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Affordability of energy cost increases for Korean companies due to market-based climate policies: a survey study by sector

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ABSTRACT

This paper estimates the affordability of energy cost increases for energy-intensive companies due to the introduction of market-based climate policies in Korea. Data were collected from 62 respondents from iron & steel, cement and petrochemical industries, over 90% of which are under control of the 'Target Management Scheme', an ongoing mandatory system limiting the greenhouse gases (GHG) emissions of large energy-consuming entities. The affordable energy cost increase was estimated using the multiple-bounded discrete choice (MBDC) format, results of which show that a mean energy cost increase of 2.6% is acceptable for all the entities sampled. Companies from the three sectors had similar affordability, with an average acceptable energy cost increase of 2.5–2.8%. The affordable policy-induced energy cost increases equate to carbon prices of 2500–4000 KRW/t-CO_2 (about 2.3–3.5 USD/t-CO_2) for the companies surveyed. Econometric analysis confirmed a strong correlation between energy price level and company ownership with cost affordability. With a view to developing carbon tax policy and a domestic GHG emissions trading scheme in Korea, this research provides a basis, from an industrial perspective, for carbon pricing.

1. Introduction

Korea is committed to being one of the leading low-carbon green growth hubs in Asia, and pledged in 2009 to reduce its greenhouse gases (GHG) emissions by 30% from the business as usual (BAU) scenario by 2020 compared with 2005 levels under the new national vision of the 'Low Carbon Green Growth' announced in 2008 (PCGG, 2009). In order to realise this target, regulatory measures such as the 'Target Management Scheme (TMS)' were launched, and since 2011 have limited the emissions of large energy-consuming entities (PCGG, 2010). TMS covers 471 business sites, with GHG emissions accounting for about 60% of the country's total in 2007 (MOE, 2010). Korea's government has also considered the use of market-based instruments (MBIs), particularly GHG emissions trading schemes (GHG ETS) and carbon tax policy, to reduce GHG emissions.

GHG ETS allows target entities to trade their GHG emissions permits. Theoretically, those who can reduce emissions most cheaply will do so, achieving reductions at the lowest cost to society (Montgomery, 1972). As the first large-scale GHG trading programme, Europe launched EU-ETS in 2005, which covered 11,400 installations in the initial phase (2005–2007). Allowances were allocated on the basis of historical emission levels of the target entities and member countries could auction up to 5% of their allowances, and any excess emissions incurred a penalty of 40 Euro/t-CO_2. During the second phase (2008–2012), EU-ETS was extended from its 27 EU members to 30 countries by the inclusion of Iceland, Liechtenstein and Norway. Fully-free emissions allowances for the power sