 Valuation of the variables

The dependent for the econometric analysis is the estimated mean of affordability for companies. The abbreviation, description and valuation of determinant factors as independents and company characteristics as controls are listed in table 12.1.

A five-point scale was applied to evaluate the two external pressures, ENPRICE and COMPETITION, company energy saving strategy (AWARENESS and WILLINGNESS) and awareness of energy saving technologies (AWAREEXTTECH and AWARENEWTECH), with '1' = very low; '2' = relatively low; '3' = moderate; '4' = relatively high; and, '5' = very high. A four-level point was applied to the level of a company's energy saving potential, SAVPOTENTIAL, with '1' = almost no potential; '2' = limited potential; '3' = large potential; and, '4' = very high potential. The training of employees for energy saving, TRAINING, was used as the proxy for a company's learning capacity. Five categories were applied, with '1' = never arranged training for the employees in the past; '2' = 1 to 3 times per year; '3' = 4 to 6 times per year; '4' = 7 to 12 times per year; and, '5' = over 12 times per year.

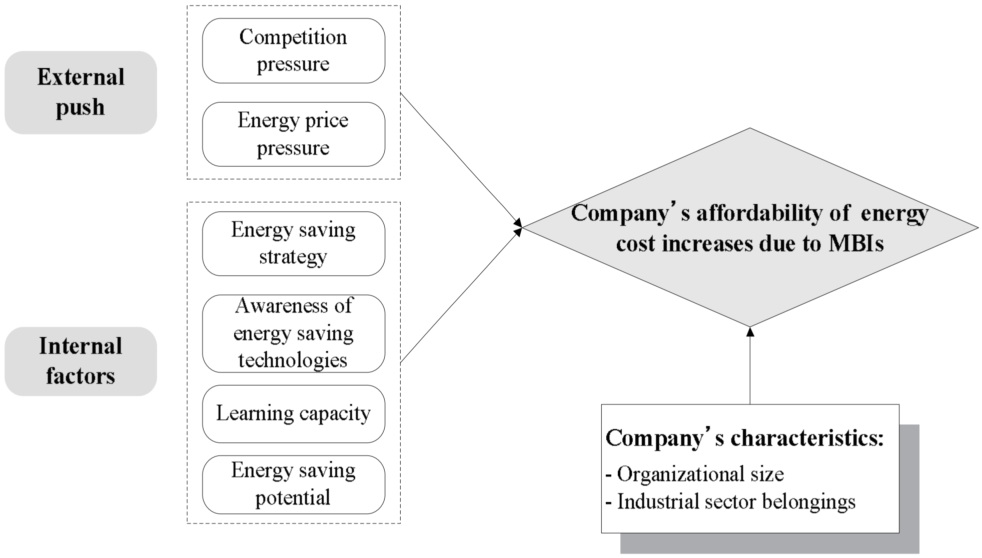

Figure 12.2 Analytical framework for the econometric analysis of cost affordability

Table 12.1 Abbreviation, description and valuation of independent variables and controls

Category	Abbreviation	Description	Valuation
External pressures	ENPRICE	Perception of domestic energy price levels	A five-point scale applied:
	COMPETITION	Competition degree of the company's sales market	1: very low
Internal factors	AWARENESS	Company's awareness of internal energy management problems	2: relatively low
	WILLINGNESS	Company's willingness for improving energy efficiency	3: moderate
	AWAREEXTTECH	Company's awareness of existing energy saving technologies	4: relatively high;
	AWARENEWTECH	Company's awareness of new energy saving technologies	5: very high
	SAVPOTENTIAL	The level of energy saving potential of the company	A four-level point applied
	TRAINING	Training of company's employees for energy saving	A five-level point applied
Controls	SIZE	The organisational size	Two types applied
	SECTOR	Industrial sector to which the company belongs	Five types applied

For the controls, company size is classified into two types, small and medium-sized and large, respectively written as SME and LARGE. Company sectors are categorised into five types: food processing, chemical, iron & steel, electronics and other, which are individually named as FOOD, CHEMICAL, STEEL, ELECTRONICS and OTHER.

2.3 Econometric model

The model capturing the relationship between the company's mean affordability, abbreviated as *MEANAFFORD*, and the identified variables can be written as the equation below, where ε is the error term and β_0 is the constant.

$$\begin{aligned} MEANAFFORD = \beta_0 + \beta_1 ENPRICE + \beta_2 COMPETITION + \beta_3 AWARENESS \\ + \beta_4 WILLINGNESS + \beta_5 AWAREEXTTECH + \beta_6 AWARENEWTECH \\ + \beta_7 SAVPOTENTIAL + \beta_8 TRAINING + \beta_9 SIZE + \beta_{10} SECTOR + \varepsilon \end{aligned}$$

3. Outline of the survey and samples

The dataset for this analysis was collected by the same questionnaire survey as for chapters 6 and 9. The format consists of six components: general information of the company; company energy use and management status; company energy saving practices; barriers hindering company investments in energy saving technologies; awareness and acceptability degrees of energy saving policies; and, company affordability for alternative energy cost increases. This chapter describes the estimation of company affordability for policy-originated energy cost increases and the factors affecting such.

A total of 230 respondents were confirmed to be valid for this analysis. The distribution of useful samples by sector and organisational size is listed in table 12.2. Samples from food processing, chemical, iron & steel and electronics industries individually account for 18.3%, 13.0%, 8.7% and 10.9% of the total. The remaining 49.1% are the respondents from other various but minor sectors. Of the 230 samples only 4 are small companies having a staff of less than 20, 62 are large companies, with more than 300 employees and a registered capital of over 300 million JPY, and the remaining 164 are medium-sized companies.

Table 12.2 Distribution of valid respondents by sector and size

Sector	Size			Number in total
	Small	Medium	Large	(%)
Food processing	0	32	10	42 (18.3)
Chemical	0	24	6	30 (13.0)
Iron & steel	0	12	8	20 (8.7)
Electronics	0	12	13	25 (10.9)
Other	4	84	25	113 (49.1)
Number in total (%)	4 (1.7)	164 (71.3)	62 (27.0)	230 (100.0)

4. Results and discussions

4.1 Affordability of energy cost increases for companies

The affordability of energy cost increases for companies was monitored by the MBDC card.

Twelve thresholds of energy cost increase ratios are listed for the companies to circle their acceptability degree for each. The reliability of this measurement was tested by the calculation of Cronbach's alpha, which revealed an all-sample alpha of 0.8972 and over 0.70, confirming the reliability of the dataset by the criteria of Nunnally and Bernstein (1994).

4.1.1 Statistics of cost affordability of all the samples

Table 12.3 lists statistics of affordability of all the respondents for energy cost increase ratios in the MBDC format. A total of 153 companies provided fully circled answers, which were used for the statistics. At the lowest cost increase ratio of 0.1%, 32.7% of companies indicated that this increase is very low and easily acceptable for them; 46.4% of the respondents expressed no problem to afford this increase; and the remaining 20.9% selected 'barely acceptable'. In summary, all the respondents could afford this increase. The share of companies with acceptance degrees of barely acceptable and beyond dropped to 84.3% at the increase ratio of 1.0% and further dropped to 47.1% at the ratio of 3.0%. The ratios of companies with affordability degrees of 'barely acceptable' and over continue to decrease with the rise in energy cost. More than 75% of the companies viewed an increase of 5.0% to be high and circled rejection or strong rejection. Almost all the companies would strongly reject or reject an energy cost increase of 10.0%.

Table 12.3 Statistics of affordability responses of all the samples (N=153)

Energy cost increase ratio (%)	Strong rejection (%)	Rejection (%)	Barely acceptable (%)	Acceptable (%)	Easily acceptable (%)	Total (%)
0.1	0.0	0.0	20.9	**46.4**	**32.7**	100.0
0.3	0.0	0.0	25.5	**52.3**	**22.2**	100.0
0.5	0.0	1.3	**39.9**	**43.8**	**15.0**	100.0
0.7	0.0	8.5	**47.7**	**33.3**	10.5	100.0
1.0	0.0	15.7	**56.9**	**20.9**	6.5	100.0
3.0	**7.2**	**45.8**	**34.6**	**11.8**	0.7	100.0
5.0	**25.5**	**51.6**	21.6	1.3	0.0	100.0
7.0	**48.4**	**45.8**	5.2	0.7	0.0	100.0
10.0	**77.8**	**20.3**	2.0	0.0	0.0	100.0
20.0	96.1	3.9	0.0	0.0	0.0	100.0
30.0	98.7	1.3	0.0	0.0	0.0	100.0
50.0	99.3	0.7	0.0	0.0	0.0	100.0

Figure 12.3 depicts the results of aggregated data in table 12.3 and the simulation curves. Two groups of data, easily acceptable and acceptable, and barely acceptable and beyond, are shown because they are meaningful for isolating the range of energy cost increase ratios acceptable for the samples. A reversed cumulative normal distribution model was applied for the simulations,

with the aggregative shares of samples as the dependent and energy cost ratios as the independent. The R-squared figures for regressions of the two sets of data are 0.9833 and 0.9903 respectively, indicating a good fit between the observed data and regression curves. Affordability on the part of 50% of samples corresponds to energy cost increase ratios of 0.6% and 3.2% on the two curves. The mean of energy cost increase ratios affordable for the samples is therefore between 0.6% and 3.2%.

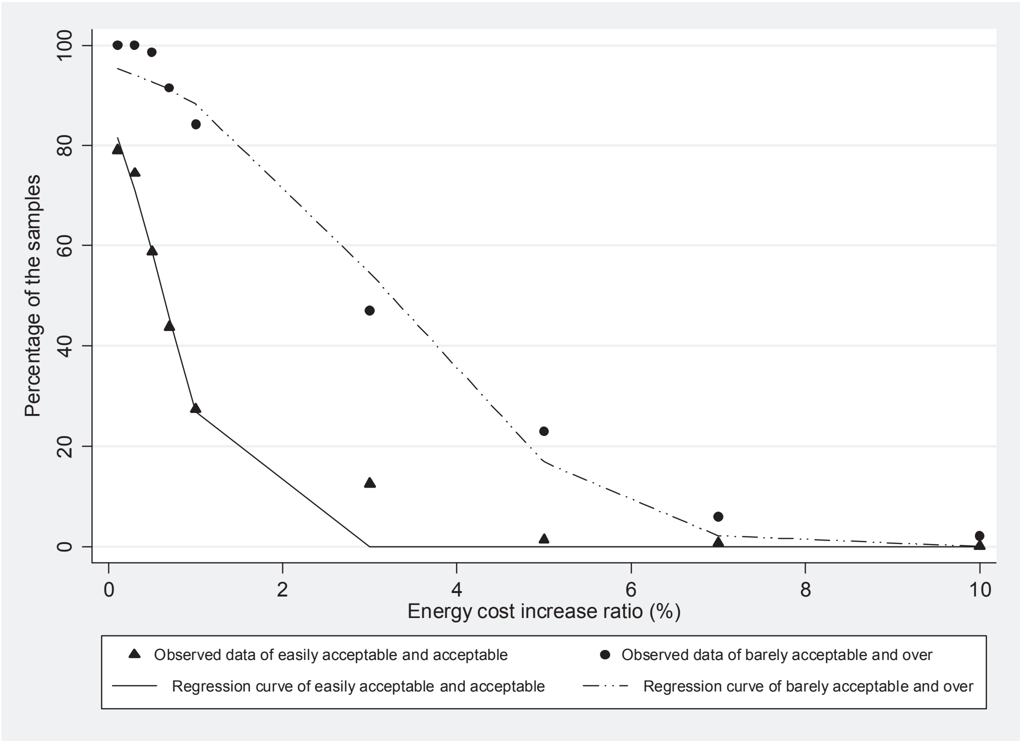

Figure 12.3 Affordability of energy cost increases of all the samples (N=153)

4.1.2 Statistical summary of the affordability for food processing companies

Table 12.4 lists the statistics of affordability for the samples from the food processing industry. At the lowest cost increase ratio of 0.1%, 27.6% of the respondents indicated the increase to be too low and easily acceptable, and 58.6% of the companies thought it no problem to accept this increase. The remaining 13.8% selected 'barely acceptable'. Therefore, all the respondents could accept this ratio. The share of samples with selections of barely acceptable and beyond dropped to 89.7% when energy cost increased to a ratio of 1.0%. This share became 44.8% at the ratio of 3.0%. More than 80% of food processing companies viewed an increase of 5.0% to be high and selected rejection or strong rejection. All of them would strongly reject or reject an energy cost increase of 10.0%.

Figure 12.4 presents the aggregated results of observed data in table 12.4 and their regression curves. The R-squared for the regressions of the two sets of data is 0.9932 and 0.9935 respectively, confirming that the simulations are appropriate. The affordability of 50%

corresponds to an energy cost increase ratio of 0.6% and 3.0% on the two curves. This shows that the affordability range of the food processing sector almost equates to that of all the samples.

Table 12.4 Statistics of affordability responses of food processing companies (N=29)

Energy cost increase ratio (%)	Strong rejection (%)	Rejection (%)	Barely acceptable (%)	Acceptable (%)	Easily acceptable (%)	Total (%)
0.1	0.0	0.0	13.8	**58.6**	**27.6**	100.0
0.3	0.0	0.0	20.7	**58.6**	**20.7**	100.0
0.5	0.0	0.0	**37.9**	**51.7**	**10.3**	100.0
0.7	0.0	10.3	**51.7**	**31.0**	6.9	100.0
1.0	0.0	10.3	**69.0**	**17.2**	3.4	100.0
3.0	3.4	**51.7**	**37.9**	**6.9**	0.0	100.0
5.0	27.6	**55.2**	17.2	0.0	0.0	100.0
7.0	**48.3**	**48.3**	3.4	0.0	0.0	100.0
10.0	**86.2**	**13.8**	0.0	0.0	0.0	100.0
20.0	100.0	0.0	0.0	0.0	0.0	100.0
30.0	100.0	0.0	0.0	0.0	0.0	100.0
50.0	100.0	0.0	0.0	0.0	0.0	100.0

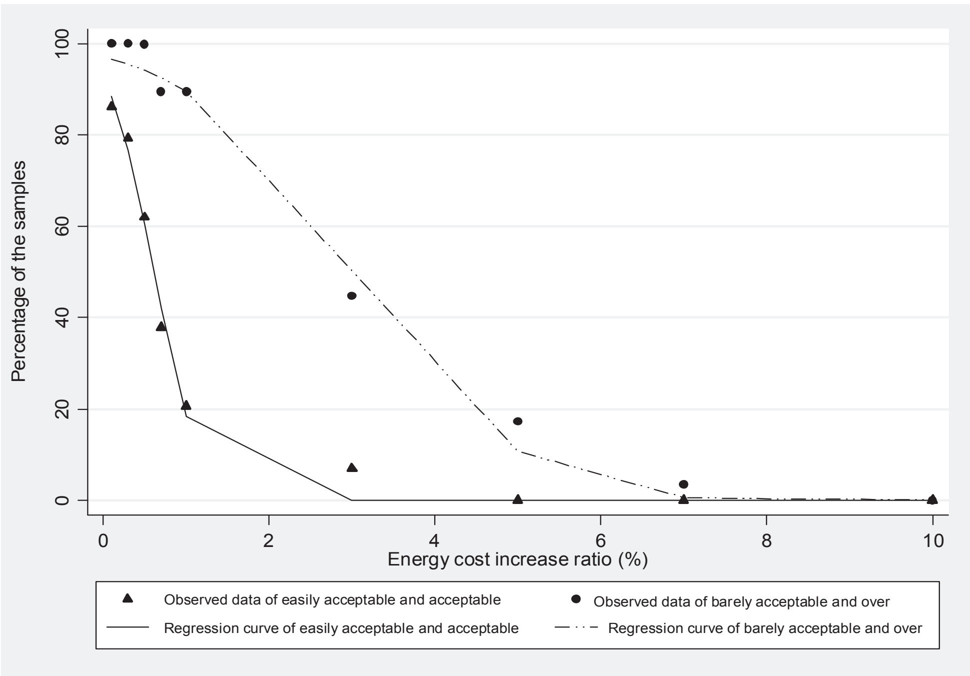

Figure 12.4 Affordability of energy cost increases of food processing companies (N=29)

4.1.3 Statistical summary of the affordability for chemical companies

Table 12.5 shows the statistics of affordability for samples from the chemical industry to energy cost increases. The number of usable respondents in this sector is 26. At the lowest cost increase ratio of 0.1%, 30.8% of the respondents indicated this increase to be too low and easily acceptable and 46.2% of the companies indicated no problem for them to afford this ratio. Another 23.1% selected the option of 'barely acceptable'. This confirms the acceptance of all the respondents from this sector for this increase. The share of samples with selections of barely acceptable and beyond dropped to 84.6% at the increase ratio of 1.0%, and fell quickly to 53.8% at the ratio of 3.0%. The affordability continues to decrease as the energy cost rises. Nearly 90% of the chemical companies viewed an increase of 7.0% to be too high and selected the answer of rejection or strong rejection. Figure 12.5 presents the aggregated results of observed data listed in table 12.5 and their regression curves. The R-squared figures for the two regressions are 0.9451 and 0.9866, respectively, indicating the suitability of simulations. The affordability of 50% corresponds to an energy cost increase of 1.2% and 3.8% respectively on the two curves.

4.1.4 Statistical summary of the affordability for iron & steel companies

Table 12.6 shows the statistics of affordability for samples from the iron & steel industry to energy cost increases. The number of usable respondents in this sector is only 11. At the lowest ratio of 0.1%, 27.3% of the respondents indicated the increase to be too low and easily acceptable and 27.3% of the companies indicated no problem for them to afford this increase. The remaining 45.5% of respondents selected 'barely acceptable' for this ratio. The share of the samples with selections of barely acceptable and beyond is maintained at 100.0% until the increase ratio of 1.0% but then suddenly drops to 18.2% at the ratio of 3.0%. More than 90% of iron & steel companies viewed an increase of 5.0% to be too high and selected rejection or strong rejection.

Table 12.5 Statistics of affordability responses of chemical companies (N=26)

Energy cost increase ratio (%)	Strong rejection (%)	Rejection (%)	Barely acceptable (%)	Acceptable (%)	Easily acceptable (%)	Total (%)
0.1	0.0	0.0	23.1	**46.2**	**30.8**	100.0
0.3	0.0	0.0	23.1	**50.0**	**26.9**	100.0
0.5	0.0	3.8	**38.5**	**34.6**	**23.1**	100.0
0.7	0.0	7.7	**42.3**	**26.9**	**23.1**	100.0
1.0	0.0	15.4	**46.2**	**26.9**	11.5	100.0
3.0	7.7	**38.5**	**26.9**	**23.1**	3.8	100.0
5.0	**23.1**	**42.3**	26.9	7.7	0.0	100.0
7.0	**42.3**	**46.2**	7.7	3.8	0.0	100.0
10.0	**73.1**	**19.2**	7.7	0.0	0.0	100.0
20.0	92.3	7.7	0.0	0.0	0.0	100.0
30.0	96.2	3.8	0.0	0.0	0.0	100.0
50.0	100.0	0.0	0.0	0.0	0.0	100.0

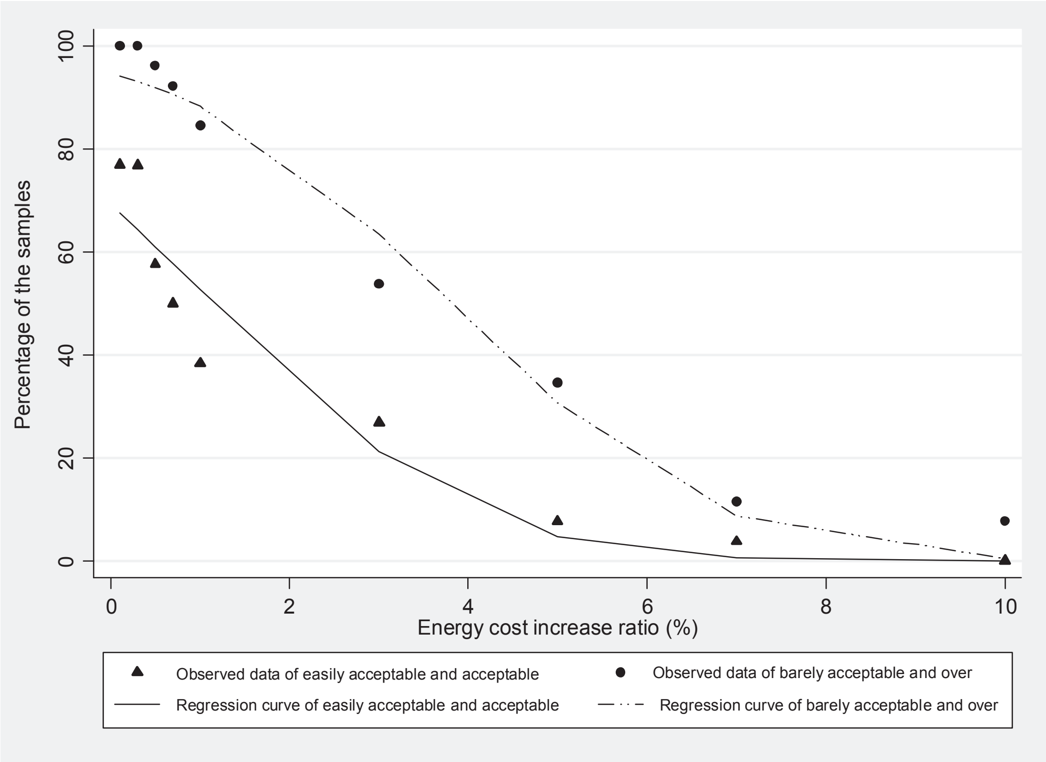

Figure 12.5 Affordability of energy cost increases of chemical companies (N=26).

Table 12.6 Statistics of affordability responses of iron & steel companies (N=11)

Energy cost increase ratio (%)	Strong rejection (%)	Rejection (%)	Barely acceptable (%)	Acceptable (%)	Easily acceptable (%)	Total (%)
0.1	0.0	0.0	45.5	**27.3**	**27.3**	100.0
0.3	0.0	0.0	45.5	**36.4**	**18.2**	100.0
0.5	0.0	0.0	**45.5**	**45.5**	**9.1**	100.0
0.7	0.0	0.0	**72.7**	**27.3**	0.0	100.0
1.0	0.0	0.0	**90.9**	9.1	0.0	100.0
3.0	0.0	**81.8**	18.2	0.0	0.0	100.0
5.0	9.1	**81.8**	9.1	0.0	0.0	100.0
7.0	**54.5**	**45.5**	0.0	0.0	0.0	100.0
10.0	**90.9**	9.1	0.0	0.0	0.0	100.0
20.0	100.0	0.0	0.0	0.0	0.0	100.0
30.0	100.0	0.0	0.0	0.0	0.0	100.0
50.0	100.0	0.0	0.0	0.0	0.0	100.0

Figure 12.6 presents the aggregation results of observed data in table 12.6 and their regression curves. The R-squared figures for the two regressions are 0.9463 and 0.9970, respectively,

indicating the suitability of simulations. An affordability of 50% corresponds to an energy cost increase ratio of 0.3 % and 2.6% respectively on the two curves.

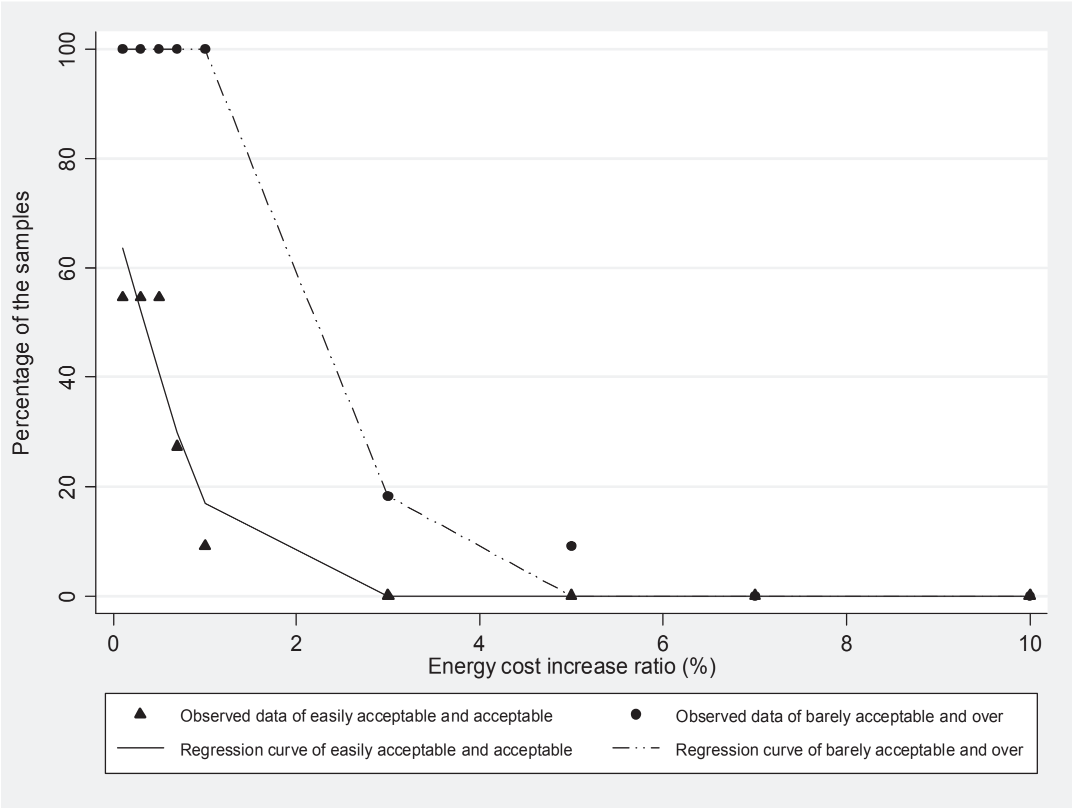

Figure 12.6 Affordability of energy cost increases of iron & steel companies (N=11)

4.1.5 Statistical summary of the affordability for electronics companies

Table 12.7 shows the statistics of affordability for samples from the electronics industry to energy cost increases. The number of usable respondents in this sector is only 12. At the lowest cost increase ratio of 0.1%, 33.3% of respondents indicated the increase to be very low and easily acceptable and 58.3% of the companies indicated no problem for them to afford this increase. Another 8.3% of the samples selected ‘barely acceptable’. This shows the full acceptance of the respondents for this ratio. The share of the samples with selections of barely acceptable and beyond dropped to 83.3% at the increase ratio of 1.0%, and 50.0% at the ratios of 3.0%. More than 80% of the electronics companies viewed an increase of 5.0% to be too high and selected rejection or strong rejection.

Figure 12.7 presents the aggregation results of observed data listed in table 12.7 and their regression curves. The R-squared for the two regressions is 0.9951 and 0.9877 respectively, indicating the suitability of simulations. The affordability of 50% corresponds to an energy cost increase ratio of 0.8% and 3.1% respectively on the two curves.

Table 12.7 Statistics of affordability responses of electronics companies (N=12)

Energy cost increase ratio (%)	Strong rejection (%)	Rejection (%)	Barely acceptable (%)	Acceptable (%)	Easily acceptable (%)	Total (%)
0.1	0.0	0.0	8.3	**58.3**	**33.3**	100.0
0.3	0.0	0.0	16.7	**66.7**	**16.7**	100.0
0.5	0.0	0.0	**25.0**	**66.7**	**8.3**	100.0
0.7	0.0	8.3	**33.3**	**50.0**	**8.3**	100.0
1.0	0.0	16.7	**50.0**	**25.0**	8.3	100.0
3.0	8.3	**41.7**	**41.7**	**8.3**	0.0	100.0
5.0	**16.7**	**66.7**	16.7	0.0	0.0	100.0
7.0	**41.7**	**50.0**	8.3	0.0	0.0	100.0
10.0	**83.3**	8.3	8.3	0.0	0.0	100.0
20.0	91.7	8.3	0.0	0.0	0.0	100.0
30.0	100.0	0.0	0.0	0.0	0.0	100.0
50.0	100.0	0.0	0.0	0.0	0.0	100.0

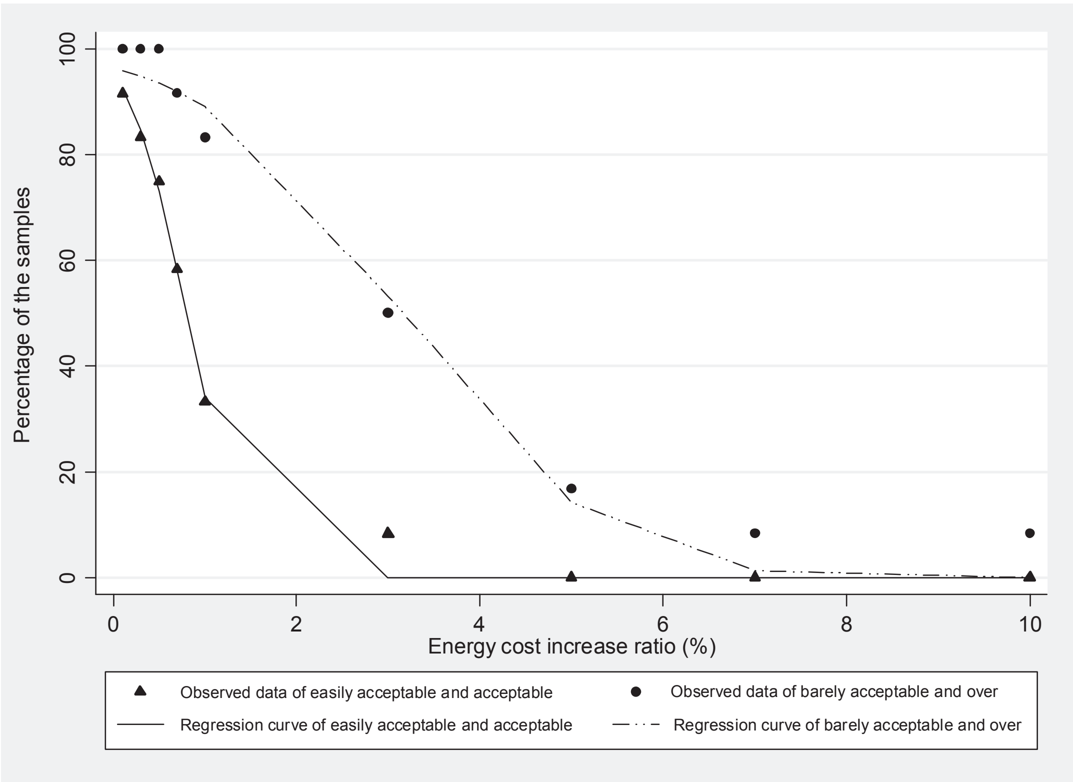

Figure 12.7 Affordability of energy cost increases of electronics companies (N=12)

4.2 Estimations of cost affordability for individual companies

The mean and standard variance of affordability of each company for energy cost increases was estimated. A one-way analysis of variance (ANOVA) was conducted to find whether differences exist between the means of affordable energy cost increases for the two groups of samples, collected in cooperation with the environmental association and Hyogo government. The F value is 1.98 and no statistically significant difference was found. Table 12.8 lists the means and percentiles of all the samples and the four sectors.

Table 12.8 Distribution of estimated cost affordability of individual companies

Variable	Percentile	Centile (%)	95% confidence interval (%)	
Panel A: All the samples (N=153)				
	10	0.4	0.4	0.5
Mean of μ: **2.3%**	30	0.6	0.5	0.9
Mean of std. dev. of μ: 3.7%	50	**1.9**	1.2	2.3
	70	2.9	2.7	3.5
	90	5.3	4.7	5.5
Panel B: Samples from food processing sector (N=29)				
	10	0.5	0.4	0.8[a]
Mean of μ: **2.0%**	30	0.9	0.6	1.6
Mean of std. dev. of μ: 3.7%	50	**1.7**	1.1	2.3
	70	2.5	1.8	3.8
	90	4.3	2.8	5.3[a]
Panel C: Samples from chemical sector (N=26)				
	10	0.5	0.4	0.5[a]
Mean of μ: **3.1%**	30	0.5	0.5	2.5
Mean of std. dev. of μ: 4.2%	50	**2.6**	0.6	4.3
	70	4.8	2.8	5.7
	90	7.4	5.0	12.0[a]
Panel D: Samples from iron & steel sector (N=11)				
	10	0.4	0.4	0.5[a]
Mean of μ: **1.5%**	30	0.5	0.4	1.9
Mean of std. dev. of μ: 3.1%	50	**1.6**	0.5	2.2
	70	2.0	0.6	4.2
	90	4.0	2.0	4.3[a]
Panel E: Samples from electronics sector (N=12)				
	10	0.3	0.2	1.1[a]
Mean of μ: **2.6%**	30	1.1	0.2	2.7
Mean of std. dev. of μ: 3.7%	50	**2.5**	0.9	3.1
	70	2.8	2.0	7.6
	90	7.3	2.8	8.1[a]

[a] Lower (upper) confidence limit held at minimum (maximum) of sample

The mean of energy cost increase ratios affordable for all the surveyed companies is 2.3%, based on a range of 0.6% to 3.2%, preliminarily observed from fig.12.3. The sample's standard deviation is 3.7%. The medium value of affordability of companies on energy cost increases is 1.9%. Comparatively, the companies in the chemical sector have a mean energy cost increase affordability of 3.1%, slightly higher than the samples as a whole. The mean of iron & steel companies is 1.5%, lower than that of all the samples. The standard deviation of affordability for chemical and iron & steel sectors is 4.2% and 3.1%, respectively. The food processing and electronics industries have a mean of affordability similar to that of the surveyed companies overall.

4.3 Statistics of the determinant factors and controls

Table 12.9 summarises the statistics of determinants as independents. The surveyed companies presented higher scores to COMPETITION (The level of market competition), with an average of 4.25. ENPRICE (The level of domestic energy prices) achieved another higher mean of 4.12, which indicates that the companies felt strong pressure from energy prices and their competitors. Average scores of 3.75 and 4.30 were respectively given to AWARENESS and WILLINGNESS, implying that companies are well aware of their internal energy management problems and have strong motivation for energy-saving. Company awareness of energy-saving technologies is not optimistic, with AWAREEXTTECH and AWARENEWTECH averaged at 2.87 and 2.69 individually. A mean of 2.22 for the variable of SAVPOTENTIAL reveals that the surveyed companies have limited potential for further improvement in energy efficiency. A mean of 2.04 for TRAINING indicates that the training of employees specific for energy saving is not frequently arranged, at about 1 to 3 times per year.

Table 12.9 Statistical summary of the determinant factors

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
COMPETITION	224	4.25	0.68	2	5
ENPRICE	228	4.12	0.60	2	5
AWARENESS	229	3.75	0.73	1	5
WILLINGNESS	230	4.30	0.63	2	5
TRAINING	222	2.04	0.70	1	5
AWAREEXTTECH	229	2.87	0.80	1	5
AWARENEWTECH	229	2.69	0.80	1	5
SAVPOTENTIAL	227	2.22	0.53	1	4

4.4 Correlation matrix and bi-variable results

Pair-wise correlation was calculated to roughly explore the relationships between the estimated cost affordability, *MEANAFFORD*, and the independents, the correlation matrix of which is shown in table 12.10. The only high coefficient is 0.816 for AWARENEWTECH (Awareness of new energy saving technologies) and AWAREEXTTECH (Awareness of existing energy saving technologies). Harmful levels of multi-collinearity are not expected until the correlation coefficient reaches ±0.9 (Farrar and Glauber, 1967), which confirms that the independent variables are mutually exclusive in this analysis. This correlation result indicates that COMPETITION (The level of the market competition) and ENPRICE (The level of domestic energy prices) are significantly but negatively associated with *MEANAFFORD* at $P<0.01$ and $P<0.1$ respectively. The other variables indicate no significant correlations with *MEANAFFORD*.

Table 12.10 Correlation matrix of estimated affordability and the determinants

	MEAN.	COM.	ENP.	AWA.	WIL.	TRA.	EXT.	NEW.	SAV.
MEANAFFORD	1								
COMPETITION	-0.250[a]	1							
ENPRICE	-0.145[c]	0.278[a]	1						
AWARENESS	0.035	0.107	0.172[a]	1					
WILLINGNESS	-0.018	-0.049	0.068	0.307[a]	1				
TRAINING	0.077	-0.026	-0.012	0.035	0.119[c]	1			
AWAREEXTTECH	-0.021	0.076	0.017	0.270[a]	0.228[a]	0.098	1		
AWARENEWTECH	-0.029	0.029	0.044	0.290[a]	0.240[a]	0.077	0.816[a]	1	
SAVPOTENTIAL	0.076	0.138[b]	0.139[b]	0.110[c]	-0.067	0.002	0.042	0.056	1

[a] Significant at 1% level. [b] Significant at 5% level. [c] Significant at 10% level

4.5 Multivariate regression results of the estimated affordability

Table 12.11 presents the results of econometric analysis of the determinants on estimated affordability. The robustness of the analysis was tested by repeating the regression with the independent variables and controls gradually introduced. Three models were adopted: Model 1 is the case of only importing external pressures as independent variables, model 2 adds the internal factors, and model 3 includes all the independent variables and controls. There are no obvious changes in the determinants with significance. It is indicated that COMPETITION and ENPRICE are significantly but negatively associated with MEANAFFORD, which would be expected, as if a company felt high pressure from market competition or energy prices, it would be unwilling to take additional burdens onboard, including energy cost increases attributed to carbon pricing policies. Another finding is that cost affordability is significantly and positively associated with SAVPOTENTIAL. This is because companies with higher saving potentials may be more flexible in terms of the policy costs by self-reductions. In terms of controls, chemical companies indicate a higher cost affordability than iron & steel companies. The other control, company size, has no significant effect on the estimated cost affordability.

Table 12.11 Regression results with company's cost affordability as dependent variable

Independent variables and controls		Coefficients		
		Model 1	Model 2	Model 3
COMPETITION		-0.0069[a]	-0.0068[b]	**-0.0067[b]**
ENPRICE		-0.0038	-0.0052	**-0.0056[c]**
AWARENESS			0.0023	0.0014
WILLINGNESS			-0.0012	-0.0006
AWAREEXTTECH			-0.0003	0.0009
AWARENEWTECH			-0.0025	-0.0037
TRAINING			0.0031	0.0034
SAVPOTENTIAL			0.0053[c]	**0.0055[c]**
Size	SME			0.0028
	LARGE			--
Sector	FOOD			0.0028
	CHEMICAL			**0.0136[c]**
	STEEL			--
	ELECTRONICS			0.0126
	OTHER			0.0049
Obs.		150	144	144
R squared		0.071[a]	0.072[c]	0.144[c]

[a] Significant at 1% level. [b] Significant at 5% level. [c] Significant at 10% level

4.6 Carbon prices affordable for the companies

The energy cost increase affordable for a specific company or a sector overall, *MEANAFFORD*, is equivalent to its affordable carbon price in response to the policies. Using the mean of affordable ratios of energy cost increases (*MEANAFFORD*) and the ratios of energy uses of companies by type, carbon prices affordable for the respondents can be calculated by the following equation.

$$Affordable\ carbon\ price = MEANAFFORD \times \frac{\sum_i Energy\ price_i \times Energy\ ratio_i}{\sum_i Emission\ factor_i \times Energy\ ratio_i}$$

The data sources and calculation results of affordable carbon prices of all the samples and by sector are listed in table 12.12. A total of 12 types of energies, including electricity, coal, oil, natural gas and city gas, are covered. An underlying assumption for this calculation is that price increases of the secondary energies, including electricity and heat here, are fully transferred to the final users. An obvious gap exists in the affordable carbon prices of different sectors. A carbon price of 1,062 JPY/t-CO_2 (about 13.1 USD/t-CO_2, 1 USD = 80.9 JPY as of November 2012 on average) would be acceptable for the chemical companies. The affordable carbon price for the iron & steel sector is much lower, at 426 JPY/t-CO_2 (about 5.3 USD/t-CO_2). The affordable carbon price for food processing and electronics companies is 683 JPY/t-CO_2 (about 8.4 USD/t-CO_2) and 801 JPY/t-CO_2 (about 9.9 USD/t-CO_2), respectively. Overall, the carbon prices affordable for the companies in Hyogo are in the same range as Chinese companies (6–12 USD/t-CO_2) in our earlier survey analysis (Liu et al., 2013a; 2013b).

Table 12.12 Estimation results of affordable carbon prices by sector

Energy type	Energy use ratios (%)					Energy price* (JPY/GJ)	Emission factor* (t-CO_2/GJ)
	All samples	Food processing	Chemical	Iron & steel	Electronics		
Electricity	49.72	43.19	48.87	56.31	73.88	1433	0.0467
Coal	1.80	0.00	1.03	3.94	0.00	407.8	0.0907
Oil	1.71	0.86	3.33	3.38	4.80	1188.5	0.0686
Natural gas	4.91	9.43	8.43	0.00	0.00	781.9	0.0495
Heavy oil	6.64	6.50	8.93	1.81	3.76	2110	0.0693
City gas	26.03	33.83	18.50	27.63	11.28	1834.3	0.0496
Heat	2.47	4.02	6.43	0.00	0.00	5649.0	0.060
LPG	2.83	1.59	1.33	3.00	0.28	1298.6	0.0589
Gasoline	0.05	0.02	0.00	0.00	0.00	3927.7	0.0671
Diesel	0.79	0.02	0.03	0.13	0.00	2859.4	0.0684
Kerosene	2.72	0.45	3.10	0.06	6.00	2356.9	0.0678
Cokes	0.28	0.00	0.00	3.69	0.00	1475.2	0.1078
MEANAFFORD	2.3%	2.0%	3.1%	1.5%	2.6%		
Affordable carbon price (JPY/t-CO_2)	**739**	**683**	**1062**	**426**	**801**		

* Data sources: (METI, 2011); (ANRE, 2011); (MOF, 2011)

The affordable carbon prices estimated in this paper have meaningful implications and may be referred to in developing carbon tax policies and GHG ETS in Japan. Japan launched its 'Global Warming Countermeasure Tax' in October of 2012, which involves a tax rate of 289 JPY/t-CO_2 as of April of 2016 (MOEJ, 2012), arrived at via gradual incremental increases. The transaction price of carbon credits was 750 JPY/t-CO_2 on average in 2009 under J-VETS (MOEJ, 2011). Therefore, the actual policy practices in the pricing of carbon emissions in Japan were carried out within the affordability of companies in this survey. On the other hand, economy-wide analyses have pointed to the fact that a much more ambitious pricing of GHG emissions is necessary for Japan to realise its mitigation targets in the medium and long terms. As examples, Nakata and Lamont (2001) examined the impacts of carbon and energy taxes for reducing GHG emissions of Japan up to 2040 by a partial equilibrium model, and confirmed that a carbon tax of 160 USD/t-C (43.6 USD/t-CO_2) would be needed to realise a reduction of around 20% in GHG emissions. Calvin et al. (2012) analysed the possibility of realising the Copenhagen pledges of various countries and regions by comparing the results of 23 models under the Asia Modeling Exercise (AME), which indicated that Japan's commitment of a 25% reduction in GHG emissions would require a price of at least 30 USD/t-CO_2 based on 15 models. Of the 16 models including Japan in the analysis region, 14 confirmed a necessary price of 50 USD/t-CO_2. Den Elzen et al. (2011) concluded that a carbon price of 79 USD/t-CO_2 is required to achieve the Japanese pledge, and that of Wada et al. (2012) rose as high as 573 USD/t-CO_2. According to an Energy and Environmental Conference (2012) reference document, Japan has to revise its GHG emissions reduction target for the medium term due to changes in the country's energy and environmental strategy resulting from the Great East Japan Earthquake of 11 March 2011 and the Fukushima Nuclear Power Plant accident. Nevertheless, continuous efforts need to be made in Japan to gradually increase domestic carbon prices up to an appropriate level in order to mitigate its GHG emissions in a cost-efficient manner. Besides the price level, other aspects for the design of carbon pricing tools are important in order to achieve the acceptability of industry as whole – for instance, a stronger double dividend would arise if using the carbon tax revenues to reduce the existing taxes with higher distortion, with the reduction of capital tax as a preferred option in Japan (Takeda, 2007).

5. Conclusions

This chapter extended application of the MBDC technique to estimate the affordability of companies in Hyogo of Japan for energy cost increases due to carbon pricing policies. The results indicate that a mean energy cost increase of 2.3% would be acceptable for all the respondents. The chemical sector expressed a slightly higher affordability with a mean of 3.1%, while that for the iron & steel industry was much lower, at 1.5%. Econometric analysis identified market competition and energy price pressure as significant determinants negatively affecting the affordability of companies. Deducing exactly what constitutes an affordable carbon price for companies in the study area is likely to be of utility in future discussions on establishing a carbon tax and domestic GHG ETS in Japan.

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PART VI:

CHOICE PREFERENCE OF COMPANIES TO CARBON TAX POLICY AND GHG ETS

Chapter 13:

An analysis of company choice preference to carbon tax policy in China

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Chapter Highlights:

- This chapter presents an analysis of Chinese company preferences to carbon tax policy alternatives by a choice experiment.
- Data was collected from 201 companies based in the eastern Jiangsu Province and the western Shanxi Province of China.
- Analysis identifies tax rates, tax relief measures and utilisation of tax revenues as the policy attributes significantly determining company preference to carbon tax policy.
- A carbon tax of 10−30 Yuan/t-CO_2 in the initial phase is feasible for China. Providing tax relief to energy-intensive industries and using tax revenues earmarked for climate change are principle factors in the design of this policy.

1. Introduction

The core to climate policy insufficiency of China is the lack of experience in adopting market-based instruments (MBIs) to apply appropriate prices for carbon emissions (Liu et al., 2011). In recent years, experts at research institutes under the Ministry of Finance (MOF), Ministry of Environmental Protection (MOEP) and State Administration of Taxation (SAT) began discussion on developing a carbon tax policy in China (Liu et al., 2011). Out of concern over negative impacts this policy could have on economic growth and international competitiveness of industry, the proposed tax rates are very conservative. Further, the expected policy effectiveness in carbon emissions reduction would be marginal. Thus debate continues at the expert level on how to design an appropriate carbon tax policy for China (Su et al., 2011).

It has been argued that the design of a specific instrument rather than the choice of policy type is the key to progress on this issue (Vollebergh, 2007). The design features of climate policies usually include stringency, predictability, flexibility, degree of obligation, scope and coverage as well as timing, enforcement, fit with policy mix, sector fit and the policy style (Norberg-Bohm, 1999). Of these, stringency and predictability are the two most important aspects for the development of policy (Frondel et al., 2007). *Stringency* measures the necessary monetary efforts for complying with the policy. It is not enough to consider stringency in terms of the tax rate associated with carbon tax policy – specific rules, such as tax exemptions or permission for compensatory measures with lower compliance costs, also need consideration. *Predictability* captures the certainty associated with an instrument, such as the content and timing of the policy.

Aiming to support ongoing discussions of carbon taxes in China, particularly from the business perspective, this research measures the choice preference of companies to the alternatives of carbon tax policy. The companies in Shanxi Province in the west and Jiangsu Province on the eastern coast were targeted in the survey. Two issues are discussed in this chapter. One is the analysis of relationships between various policy attributes and company policy choice preference and the other is gauging the trade-off between different attributes in influencing policy choices.

This chapter is arranged as follows. Section 2 explains the models used for analysing the policy choice dataset for this survey, section 3 describes the experiment design of carbon tax policy in detail, including the selection of policy attributes, classification of attribute levels and the example of choice sets, section 4 outlines the questionnaire survey for data collection and the statistics of samples, section 5 summarises the analysis results by various models specific for discrete choice data and section 6 concludes this survey analysis.

2. Model used in this study

The analysis model of discrete choices originates from random utility theory, which basically states that individual companies tend to maximise the utility of their policy choices. In this analysis, we applied models similar to Shen and Saijo (2009), which identified the influence of energy efficiency labeling on consumer purchasing preferences. The models are explained below.

The utility of a policy alternative for an individual company (U) can be expressed as the sum of a deterministic component (V) and a random error term (ε). Specifically, the utility of company q for policy alternative i can be written as:

$$U_{iq} = V_{iq} + \varepsilon_{iq} \qquad (1)$$

The probability that the company q chooses policy alternative i from a particular set J that comprises j alternatives can be written as:

$$P_{iq} = P(U_{iq} > U_{jq}; \forall\ j(\neq i) \in J) \qquad (2)$$

For converting the random utility model into a choice model, a certain assumption is required for the vector distribution of random error terms. If the random error terms are assumed to follow the distribution of type I extreme value and to be independently and identically distributed (IID) across alternatives and observations, the multinomial logit (MNL) model is obtained (McFadden, 1974). In the MNL model, the choice probability in equation (2) is expressed as:

$$P_{iq} = \exp(\mu V_{iq}) / \sum_{j=1}^{J} \exp(\mu V_{jq}) \qquad (3)$$

Further, assuming that the deterministic component of utility is linear and additive in parameters, the probability in equation (3) can be expressed as:

$$P_{iq} = \exp(\mu\beta' X_{iq}) / \sum_{j=1}^{J} \exp(\mu\beta' X_{jq}) \qquad (4)$$

where μ represents a scale parameter determining the scale of utilities, which is typically normalized to 1.0 in the MNL model. X_{iq} is the vector of explanatory variables of V_{iq}, including alternative specific constants (ASCs), the attributes of alternative i and the characteristics of company q, and β' is the parameter vector associated with X_{iq}.

In spite of widespread application of the MNL model, the heterogeneity among individuals is extremely difficult to examine by this model (Shen, 2006), a shortfall overcome to a certain extent by adding interaction terms between individual specific characteristics and various choices. The method requires a priori selection of key individual characteristics and attributes and can only involve a limited selection of individual specific variables (Boxall and Adamowicz, 2002). The other route is to make estimations by applying the latent class (LC) model, which assumes that the samples consist of a number of latent classes (S). The unobserved heterogeneity can be captured by the classes through estimating a different parameter vector in the utility function. Formally, the choice probability of company q of class S is expressed as:

$$P_{iq|s} = \exp(\mu_s \beta_s' X_{iq}) / \sum_{j=1}^{J} \exp(\mu_s \beta_s' X_{jq}) \quad s = 1,...,S \qquad (5)$$

where μ_s and β_s' are class-specific scale and utility parameters, respectively. According to Boxall and Adamowicz (2002), the probability of company q in class S (H_{qs}) is:

$$H_{qs} = \exp(\alpha\lambda_s' Z_q) / \sum_{s=1}^{S} \exp(\alpha\lambda_s' Z_q) \qquad (6)$$

where α is a scale factor usually normalized to 1.0, $\lambda_s^{'}$ is the parameter vector in class *S*, and Z_q denotes a set of characteristics determining the classification probability. Combining the conditional choice equation (5) and membership classification equation (6), the unconditional probability of choosing alternative *i* is given as:

$$\begin{aligned} P_{iq} &= \sum_{s=1}^{S} P_{iq|s} H_{qs} \\ &= \sum_{s=1}^{S} [\exp(\mu_s \beta_s^{'} X_{iq}) / \sum_{j=1}^{J} \exp(\mu_s \beta_s^{'} X_{jq})] \times [\exp(\alpha \lambda_s^{'} Z_q) / \sum_{s=1}^{S} \exp(\alpha \lambda_s^{'} Z_q)] \end{aligned} \qquad (7)$$

In equation (7), when setting μ_s and α equal to 1 (Boxall and Adamowicz, 2002), the parameter vector $\beta_s^{'}$ and $\lambda_s^{'}$ can be simultaneously estimated by the maximum likelihood method.

The LC model cannot be estimated unless the number of classes in equation (7) is given. *S* is discrete, but maximum likelihood estimation requires the parameter space to be continuous and estimates to be within the space (Swait, 2007). The central issue in using the LC model is to determine *S*. The available literature recommends a number of information criteria (Shen, 2006; Swait, 2007); however, we chose four measures based on the log likelihood at convergence with *S* classes, sample size and number of parameters, for this analysis:

Akaike Information Criterion: $AIC = -2(\log L_s^* - K_s)$ (8)

Bozdogan Akaike Information Criterion: $AIC3 = -2\log L_s^* + 3K_s$ (9)

Bayesian Information Criterion: $BIC = -\log L_s^* + (K_s \log N)/2$ (10)

Hannan-Quinn Information Criterion: $HQIC = -2\log L_s^* + K_s \log\log N$ (11)

In the above, $\log L_s^*$ is the log likelihood at convergence with *S* classes, K_s is the number of parameters and N is the sample size.

Another approach to account for individual heterogeneity is the Random Parameter Logit (RPL) or Mixed Logit (ML) model, which allows parameters to vary randomly through assumed distributions over samples (Greene and Hensher, 2003). In this approach, each company has its own set of scale and utility parameters. Therefore, the RPL/ML model may be viewed as treating each company as a class, which is indeed the LC model with N classes (N is the sample size). Compared with the RPL model, there are two major advantages with the LC model – one being that the LC approach is semi-parametric and does not require specific assumptions about distributions of parameters across individuals (Greene and Hensher, 2003) and the other is that the LC model provides the probabilities in each class.

3. Experimental design for this survey

The choice experiment (CE) requires the survey document to be appropriately designed. All the recommendations for contingent valuation (CV) surveys are applicable to a CE (Mitchell and Carson, 1989). A compatible choice question is required to ensure true preferences are elicited from the respondents. Further, the choice format should mimic the real choice context as much as possible (Harrison, 2007). The design of a CE involves four steps: a) Definition of the attributes and levels; b) Experimental design; c) Questionnaire development; and d) The sampling strategy.

The attributes and levels of choice alternatives are critical for a CE (Hensher, 2010). The attributes may be quantitative or qualitative, and even generic with the same level for all alternatives or alternative-specific with some attributes or levels differing across alternatives. Previous studies on the characteristics of survey targets and expert advice may facilitate the appropriate definition of attributes and their levels. The trade-off between the possibility of omitted variable bias, task complexity and cognitive burden placed on respondents may be tested by pilot surveys, for which focus groups could be used to identify the possible interaction effect between attributes (Schkade and Payne, 1994). The design of a CE is concerned with how to create the choice sets in an efficient way (Alpízar et al., 2003). A full factorial design allows for estimation of main and interaction effects independently; however, a full factorial design would generate too many choice sets, which would be cumbersome for the respondents to answer, thus fractional factorial designs are usually implemented.

During a typical CE, the respondent is repeatedly asked to choose one from each choice set with two or more alternatives. The alternative is expressed by a number of attributes with levels varying among the choice sets. The respondent's choices in a CE are based on a trade-off between different attributes. If a price attribute is included, the marginal willingness-to-pay (WTP) of other attributes can be calculated. However, WTP values in a CE analysis are not direct answers from respondents but calculated by the estimated coefficients of price attributes and the other ones (Louviere et al., 2000). The empirical evidence suggests that when accounting for scale effects, the structure of preferences and WTP estimates does not significantly differ if the price vector is changed (Hanley et al., 2005).

3.1 Attributes and levels for carbon tax policy

Many aspects need to be considered in the design of a tax policy – such as tax-payers, coverage for taxation, method of tax calculation, tax rate, preferential tax measures and utilisation of tax revenues. In this survey, four major aspects are selected as the attributes of carbon tax to be introduced in China, which are tax rate, tax relief measures, use of tax revenues and starting time. Table 13.1 lists the levels for each of these attributes.

Table 13.1 Attributes of carbon tax policy and their levels in this survey

Attributes	**Levels of attributes**
Tax rate (Yuan/t-CO_2)	1) 10; 2) 30; 3) 50; 4) 100
Tax relief measures	1) No relief; 2) Preferential treatment to energy-intensive companies; 3) Preferential treatment to companies actively reducing emissions to a certain level
Use of tax revenues	1) General budget; 2) Specific fund for energy saving and climate change ; 3) To reduce company's other taxes
Starting time	1) During the 13th five-year plan (2016-2020); 2) During and after the 14th five-year plan

3.1.1 Tax rate

As the only quantitative attribute, tax rate is presented with four levels, 10, 30, 50 and 100 Yuan/t-CO_2 in sequence. This is based on the literature analysing economic and environmental impacts of carbon taxes at the macro-economy level and our earlier estimations of carbon prices affordable for Chinese companies.

As representative macro-economic analyses, Cao et al. (2012) modeled carbon tax as a direct unit tax proportional to the carbon content of fossil fuels. Their results confirmed that a carbon tax at a lower rate of 100 Yuan/t-C (nearly 30 Yuna/t-CO_2) would lead to a very slight fall in the national GDP if recycling the revenues in a lump sum to the households. The researchers from MOF came to similar conclusions from their modeling analysis of carbon tax policy (Su et al., 2011). Without considering the technological dynamics, the GDP and investment would decrease to some degree if introducing this policy, but the impact is very limited. Specifically, at a low rate of 10 Yuan/t-CO_2 starting from 2011, the accumulative drop in GDP would be 0.19% during 2011–2020. At a higher rate of 70 Yuan/t-CO_2, the decrease of GDP would be 1.67% in the same period. They thus proposed to phase-in carbon tax policy from a low rate of 10 Yuna/t-CO_2 in China and then raise the rate to 40 Yuan/t-CO_2 in 2020 (Su et al., 2011). Calvin et al. (2012) compared the results of 23 different modeling studies under the Asia Modeling Exercise (AME). In approximately half of the models with China as a region, the country's mitigation target would be met with the imposition of a carbon price of 10 USD/t-CO_2

(slightly over 60 Yuan//t-CO_2). A carbon price of 30 USD/t-CO_2 (nearly 200 Yuan//t-CO_2) could limit emissions intensity to the lower goal of a 40% reduction by 2020 in all models.

At the business level, we conducted two empirical analyses measuring the carbon prices affordable for Chinese companies (Liu et al., 2013a; 2013b). One involved a survey to companies in a county-level city, Taicang of Jiangsu Province and the other targeted companies from energy-intensive sectors, including iron & steel, cement and chemical industries. The results indicate that a carbon price of around 60 Yuan/t-CO_2 would be affordable for all 121 sampled companies in Taicang, but only a quarter of them would accept a price of 100 Yuna/t-CO_2. Almost all the samples strongly reject or reject a carbon price of 200 Yuna/t-CO_2 (Liu et al., 2013a). The estimation by sector generates similar conclusions – affordable carbon prices for the sampled 170 companies range from 40–80 Yuna/t-CO_2 (Liu et al., 2013b).

From the above evidences, we may infer that a low tax rate, e.g., 10 Yuan/t-CO_2, would make it highly possible for China to instigate a carbon tax policy. This rate could be raised to 30–50 Yuan/t-CO_2 a few years thereafter, but should not approach 100 Yuan/t-CO_2 as this would not be accepted. We thus defined four levels for the tax rate respectively at 10, 30, 50 and 100 Yuan/t-CO_2.

3.1.2 Tax relief measures

Preferential treatment for industry on carbon tax is usually carried out in two ways (Li, 2010). One is to provide a conditional preferential tax rate for energy-intensive industries due to concern over global competitiveness, as some energy-intensive industries would be significantly influenced by this policy. Such companies could receive tax refunds or exemptions in exchange for signed agreements with governments on carbon reductions or energy saving. The other approach is to offer tax refunds for the companies with significant energy-saving achievements. For this survey, we assume three options for carbon tax relief measures: Providing no relief for all the tax payers, providing preferential treatment to energy-intensive companies, and providing preferential treatment to companies actively reducing their emissions to certain levels. A survey by Su et al. (2011) indicates that the third option is preferable, from the point of view of Chinese experts. Nearly 60% of the surveyed 43 experts suggest providing a preferential tax rate for companies that adopt low carbon technologies, but only 8.7% agree with giving preferential treatment to energy-intensive companies.

3. 1.3 Use of tax revenues

There are two basic options for the use of carbon tax revenues: One is to mix the revenues with other tax revenues as a general budget, and the other is to use the revenues as a fund dedicated either to climate change countermeasures or to reducing other taxes. The volume of carbon tax revenue is not likely to be large and shall be used for the purpose of environmental protection or non-environmental welfare. Based on our correspondence with researchers at MOF, the issue of how to use carbon tax revenue is still a subject of inter-ministerial debate: The National Development and Reform Commission (NDRC) and MOEP suggest using the revenue as a specific fund for energy saving and carbon mitigation, but the MOF wants to combine the tax revenues into the general budget. Of the 42 experts responding to the survey of Su et al. (2011), nearly 80% thought that the tax revenue should be used as a special fund for climate change. Only 15.9% suggested carbon tax revenue should be used in the general budget and 6.8% suggested carbon tax revenue should be used to reduce the other tax burdens. Accordingly, these three options are defined for this attribute, to use the tax revenues as general budget, as a specific fund for energy saving and climate change, or to reduce a company's other taxes.

3.1.4 Starting time

The researchers at MOF initially suggest the carbon tax be introduced in 2012 (Su et al., 2009). The real situation, however, is that the consumption tax on oil was increased in 2009 instead of levying a particular fuel tax proposed by the government previously. The reform of resource taxes started in November 2011, which covers crude oil, gas, coal, non-metal raw materials and solid salt. Levying a carbon tax from one to three years after the resource tax reform would be feasible since tax payers would face high pressures if the energy-related taxes were introduced too frequently. Su et al. (2011) modified their proposal by suggesting a carbon tax be introduced in the latter part of the 12th five-year plan (FYP) period (2011–2015). Their survey to the experts confirms that more than half of the respondents agree to starting a carbon tax before 2015, and that nearly 40% of them chose the 13th FYP (2015–2020) as a reasonable starting time, thus for this survey we defined two categories for this attribute: One is the 13th FYP period (2015–2020) and the other is during and after the 14th FYP period. This is because the central government of China has recently shifted focus to discussions over pollution taxes, e.g., sulfur tax and heavy metal tax, to gradually replace the pollution fee currently in force. The starting time of the carbon tax proposed in Su et al. (2011) would thus probably be postponed until the 13th FYP or even later.

3.2 Design of the choice sets for this experiment

Fractional factorial designs can be 'orthogonal', pursuing no correlation between the attribute levels, or so-called 'efficient designs', for the minimum predicted standard errors of the parameter estimates. Efficient design is usually performed to maximise a chosen optimality criterion based on the pre-specified model, e.g., MNL model. Various efficiency criteria have been proposed, such as D, A or G-efficiency. The D-optimal approach has become the most widely used measure because of its insensitivity to the magnitude of the scale of parameters (Street et al., 2005). The D-efficiency is given as:

$$D - efficiency = [|\Omega|^{1/K}]^{-1} \quad (12)$$

where K is the number of parameters to estimate and Ω is the covariance matrix of a vector of the parameters. The other reason for choosing D-efficiency in this research is that it is less computationally burdensome and the software is readily available.

Running the D-optimal design by Design Expert 8.0 (Stat-Ease, Inc.), 12 choice sets were created for carbon tax policy. These choice sets were randomly divided into two versions, each consisting of six sets. The sampled companies were requested to select the more preferable policy profile in each choice set and answer other questions on their characteristics. A choice set example for carbon tax policy is presented in table 13.2.

Table 13.2 Example of choice set for carbon tax policy

Policy attribute	Option A01	Option B01
Tax rate (Yuan/t-CO_2)	50	10
Tax relief measure	No relief measure	Preferential treatment for energy-intensive companies
Use of tax revenues	General budget	Specific fund for energy saving and climate change
Starting time	During and after the 14^{th} five-year plan	During and after the 14^{th} five-year plan
Please tick the one you prefer	□	□

4. Outline of the survey and distribution of the samples

The data for this analysis was collected by questionnaire surveys from August 2012 to January 2013. A questionnaire was developed with the main objectives of measuring the choice preferences of companies to carbon tax policy and GHG emissions trading scheme (ETS), and identifying their viewpoints regarding current financial subsidy policies for industrial energy saving. The questionnaire consists of four major components: background of the company; company viewpoint on energy saving subsidies and rewards, choice preferences of companies for carbon tax policy; and, the choice preferences to GHG ETS. The choice sets of carbon tax policy and GHG ETS are individually separated into two versions, each consisting of six policy choice sets. This chapter summarises the results of company choice preference to carbon tax policy since analysis of the dataset on the choices of GHG ETS in China obtained no significant results.

Referring to our previous experiences in similar surveys involving the companies (Liu et al., 2012), we targeted company energy or environmental managers at the middle level for this survey as such people are responsible for energy management in their companies and should be fully conversant with the policy impacts on their businesses. In the questionnaire preface explaining the survey objectives and requirements, we requested the energy or environmental managers to answer the questions on behalf of their companies and consult with related staff, such as financial managers, as necessary. As such, their answers are regarded to accurately represent the choices of their companies. The surveys were conducted over a period of six months under the coordination of two universities as local research partners – the School of Environment, Tsinghua University, in Beijing and the College of Environmental Science and Engineering, Tongji University, in Shanghai. Tsinghua University used one questionnaire format in Shanxi Province in western China and Tongji University used another version in Jiangsu Province neighboring Shangai in eastern China. The geographical locations of the survey areas are depicted in fig.13.1.

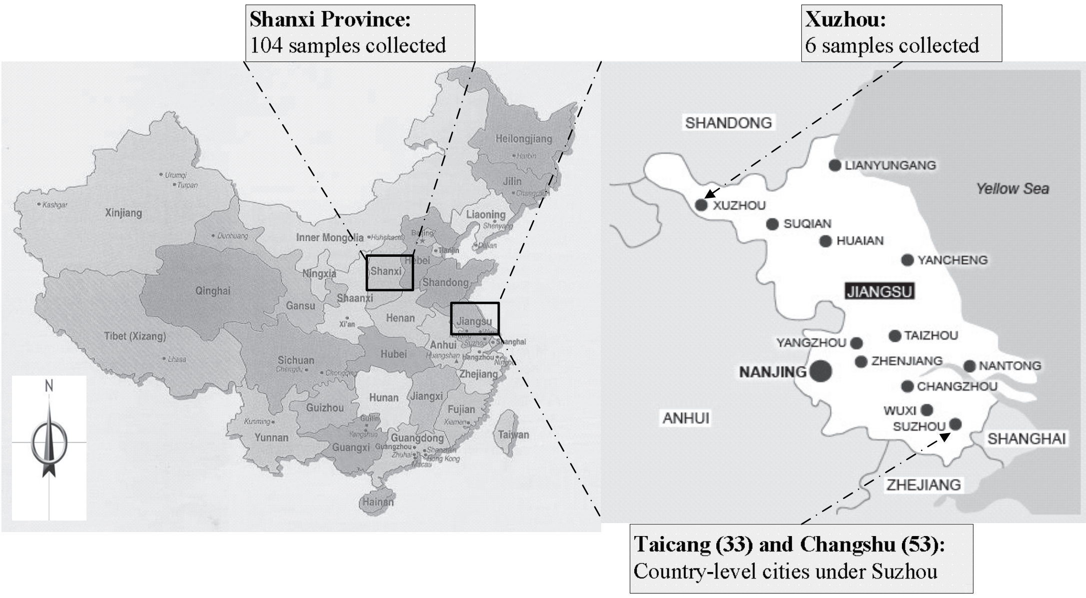

Figure 13.1 Geographical locations of the survey areas

We initially carried out experimental surveys with seven companies together with Tsinghua University to test the feasibility of the question and answer format. The final format was then sent to the companies either by mail or email. For the survey in Shanxi, a local research institute, ‘Shanxi Academy for Environmental Planning’, assisted in the postal and collection of questionnaires from the companies, which resulted in 104 responses from companies in Shanxi. For the survey in Jiangsu, two county-level cities (Taicang and Changshu) under Suzhou city and a municipality named Xuzhou were targeted. The local environmental protection bureaus (EPBs) helped in the collection of questionnaires. Large energy-consuming companies were purposely selected in the survey. In Taicang, the questionnaires were posted to 50 companies and 33 responded. The numbers of questionnaires posted in Changshu and Xuzhou were respectively 59 and 20. The numbers of respondents were 53 and 6, respectively. Another 5 questionnaires were collected in other places of Jiangsu. The total number of samples from Jiangsu was 97. Overall, 201 respondents were confirmed to be useful for this analysis.

The distribution of valid samples by size, sector and ownership is listed in table 13.3. The samples from chemical, power generation and iron & steel industries individually account for 19.9%, 15.4% and 11.4% of the total. Twelve cement companies and seven paper companies responded to the survey, with a share of 6.0% and 3.5% of the total. The remaining 43.8% represents companies from other industries. By size, 51 are small companies, having a staff of less than 300 or annual turnover of below 30 million Yuan or registered capital of less than 40 million Yuan. Seventeen companies are large, with more than 2,000 employees, an annual turnover of more than 300 million Yuan and a registered capital of over 400 million Yuan. The remaining 133 are medium-sized as classified by the National Bureau of Statistics of China. The ratio of small, medium-sized and large companies in total is respectively 25.4%, 66.2% and 8.5%. By ownership, 77 are domestically private, accounting for 38.3% of the total. Stated-owned companies have the second share of nearly 25%. Foreign-funded companies, including fully foreign-funded and joint-ventures, account for 27.3%.

Table 13.3 Distribution of the usable respondents by size, sector and ownership

	Size			In total
	Small	Medium	Large	(%)
Panel A: By sector				
Iron & steel	0	15	8	23 (11.4)
Cement	3	9	0	12 (6.0)
Paper	3	3	1	7 (3.5)
Chemical	10	28	2	40 (19.9)
Power	3	26	2	31 (15.4)
Other	32	52	4	88 (43.8)
In total (%)	51 (25.4)	133 (66.2)	17 (8.5)	201 (100.0)
Panel B: By ownership				
State-owned	3	40	7	50 (24.9)
Collective-owned	1	4	0	5 (2.5)
Domestically private	22	47	8	77 (38.3)
Full foreign	12	16	2	30 (14.9)
Joint-venture	8	17	0	25 (12.4)
Other	5	9	0	14 (7.0)
In total (%)	51(25.4)	133(66.2)	17 (8.5)	201 (100.0)

5. Results and discussions

5.1 Determination of the number of latent classes

The criteria of AIC, AIC3, BIC and HQIC were applied to determine the number of latent classes. We attempted various numbers of classes and summarised the statistics of 1, 2 and 3 classes in table 13.4. The log likelihood values (column 3) at convergence reveal that the greater the class number was, the better the model would fit, especially for 1 to 2 class models. This is not surprising since log likelihood values normally increase in magnitude when more parameters are estimated. The result indicates that the minimum values of BIC and HQIC (columns 6 and 7) have clear relevance to the 2-class model, suggesting that the 2-class model is optimal for these two information criteria. The reductions of AIC and AIC3 (columns 4 and 5) are very small from 2-class to 3-class, confirming the negligible improvement between these two cases. Therefore, the 2-class LC model was selected in this estimation.

Table 13.4 Information criterions for different numbers of latent classes

Classes	#Par	Log-likelihood	AIC	AIC3	BIC	HQIC
A: Choices of carbon tax policy						
1	6	-559.32	1130.7	1136.7	1160.3	1141.9
2	13	-311.20	648.4	661.4	712.7	672.8
3	20	-297.78	635.6	655.6	734.5	673.1

5.2 Analysis results with various models

NLOGIT 5.0, the latest version of the discrete choice modeling package of LIMDEP (Econometric Software, Inc.) was used to analyse the dataset in this survey. The estimation result of the 2-class LC model for the choices of carbon tax policy is listed in table 13.5.

Table 13.5 Estimation results for the choices of carbon tax policy

Attribute	MNL	RPL	LC	
			Class 1	Class 2
TAXRATE	-0.011***	-0.012***	-0.029***	0.004
RELIEF-B	0.972***	1.030***	2.671***	0.356
RELIEF-C	1.249***	1.328***	2.220***	1.834***
REVENUE-B	0.342**	0.340**	1.106**	-0.449
REVENUE-C	1.031***	1.075***	0.586	0.675
TIME	-0.175	-0.230*	-0.528	0.887
Class probability			0.671	0.329
Log-likelihood	-559.33	-554.65	-308.53	
Pseudo R squared	0.225	0.231	0.572	
Obs.	1041	1041	1041	

Notes: Standard errors are not reported, to save space; Asterisks *, ** and *** respectively denote parameters significant at 10%, 5% and 1% levels

For comparison, the estimation results using the MNL and RPL models are also provided in the table. To apply the RPL model, the tax rate is assumed to be normally distributed across the respondents and the parameters of all the other attributes are held fixed, i.e., equal among individual companies. Overall, for the MNL, RPL and LC estimates, goodness of fit was significantly improved by applying the LC approach compared with the MNL and RPL models (pseudo R-squared values greatly increased for the LC model). As shown in table 13.5, the total number of observations is 1,041 since some respondents failed to answer all six choice sets of carbon tax policy or just checked part of the choice sets. To apply the LC model, the possibility of the respondents in class 1 is 67.1% and the possibility of the samples categorised as class 2 is 32.9%. Some variation exists between the two classes of companies in their choice preference to carbon tax policy, due to various policy attributes.

The results for class 1 respondents in the LC model are similar to the estimations by the MNL and RPL models. The level of tax rate significantly but negatively determines the company's choice preference to carbon tax policy, a result that could be considered to be expected since a higher tax rate would increase the cost burden for company energy usage and thus increase resistance to this policy. A significant and positive relationship was revealed between tax relief measures and a company's policy preferences, which confirms that allowing preferential tax treatment would increase the acceptability of companies to carbon tax policy, by cutting down the taxes either for energy-intensive industries (RELIEF-B) or for companies that satisfied certain energy efficiency improvement criteria (RELIEF-C). Utilisation of carbon tax revenues also has a significant influence on company preferences in that the respondents prefer to use the revenues as specific funds for climate change (REVENUE-B) rather than for a general budget (REVENUE-A). In spite of the significant and positive relationship between the choice preference and REVENUE-C (To use the revenues for reducing a company's other taxes) confirmed in the MNL and RPL models, no significant relationship could be found in the LC model estimations. An additional finding is that the starting time appears not to be important in determining a company's choice preference to carbon tax policy, which implies that postponing introduction of a carbon tax from the 13th FYP period (2016–2020) to the 14th FYP period (2021–2025) or even later would not significantly increase a company's choice preference to this policy.

In summary, the result in table 13.5 confirms that a carbon tax policy characterised with a low tax rate, with tax relief measures for energy-intensive or energy-efficient industries, and tax revenues used specifically for climate change would be more preferable from the perspective of the surveyed Chinese companies.

5.3 Relationships between the attributes of carbon tax policy

An advantage of the CE method is its ability to quantitatively estimate willingness-to-pay (WTP) of the respondents by introducing a price attribute in the experiment. In this study, the tax rate may be regarded as this kind of attribute. To illustrate how the companies evaluate the other policy attributes in comparison with the monetary value, we provided their WTP values in table 13.6. Thus WTP may be viewed as a trade-off between the target attribute and the price attribute in determining a company's policy preferences. WTP values vary across different policy attributes and for the attributes of carbon tax policy, the WTP values of RELIEF-C, REVENUE-C and TIME are not statistically significant. Nevertheless, setting a relief measure for energy-intensive industries, RELIEF-B, equates to a decrease in tax rate of 65.9 Yuan/t-CO_2 in influencing a company's choice preference to this policy. Similarly, the effect of changing the utilisation of carbon tax revenues as a general budget (REVENUE-A) to the specific fund for climate change (REVENUE-B) equals a tax rate decrease of 23.3 Yuan/t-CO_2.

Table 13.6 Willingness-to-pay (WTP) indicating the tradeoff of attributes

Attribute	WTP (Yuan/t-CO_2)	95% Confidence Interval (Yuan/t-CO_2)	
RELIEF-B	-65.9	-108.1	-23.8
RELIEF-C [a]	-65.4	-185.8	55.1
REVENUE-B	-23.2	-39.3	-7.1
REVENUE-C [a]	-18.6	-61.0	23.9
TIME [a]	6.4	-38.6	51.5

Notes: [a] Estimated WTP is not statistically significant; Tax rate is used as the denominator for choices of carbon tax policy in this estimation

6. Conclusions

This chapter summarises a choice experiment study based on Chinese companies to measure their choice preferences to carbon tax policy. The modeling analysis identified policy attributes that significantly influenced a company's choices of design options for this policy and the findings provide meaningful implications for the development of carbon tax policy in China. This analysis confirms that the tax rate as an essential attribute significantly but negatively determines a company's policy preference. A lower tax rate is more acceptable for the businesses – our surveys and earlier estimations indicate that a carbon price of 40 Yuan/t-CO_2 would be affordable for Chinese companies in the current context, even for those in energy-intensive sectors (Liu et al., 2013a; 2013b). Macro-economic modeling reveals a very slight drop in GDP and employment if a carbon tax of around 30 Yuan/t-CO_2 were levied (Cao et al., 2012). Therefore, to impose a carbon tax of 10–30 Yuan/t-CO_2 in the initial phase would be feasible and realistic for China. In terms of the other principles for the policy deign, allowing tax relief for energy-intensive sectors and using the tax revenues solely for climate change would be more preferable for the companies. Since there is no statistically significant influence on the starting time, launch of a carbon tax policy as early as the 13th FYP period (2016–2020) can be recommended as an additional effort after the ongoing resource tax reform.

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Chapter 14:

An analysis of company choice preferences to carbon tax policy and GHG emissions trading schemes in Korea

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Chapter Highlights:

- This chapter presents an analysis of company preferences to carbon tax policy and GHG ETS in Korea using data collected from 150 respondents, predominantly from iron & steel, cement and chemical industries.
- The results indicate that tax rate, tax relief measures, utilisation of tax revenues and starting time significantly influence company choices on carbon tax policy.
- For GHG ETS, cap setting and auction ratios for allowance allocation are significantly associated with company policy preference. A penalty of up to triple the credit market price significantly decreases company choice of this policy. Companies prefer to use carbon intensity rather than trade intensity as the criteria for defining sectors with carbon leakage risks.
- This policy experiment clarifies certain basic principles for the development of carbon tax policy and GHG ETS in Korea from the viewpoint of businesses.

1. Introduction

The introduction of a carbon tax has been considered since 2000 in Korea owing to criticism levelled at energy prices and the taxation system for not properly reflecting the social cost of environmental damage. Much discussion and debate has taken place between core government institutes, including the Congress, Ministry of Strategy and Finance (MOSF), Korea Institute of Public Finance (KIPF), and the Citizens' Coalition for Economic Justice (CCEJ). MOSF initiated a three-year project over 2008 to 2010 to explore energy tax reform and discuss scenarios for the introduction of a carbon tax in Korea. This project was mainly conducted by KIPF, who advocate the early introduction of a low-rate carbon tax alongside the existing tax system, since such was launched at the start of Lee's term in office (2008-2012) and covers income tax and corporation tax (Kim et al, 2009). Initially, the KIPF report suggested a carbon tax be introduced from 2013 to replace the existing transportation-energy-environment tax, scheduled to end in 2012. Although the transportation-energy-environment tax has been extended to 2015, carbon taxing has received much attention from policymakers. During the last presidential election in 2012, major political parties (i.e., Saenuri party as the ruling party and Minjoo party as the leading opposition) examined converting the current transportation-energy-environment tax into a carbon tax. The Progressive Justice Party, another minor opposition party, chose carbon taxing as an election pledge and more recently has proposed a carbon tax bill to start in 2016. To a certain degree, the key government institutes of Korea have actually acknowledged the need for a carbon tax but have yet to reach a consensus that bridges the full breadth of opinion of the various stakeholders on this policy.

In Korea, a preliminary GHG ETS proposal was formulated in November 2010 and suggested the introduction of domestic GHG ETS from 2013 in three phases. Several studies analysing the economic effects and impacts of GHG ETS on Korean industries were reported at that time, some of which indicated that it would be more cost-effective than mandatory regulations, such as TMS (Target Management System), and could reduce the cost of achieving the nation's GHG 2020 reduction target by 44–68% (PCGG press, 2011; Kim, 2010a; Lee, 2009). Kim (2009a) argued that Korea's industrial global competitiveness might be weakened by this policy due to an average price increase for all sectors of 1.38%, but higher prices for metal products, electricity, gas, tap water, non-metallic products would be higher, at around 2.4%. Kim (2010b) therefore suggests adopting a differentiated method in allocating emissions allowances for the various sectors in order to maintain the country's industrial competitiveness.

In spite of the advantage of GHG ETS in economic efficiency, the preliminary proposal of such received strong opposition from Korea's industrial sector. The second GHG ETS proposal reflected opinions of the industry and was submitted to the parliament in April 2011 and was finally enacted in May 2012. The bill states that domestic GHG ETS will formally start on 1 January 2015 in Korea. Nevertheless, discussions between industry and the government on specific aspects of Korean GHG ETS are dragging on and heavy lobbying from industry is likely to further water the policy down and delay the start time until demands for the provision of allowances for international offsets are satisfied.

An earlier study conducted by the authors also revealed that carbon tax and GHG ETS are much less preferable for Korean companies than other types of energy saving and GHG mitigation policies (Suk et al, 2013a). Although resistance from industry was identified as the chief barrier to actual implementation of a carbon tax and GHG ETS, few studies were carried out at the company level to obtain views on the pricing of carbon emissions. Aiming to close this research gap, we carried out a choice experiment on Korean companies to measure their preferences to various alternatives of carbon taxing and GHG ETS.

The model used in this study is the same as that used for Chinese companies and may be referred to in Chapter 13. This chapter is thus structured as follows: Section 2 describes the experiment design for carbon tax policy and GHG ETS in detail, including the selection of policy attributes, classification of the levels for each attribute and the examples of choice sets; section 3 overviews the questionnaire survey for data collection and distribution of samples; section 4 summarises the analysis results using various models specific for discrete choice data, and section 5 concludes this survey analysis.

2. Experiment design in this survey

2.1 Definition of the policy attributes and levels

2.1.1 Attributes and levels for carbon tax policy

We selected four major aspects as the attributes to be taken into account for the introduction of a carbon tax in Korea – tax rate, tax relief measures, use of tax revenues and starting time. Table 14.1 lists the levels of these policy attributes.

Table 14.1 Attributes and their levels of carbon tax policy in this study

Attributes	**Levels of attributes**
Tax rate (KRW/t-CO_2)	1) 1,000; 2) 2,000; 3) 3,000; 4) 5,000
Tax relief measures	1) No relief; 2) Preferential treatment to energy-intensive companies; 3) Preferential treatment to companies actively reducing emissions to a certain level
Use of tax revenues	1) General budget; 2) Specific fund for energy saving and climate change; 3) To reduce company's other taxes
Starting time	1) Since 2015; 2) Since 2021

2.1.1.1 Tax rate

The tax rate is presented with four levels, 1,000, 2,000, 3,000 and 5,000 KRW/t-CO_2 in sequence, chosen based on an overview of available literature analysing the impacts of carbon taxes at the macro-economic level and our own estimations of carbon prices affordable for Korean companies.

In 2008, KIPF firstly suggested a carbon tax proposal with tax rates at 34–96 KRW/l for fossil fuels, calculated according to the carbon price of EU-ETS (25 Euro/t-CO_2, equivalent to 31,328 KRW/t-CO_2) (Kim et al., 2008). The expected tax revenue would be 8.5–9.1 trillion KRW (USD 7.38–7.91 billion) per year based on 2007 emissions of Korea, which is about 1% of the country's GDP. KIPF in a later report then revised this initial rate downwards, to 1/8 that above, to minimise the policy impact (nearly 4,000 KRW/t-CO_2) (Kim and Kim, 2010). Kwon and Heo (2010) showed that a carbon tax equivalent to 36,545 KRW/t-CO_2 (about 31 USD/t-CO_2) must be imposed to realise the national mid-term GHG mitigation goal. The goal of our study was to conduct an empirical survey to measure the carbon prices affordable for Korean companies from the perspective of the target companies themselves, which spanned three energy-intensive sectors – iron & steel, cement and chemicals. Our estimates show that an average carbon price of 2,500 KRW/t-CO_2 would be accepted by all 62 sampled companies. A sensitivity analysis reveals that three quarters of the companies would not accept a carbon price of 3,500 KRW/t-CO_2 and almost all of them would strongly reject or reject a price of 5,000 KRW/t-CO_2. The estimations by sector generate similar conclusions, and affordable carbon prices for the companies range from 2,500–4,000 KRW/t-CO_2 (Suk et al., 2013b).

As mentioned earlier, a carbon tax bill was proposed by the Progressive Justice Party of Korea recently. According to this proposal, the taxes would be imposed in addition to current energy taxes. Anthracite coal would be taxed at 5.8 KRW per kg, while bituminous coal would be taxed at 3.3 KRW per kg, and electricity at 1.4 KRW per kWh (Shim, 2013). These rates are at 1/10 the level KIPF proposed in 2008, and equivalent to around 3,000 KRW/t-CO_2. If this bill was decided on, it would most likely be enacted in 2016. From the above we may infer that a low tax rate such as 1,000 KRW/t-CO_2 would be possible if a carbon tax bill went into effect in Korea, which would then be ramped up to 2,000 to 3,000 KRW/t-CO_2 a few years later. Since the companies already consider a tax rate of 5,000 KRW/t-CO_2 to be high in the current phase, we defined four levels for the tax rate: 1,000, 2,000, 3,000, and 5,000 KRW/t-CO_2.

2.1.1.2 Tax relief measures

KIPF's study addressed tax relief measures for energy-intensive industries out of concern for international competitiveness resulting from introduction of the carbon tax. One of its measures is to provide tax reductions for energy-intensive industries that would be significantly influenced by this policy, and another is to provide preferential tax treatment for companies based on their performance under the pilot GHG ETS, or voluntary agreements for energy saving and carbon mitigation (Kim and Kim, 2010). In this survey, we assume three options for carbon tax relief measures: no relief treatment for any of the taxpayers, preferential treatment to energy-intensive companies and preferential tax treatment to companies that actively lower their CO_2 emissions to certain levels.

2.1.1.3 Use of tax revenues

There are two options for the use of carbon tax revenues. One is to use the revenues for a general budget and the other is to use revenues for a specific fund, either for climate change countermeasures or to reduce other taxes. Historically, Korea's energy-related tax has been used to support the transportation sector as an objective tax. The KIPF report of 2010 suggested that revenues from the carbon tax be used for climate change countermeasures, such as renewable energy and R&D for improvements in energy efficiency or development of clean technologies. It also suggested carbon tax revenue be used as an incentive for energy-intensive and export-oriented sectors to ease their tax burden and ensure international competitiveness is maintained (Kim and Kim, 2010). Accordingly, three options are defined for this attribute: to use the tax revenues as general budget, as a specific fund for energy saving and climate change, or to reduce other company taxes.

2.1.1.4 Starting time

The timing of actual implementation of Korea's carbon tax has been subject to much discussion. In 2010 KIPF suggested 2013 as the start date, as a replacement for the transportation-energy-environment tax set to end in 2012 (Kim and Kim, 2010). Since then, however, the transportation-energy-environment tax has been extended to 2015. The carbon tax bill, proposed recently, suggests a starting time of 2016. We defined two years for start date of carbon tax in Korea, 2015 and 2021. The year 2015 was chosen as one option in consideration of the time required for deliberations leading up to approval. Hong (2011) indicated that simultaneous introduction of GHG ETS and a carbon tax in 2015 would enable significant savings of 30–50% to be made in terms of mitigation cost. Adding weight to the 2015 option is that it was also the initial year for GHG ETS implementation, meaning emissions allowances will be allocated fully for free. Further, a 2015 start date would also exert a financial pressure as early as possible for the emitters. On the other hand, the later launch date of 2021 would give companies more time to familiarise themselves with the tax and prepare for it.

2.1.2 Attributes and levels for GHG ETS

The design and institutional arrangement of GHG ETS has a decisive impact on the cost-effectiveness of this policy (Woerdman and van der Gaast, 2001). Such aspects include transaction costs, spatial and temporal dimension mechanisms, initial allocations of emission allowances, monitoring and enforcement (Antes et al., 2008). In this survey, we defined four attributes for the choice experiment of GHG ETS: cap-setting, allowance allocation, penalties and criteria for the carbon leakage industry. The levels for these attributes are listed in table 14.2.

2.1.2.1 Cap setting

GHG ETS has to be developed on the basis of emission caps. Cap setting based on historical emissions of companies is relatively easy operationally but would put companies that adopted carbon-mitigation measures at the outset at a disadvantage. In comparison, the benchmarking approach is complex since different industries, production processes and products have different emission intensities, which require different standards for cap setting. Korea's current GHG ETS bill considers both grandfathering and benchmarking to calculate emissions permits for companies. In this experiment, we defined three options in cap setting: that based on historical emissions (grandfathering), based on the sector's advanced emission levels (benchmarking), and a hybrid approach which differentiates existing sources and new entrants.

Table 14.2 Attributes and their levels of GHG ETS in this study

Attributes	Levels of attributes
Cap setting	1) Based on the company's historical emissions; 2) Based on the sector's advanced emission levels; 3) Differentiated measures for existing and new established companies
Allowance allocation	1) All for free; 2) 5% auction, the rest for free; 3) 10% auction, the rest for free; 4) 30% auction, the rest for free
Penalty	1) Fine based on current market price of carbon emissions; 2) 3 times market price; 3) 5 times market price
Criteria for carbon leakage industry	1) Carbon intensity; 2) Trade intensity

2.1.2.2 Allocation of emissions allowances

The first phase of Korean GHG ETS is from 2015 to 2017, with the first compliance date falling in 2016. The second phase will be from 2018 to 2020 and the third phase from 2021 to 2025. During the first phase, liable entities will be allocated all emissions permits for free. Demand for credits will only come from entities whose emissions exceed their allocated allowances. The free allocation ratio will drop to 97% during the second phase and below 90% in the third phase. In this survey, four allowance allocation ratios are offered to the companies: all for free; 3% auction and the remaining 97% for free allocation; 10% auction and 90% for free; and, 30% auction and the remaining 70% for free.

2.1.2.3 Penalty

A penalty mechanism is essential for GHG ETS operation and to realise the policy goals. There are two forms to the penalty. One is compensation for allowance deficits and the other is a fine. The compensation amount could be the same amount or several times the allowance deficit of a past compliance period. In the preliminary GHG ETS proposal, a penalty for non-compliant emissions of less than five times the average market price of credits was proposed. However, this received strong opposition from industry. In the final proposal, three times the average market price to a maximum of 100,000 KRW/t-CO_2 (\$90/t-CO_2) will be levied on the entities failing to submit sufficient allowances in each compliance period. We defined three levels of fines as penalty measures for Korea's GHG ETS: the same level as the market price, three times the market price and five times the market prices of CO_2 credits.

2.1.2.4 Criteria for carbon leakage industry

Carbon leakage occurs when there is an increase in GHG emissions in one country as a result of a reduction by a second country with a stricter climate policy. According to the IEA (2008), a particular country or region could be weakened in terms of international competitiveness due to such emissions reduction policy, resulting in relocation of energy-intensive production to regions with looser constraints. In 2009, the European Commission firstly granted free allowances to around 60% of industrial sectors under EU ETS. The rules and procedures to decide whether a sector is deemed to be exposed to carbon leakage are based on two indicators. One is the additional production costs defined as the sum of direct and indirect carbon costs divided by the Gross Value Added of a sector. The other is the trade intensity of a sector with countries that are not party to the EU ETS, defined as the ratio between the total value of exports to third countries plus the value of imports from third countries and the total market size for the industry (annual turnover plus total imports from third countries). Four criteria were given and if a sector qualified for one of these, it would obtain free allocation of allowances: 1) additional production costs > 5% and trade intensity > 10%; 2) additional production costs > 30%; 3) trade intensity > 30%; and, 4) for sectors not qualifying for one of the above situations, a provision has been made for more detailed analysis at a more disaggregated level and/or qualitative assessment if trade intensities and/or increase in production costs were close to the thresholds, in which the required investments, market characteristics and profit margins would flourish as alternative indicators (De Bruyn et al., 2013).

In Korea's GHG ETS bill, certain key emissions-intensive trade-exposed industries are to be exempted from reductions in free allocations for at least the second phase. Companies with a high tendency for carbon leakage may be defined by two criteria – either by carbon intensity or by trade intensity. Candidates for fully-free allowance allocation are businesses within industries that satisfy any of: 1) over 5% in carbon intensity and over 10% in trade intensity; 2) over 30% in carbon intensity; and 3) over 30% in trade intensity.

Lee (2010) analysed the trade intensity and carbon intensity of the sectors deemed to be exposed to carbon leakage in Korea. The carbon-intense sectors include the cement industry, while the iron & steel sector shows high trade intensity. Two criteria, carbon intensity and trade intensity, are thus proposed as options to determine the carbon leakage industry in this survey.

2.2 Design of choice sets for this experiment

Twelve choice sets were created for carbon tax policy and another 12 choice sets for GHG ETS by running the D-optimal design through Design Expert 8.0 (Stat-Ease, Inc.). Considering the complexity for the companies to compare and consider preferable options, these choice sets were further randomly divided into two versions. Each version of the questionnaire consists of six choice sets for carbon tax policy and six choice sets for GHG ETS. The sampled companies were requested to select more preferable policy profiles in each choice set and answer other questions related to characteristics of their companies. An example choice set for carbon tax policy is presented in table 14.3. Similarly, an example for GHG ETS is listed in table 14.4.

Table 14.3 Example of choice set for carbon tax policy

Policy attribute	Option A01	Option B01
Tax rate (KRW/t-CO_2)	2,000	5,000
Tax relief measure	No relief measure	Preferential treatment to energy-intensive companies
Use of tax revenues	General budget	Specific fund for energy saving and climate change
Starting time	From 2015	From 2021
Please tick the one you prefer	□	□

Table 14.4 Example of choice set for GHG ETS

Policy attribute	Option A01	Option B01
Cap setting	Based on the company's historical emissions	Based on the historical emissions for the existing companies, and the sector advanced emission levels for the new entrants
Allowance allocation	3% auction, the rest for free	All for free
Penalty	A fine of 3 times the market price	A fine of 5 times the market price
Criteria for carbon leakage industry	Carbon intensity	Trade intensity
Please tick the one you prefer	□	□

3. Outline of the survey and statistics of the samples

3.1 Questionnaire format and survey arrangements

The data was collected by a survey from December 2012 to January 2013. A questionnaire was developed to measure the choice preferences of Korean companies to carbon tax and GHG ETS, and to identify their viewpoint on financial subsidy policies for industrial energy saving. The format consists of four major components: background of the company; company viewpoint on economic incentives for energy saving; choice preferences of companies on carbon tax; and, choice preferences of companies on GHG ETS. This chapter presents an analysis of company choice preferences on carbon tax policy and GHG ETS.

Due to the difficulty in requesting company top management to answer the questionnaire, as noted by Suk et al., (2013c), we targeted company energy or environmental managers at the middle level as such personnel are responsible for a company's energy management in practice and are fully aware of the policy impacts on energy cost changes of their companies. In explaining the survey objective and requirements, we requested the energy or environmental managers to answer the questions on behalf of their companies and consult with related staff such as financial managers as necessary. Their answers are taken to faithfully represent the actual context and choices of their companies. The format was sent, by mail or email, to key energy-consuming companies under control of the TMS. Questionnaires were sent to 230 companies, which produced 150 responses confirmed useful for this analysis.

3.2 Distribution of samples

The distribution of samples by size and sector is listed in table 14.5.

Table 14.5 Distribution of respondents by size and sector

Sector	Size				Number in total (%)
	Small	Medium	Medium-large	Large	
Iron & steel	1	13	8	4	26 (17.3)
Cement	6	4	3	1	14 (9.3)
Chemical	3	23	13	13	52 (34.7)
Paper making	3	27	6	0	36 (24.0)
electronics	0	1	12	9	22 (14.7)
Number in total (%)	13 (8.7)	68 (45.3)	42 (28.0)	27 (18.0)	150 (100.0)

The samples from iron & steel, cement, chemical, paper-making and electronics industries individually account for 17.3%, 9.3%, 34.7%, 24.0% and 14.7% of the total. Of the total 150 samples, 13 are small companies, 27 are large ones. The remaining 110 are medium-large or medium-sized. The ratios of small, medium, medium-large and large companies in total are respectively 8.7%, 45.3%, 28.0% and 18.0%. By ownership, 110 companies are domestically private, accounting for 73.3% of the total. The number of foreign-funded companies (Fully foreign-funded and joint-ventures) is 40, with a share of 26.7%.

4. Results and discussions

4.1 Characteristics of the samples

4.1.1 Energy consumption and CO_2 emissions of the samples

The companies were requested to check the range of their energy consumptions in 2010. A total of 145 companies answered this question. The result, as shown in fig.14.1, indicates that 98% of the respondents consumed more than 2,000 toe (tonnes of oil equivalent) of energy in 2010. The samples using more than 100,000 toe account for 20.7% of the total. According to Kim (2009b), only the top 2.2% of SMEs consumed more than 2,000 toe in 2009 and 85% of the rest SMEs used less than 200 toe. This implies that the respondents in this survey represent the largest energy-consuming SMEs in Korea.

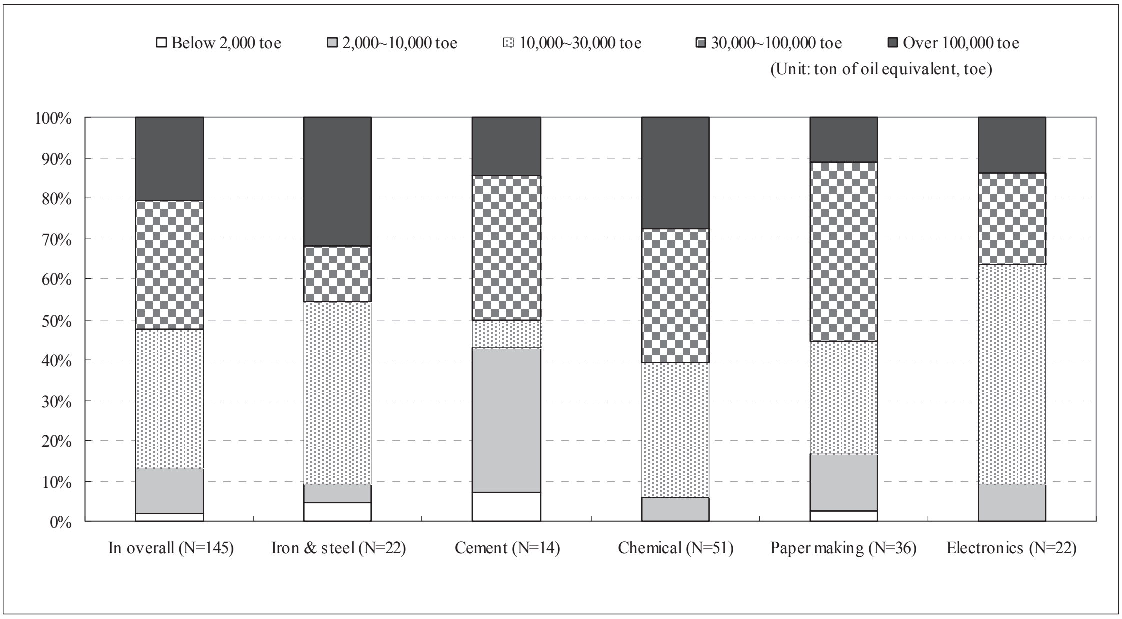

Figure 14.1 Energy consumptions of the samples by sector

The surveyed companies were also requested to elaborate on the types of energy they used and corresponding ratios of such to the total energy use. All the respondents provided answers. The energy use structure of the samples overall and by sector is summarised in fig.14.2. Electricity is the largest energy source for the surveyed companies as a whole, with a share of 55.4% of total energy use, natural gas is second and accounts for 19.1%, third is steam with a share of 7.3%, oil and coal together have shares around 9%, renewable energies account for 2.3% as minor sources and other types of energy, including LNG and Petro cokes account for the remaining 6.3%. Some differences between the energy use structures of the five sectors were observed. More than half of the energy used by iron & steel, chemical, paper-making and electronic industry is electricity, with respective shares of 60.8%, 52.7%, 50.2% and 84.0%. The ratio of electricity is less than 25% for cement companies, who instead use coal at a rate of about 60.4%, while the ratio of coal use is less than 2% for the other sectors.

Figure 14.3 shows the distribution of samples by share of energy costs of total sales. Overall, the surveyed companies indicate relatively low ratios of energy costs in the sales, revealing the low energy intensities of the samples overall; 24.7% of them have an energy cost ratio under 5%, and the majority of companies (around 47%) have an energy cost ratio of 5–10%. The companies with energy cost ratios of 20–30%, 30–50% and over 50% individually have respective shares of 4.1%, 1.4%, and 1.4%. Of the sectors, nearly 70% of iron & steel companies have an energy cost ratio of 5–10%. The cement companies exhibit high energy intensity – only 15.4% of cement companies have an energy cost ratio below 10%. Nearly 40% of them have an energy cost ratio of 10–20%, and 45% have energy cost ratios of over 20%. The surveyed chemical companies also have a relatively low energy cost ratios, with 66.0% of them having a ratio of below 10%. No companies in the chemical sector have an energy cost ratio of over 30%; 61.1% of the samples from the paper industry have an energy cost ratio of 5–10% and the share of electronic companies with energy cost ratios of less than 5% is more than 80%, indicating the lowest energy intensity of this sector compared with the other industries in this survey.

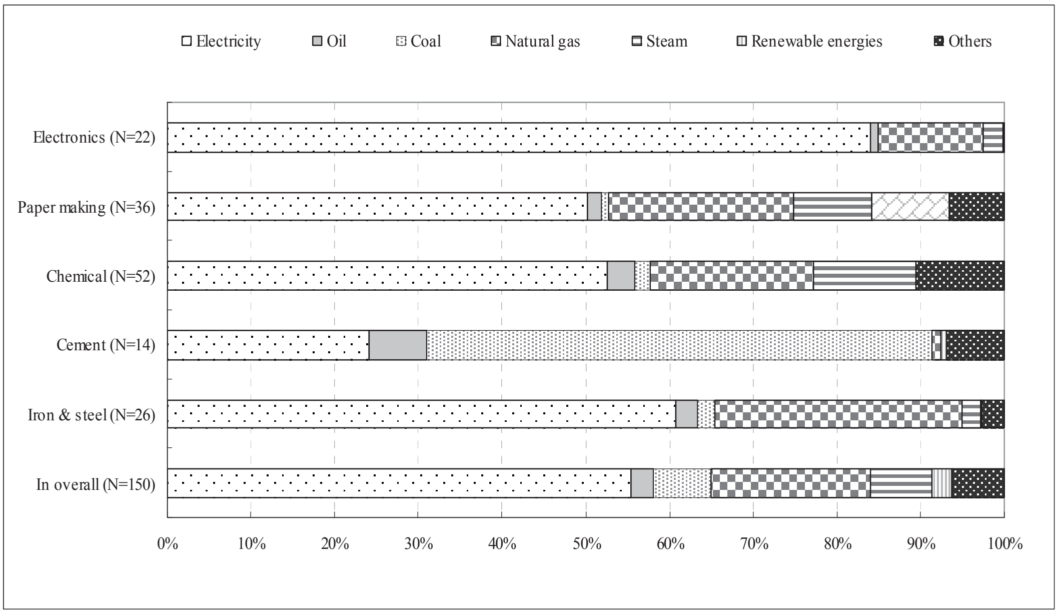

Figure 14.2 Energy use structures of the samples by sector

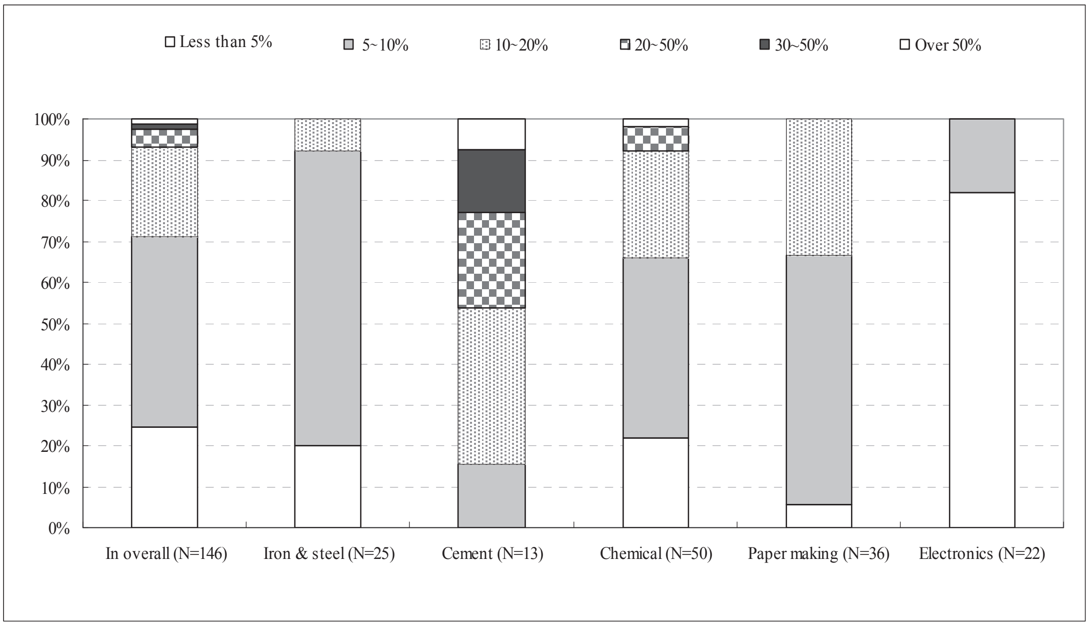

Figure 14.3 Energy cost ratios in total sales of the samples by sector

The surveyed companies were asked to indicate the range of their CO_2 emissions in 2011. As depicted in fig.14.4, the samples are large CO_2 emitters. Most of them (90.0%) emitted over

$25{,}000t\text{-}CO_2$ in 2011 and those emitting less than $5{,}000t\text{-}CO_2$ only account for 0.7%. The remaining companies answered that their CO_2 emissions are in the range of 5,000–$25{,}000t\text{-}CO_2$.

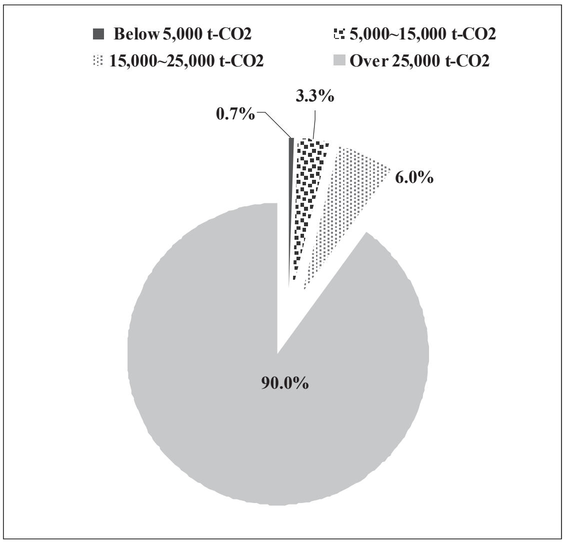

Figure 14.4 Range of CO_2 emissions of the samples in 2011 (N=150)

4.1.2 Energy saving management of the samples

The surveyed companies indicate good performance in internal energy monitoring and statistics. As shown in fig.14.5, of the 150 companies, less than 5% stated they had yet to establish a measurement and statistics system for internal energy use, whereas 76% had done so. Around 63% have specific departments and staff for energy management and adequate systems for internal energy measurement and statistics.

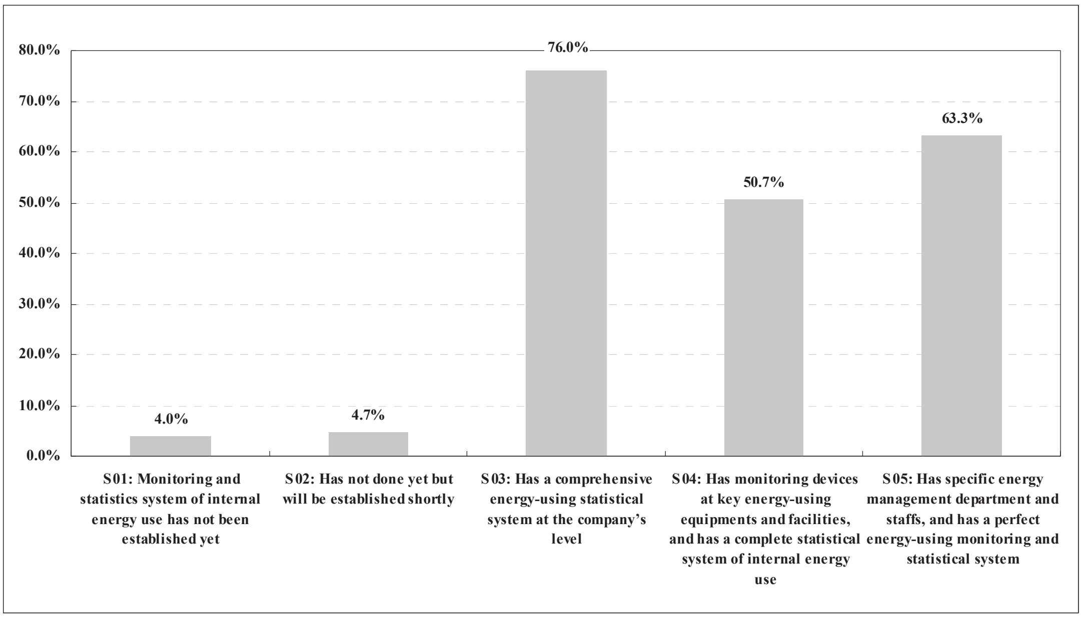

Figure 14.5 Monitoring and statistics of internal energy use of the companies (N=150)

We requested the companies to consider their technology level and the potential for energy saving. As indicated in fig.14.6, 48.7% of the samples confirmed that their production technologies are at the domestically average level, 24.0% view their technology levels to be domestically advanced and 20.0% answered that their production technologies are at the level of internationally advanced. Regarding energy saving potential, as shown in fig.14.7, nearly 65% of the companies evaluated that limited potential remains, 22% selected almost no potential and only 12.7% of the samples state that they have relatively large energy saving potentials.

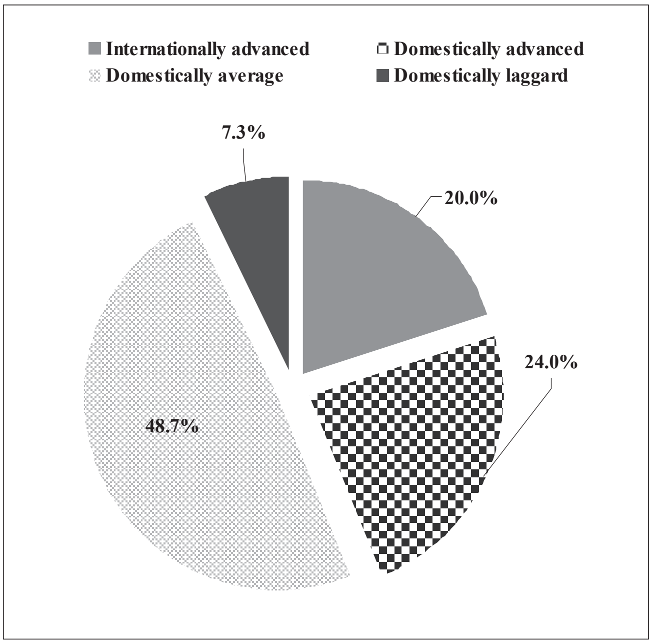

Figure 14.6 Company evaluation of its production technology level (N=150)

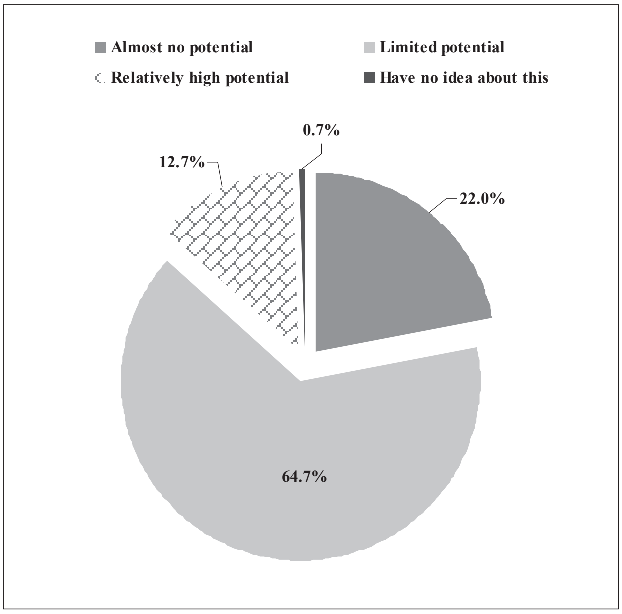

Figure 14.7 Company evaluation of its potential for energy saving (N=150)

4.2 Determination of number of latent classes

The measures of AIC, AIC3, BIC and HQIC were applied to determine the number of latent classes in this study. Regressions with various numbers of classes (1, 2, 3 and 4 classes) were performed, which produced the statistics listed in table 14.6.

Table 14.6 Information criteria for different numbers of latent classes

Classes	#Par	Log-likelihood	AIC	AIC3	BIC	HQIC
A: Choices of carbon tax policy						
1	6	-501.62	1015.2	1021.2	1044.1	1026.3
2	13	-475.08	976.2	989.2	1038.6	1000.0
3	20	-463.08	966.2	986.2	1062.2	1002.9
4	27	-457.88	969.8	996.8	1099.4	1019.3
B: Choices of GHG ETS						
1	6	-565.85	1143.7	1150.7	1172.5	1154.7
2	13	-541.19	1108.4	1121.4	1170.8	1132.2
3	20	-520.98	1082.0	1102.0	1178.0	1118.7
4	27	-517.26	1088.5	1115.5	1218.2	1138.0

The log likelihood values (column 3) at convergence reveal that the greater the number of classes was, the better the LC model would fit, especially in the cases from 1 to 2 class models for the choices of carbon tax and from 2 to 3 class models for GHG ETS. This is because log likelihood values normally increase in magnitude when there are more parameters estimated. For the choice dataset of carbon tax, the result indicates that the minimum values of BIC and HQIC (columns 6 and 7) have clear relevance to the 2-class model, suggesting that the 2-class model is optimal based on these two information criteria. The reductions of AIC and AIC3 (columns 4 and 5) are very small from 2-class to 3-class, confirming the negligible improvement between these two cases. We decided to select 2-class in the estimation for the choices of carbon tax by the LC model. For the choices of GHG ETS, the minimum values of the four information criteria (columns 4 to 7) are all associated with the 3-class model. Therefore, 3-class was determined for the regression of GHG ETS dataset using the LC model.

4.3 Characteristics of the class members

Results of class memberships for the 2-class and 3-class LC models respectively analysing the choice datasets of carbon tax and GHG ETS are reported in table 14.7.

The latent classes of the respondents are classified by the company size and sector belongings. The company size is categorised into four types – small, medium-sized, medium-large and large ones – which are represented by 'SMALL', 'MEDIUM', 'MLARGE' and 'LARGE', respectively. The sector belongings are divided into five categories: iron & steel, cement, chemical, paper and electronics, which are individually abbreviated as 'STEEL', 'CEMENT', 'CHEMICAL', 'PAPER' and 'ELECTRONICS'. The parameters of the second class for carbon tax and the third class for GHG ETS in table 14.7 (columns 4 and 7) are set to zero due to their normalisation in the estimations. The parameters of the other classes are considered as being relative to these benchmark classes. As a result, for the analysis of carbon tax, the samples from cement and chemical sectors are more likely to be in class 1 than the electronics companies. For the regression of GHG ETS, the members of class 2 may be characterised as large and medium large-sized companies from the paper industry.

Table 14.7 Relationship between class memberships and the company characteristics

	Variable	A: Choices of carbon tax policy		B: Choices of GHG ETS		
		Class 1	Class 2	Class 1	Class 2	Class 3
	Constant	-1.663 (1.350)	0	-0.184 (1.539)	-2.781 (2.218)	0
SIZE	LARGE	0.114 (1.256)	0	-0.177 (1.389)	3.720** (1.884)	0
SIZE	MLARGE	1.791 (1.185)	0	0.712 (1.386)	3.057* (1.796)	0
SIZE	MEDIUM	0.832 (1.046)	0	-0.234 (1.237)	0.755 (1.804)	0
SECTOR	STEEL	0.791 (0.952)	0	0.652 (1.155)	-0.223 (1.417)	0
SECTOR	CEMENT	2.474* (1.303)	0	34.561 (0.158D+08)	35.916 (0.158 D+08)	0
SECTOR	CHEMICAL	1.614* (0.868)	0	0.796 (1.037)	-0.081 (1.340)	0
SECTOR	PAPER	0.730 (1.014)	0	1.578 (1.250)	2.639* (1.497)	0

Note: Data in parentheses are standard errors; Asterisks * and ** respectively denote parameter significance at 10% and 5% levels

4.4 Results of the empirical analyses with various models

NLOGIT 5.0, the latest version of a LIMDEP software package specific for discrete choice modeling (Econometric Software, Inc.) was used to analyse the datasets in this survey. The estimation results of the 2-class LC model for the choices of carbon tax and the 3-class LC model for the choices of GHG ETS are listed in table 14.8 and table 14.9, respectively. For comparison, the estimation results using the MNL and RPL models are also provided in these two tables. To apply the RPL model, we assumed that the tax rate and allocation ratio of allowances by auction are normally distributed across the respondents respectively in the choices of carbon tax and GHG ETS, and held the parameters of all other policy attributes fixed. In terms of overall impression of the MNL, RPL and LC estimates, goodness of fit was significantly improved in the LC approach compared to the MNL and RPL models (pseudo R^{-}squared values greatly increased when using the LC model in tables 14.8 and 14.9). The analysis results of the choice datasets of carbon tax and GHG ETS are explained below.

4.4.1 Analysis results of choice dataset of carbon tax policy

As shown in table 14.8, the possibility of the respondents in class 1 is 57.2% and that in class 2 is 42.8% in the LC model. There are some obvious differences between the two classes of companies in their choice preference to carbon tax due to the influences of various attributes.

Table 14.8 Estimation results for the choices of carbon tax policy

Attribute	MNL	RPL	LC	
			Class 1	Class 2
TAXRATE	-0.00045***	-0.00056***	-0.00114***	-0.00017
RELIEF-B	0.419**	0.570***	1.800***	0.394
RELIEF-C	0.518**	0.592***	1.393**	0.423
REVENUE-B	0.296*	0.360**	1.348**	-0.081
REVENUE-C	-0.140	-0.101	-0.243	0.013
TIME	-1.038***	-1.058***	-2.635***	-0.031
Class probability			0.572	0.428
Log-likelihood	-501.62	-498.76	-470.35	
Pseudo R squared	0.169	0.201	0.246	
Obs.	900	900	900	

Notes: Standard errors are not reported, to save space; Asterisks *, ** and *** respectively denote parameter significance at 10%, 5% and 1% levels

The analysis results for class 1 respondents in the LC model are similar to the estimations using the MNL and RPL models. The level of tax rate significantly but negatively determines the company's choice preference to carbon tax policy, which is reasonable given that higher tax rates would incur heavier costs for a company's energy usage and thus increase resistance to this policy. Significant and positive relationships between tax relief measures and the respondent's policy preferences were confirmed in this analysis, which implies that allowing preferential tax treatments would increase the acceptability of companies to carbon taxing by cutting down the taxes either for energy-intensive industries (RELIEF-B) or for companies with energy efficiency improvements of certain levels (RELIEF-C). The utilisation of carbon tax revenues has a significant influence on a company's preference to this policy. The respondents view that use of revenues for a specific fund for climate change (REVENUE-B) is more preferable than for use as a general budget (REVENUE-A). However, the utilisation of carbon tax revenues to reduce a company's other taxes (REVENUE-C) does not differentiate their preference of this policy. The starting time is significant in determining a company's choice preference to carbon tax – the result indicates that postponing the carbon tax start date from 2015 to 2021 would significantly increase a company's preference. In summary, the analysis results in table 8 confirm that a carbon tax policy characterised as a lower tax rate, with tax relief measures for energy-intensive or energy-efficient industries, utilising tax revenues solely for climate change, and introducing such policy later rather than sooner would be more preferable from the perspective of the surveyed companies.

4.4.2 Analysis results of choice dataset of GHG ETS

Estimations of the GHG ETS choice dataset using the MNL, RPL and 3-class LC models are listed in table 14.9. In the LC model analysis, almost half of the respondents are classified into class 1, with a class possibility of 49.0%. The remaining 28.3% and 22.6% of samples belong to class 2 and class 3, respectively.

As with the results of MNL and RPL analysis, the companies in class 2 and 3 in the LC model prefer the grandfathering method in cap setting (CAP-A) rather than benchmarking (CAP-B). The samples in class 1 indicate a contrary preference between these two methods (CAP-A and CAP-B). For cap setting using a hybrid approach (CAP-C), the companies in class 2 and 3 show the contrast preferences in comparison with CAP-A; nevertheless, no significant relationship between CAP-C and a company's choice preference of GHG ETS could be found in the MNL and RPL model analyses.

Table 14.9 Estimation results for the choices of GHG ETS

Attribute	MNL	RPL	LC		
			Class 1	Class 2	Class 3
CAP-B	-0.440***	-0.440***	1.009***	-2.857***	-2.541***
CAP-C	-0.041	-0.041	0.340	-3.646***	3.337**
ALLOCATION	-4.844***	-4.846***	-7.957***	-4.293**	-12.301***
PENALTY-B	-0.622***	-0.622***	-1.071***	-0.607	-1.483**
PENALTY-C	-0.119	-0.119	-0.073	-0.866	-0.551
LEAKAGE	0.484***	0.484***	0.938***	0.844	1.861***
Class probability			0.490	0.283	0.226
Log-likelihood	-565.85	-565.84		-505.74	
Pseudo R squared	0.080	0.093		0.189	
Obs.	900	900		900	

Notes: Standard errors are not reported, to save space; Asterisks *, ** and *** respectively denote parameter significance at 10%, 5% and 1% levels

The allocation of carbon emissions allowances is a key aspect of GHG ETS. To allocate the allowances by auction would incur costs for carbon emissions of the companies and thus would be resisted by the policy-targeted companies. In this analysis, a significant but negative relationship between the variable ALLOCATION and a company's choice preference of GHG ETS was clearly indicated in all three models, which confirms the common-sense notion that increasing the auction ratio for the allowance allocation significantly reduces a company's preference of GHG ETS. With class 2 in the LC model as an exemption, a penalty of three times the credit price (PENALTY-B) significantly decreases the sample's choices of GHG ETS. A penalty of five times the market price of carbon credits (PENALTY-C) indicates no significant relationship with a company's choices of GHG ETS, which implies that a penalty as high as triple the market price of carbon credits is strict enough at present for ensuring the sampled Korean companies do not exceed their allocated allowances under GHG ETS. In addition, the criterion for the carbon leakage industry is significant in influencing a company's choice of GHG ETS. The respondents favour the use of carbon intensity as the criteria for preferential treatment under GHG ETS.

4.5 Relationships between various attributes of the policy

In this study, the tax rate and the auction ratio for allocating carbon allowances may be regarded as attributes for carbon tax and GHG ETS, respectively. To illustrate how the companies evaluate other policy attributes in comparison with monetary value, WTP values for the two policies are presented in table 14.10.

Table 14.10 Willingness-to-pay (WTP) indicating relationships between policy attributes

A: Choices of carbon tax policy				B: Choices of GHG ETS			
Attribute	WTP ($KRW/t\text{-}CO_2$)	95% Confidence Interval ($KRW/t\text{-}CO_2$)		Attribute	WTP (%)	95% Confidence Interval (%)	
RELIEF-B	-1804	-1851	-1758	CAP-B	16.2	11.5	20.9
RELIEF-C	-1607	-1688	-1526	CAP-C	12.9	6.6	19.3
REVENUE-B	-678	-785	-571	PENALTY-B	13.3	13.2	13.4
REVENUE-C	125	107	144	PENALTY-C	6.8	5.6	8.0
TIME	1665	1528	1803	LEAKAGE	-14.7	-15.1	-14.2

Notes: Tax rate is used as the denominator for choices of carbon tax policy in this estimation; For choices of GHG ETS, the allocation rate by auction is used as the denominator

WTP may be viewed as a tradeoff between the target attribute and the price attribute in determining a company's policy preferences. WTP values do vary across different policy attributes: for the carbon tax policy, the WTP values of RELIEF-B, RELIEF-C, REVENUE-B and TIME are all statistically significant. Setting tax relief measures for energy-intensive companies (RELIEF-B) equals a decrease of 1,804 $KRW/t\text{-}CO_2$ in tax rate in influencing a company's choice preference to a carbon tax. Similarly, the effect of changing from the utilisation of carbon tax revenues as general budget (REVENUE-A) to a specific fund for climate change (REVENUE-B) is the same as a decrease in tax rate of 678 $KRW/t\text{-}CO_2$. Regarding the starting time, the surveyed companies have equal choice preference to a carbon tax introduced in 2015 and the alternative of 2021 but with a tax rate increased by 1,665 KRW/t-CO2.

For GHG ETS, the WTP values of CAP-B, PENALTY-B and LEAKAGE are statistically significant. For cap setting, applying the benchmarking approach (CAP-B) rather than CAP-A is similar to an increase in auction ratio of 16.2% in influencing a company's choices of GHG ETS. An increase of 14.7% in auction ratio for carbon allowances allocation would be the same as a change in the criteria from trade intensity to carbon intensity in determining the carbon leakage industry.

5. Conclusions

This chapter summarises a choice experiment on Korean companies to measure their choice preferences to two representative carbon pricing tools – carbon tax and GHG ETS. Analyses using various models identified the policy attributes significantly determining a company's choices of policy alternatives. For carbon tax policy, a lower tax rate, allowing relief measures for energy-intensive or energy-efficient companies, use of tax revenues solely for energy saving and climate change and later introduction would increase the company's preference to this policy. For GHG ETS, different categories of companies have different preferences in cap-setting method. Around half of the sampled companies would prefer cap setting on the basis of historical emissions; the other half favours the benchmarking approach. A lower ratio of auction for allowance allocation is more preferable for the companies. Setting a penalty of three times the price of carbon credits would ensure the samples do not exceed their allocated emissions limits. Interpreting the results for industries with carbon leakage risks, carbon intensity is a more favorable option than trade intensity.

The findings of this analysis have meaningful implications for discussions and development of carbon pricing policies in Korea, especially from the perspective of industry. With carbon tax as an example, the discussions so far and our estimations of carbon prices affordable for Korean companies from earlier research indicate that introducing a carbon tax of 2,000–3,000 KRW/t-CO_2 would currently be feasible in Korea. However, TMS, as a regulative policy, has just been introduced (2011) to limit carbon emissions of large energy-consuming entities. A formal and domestic GHG ETS is slated to be launched at the start of 2015. In this context of related policy progress, Korea's government may require more time to consider whether to introduce a carbon tax and to determine how the various policies could be strung together. The result of this analysis reveals that if the start date for taxing carbon was delayed until 2021, the initial tax rate could range from 4,000–5,000 KRW/t-CO_2.

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ISBN：978-4-88788-173-0

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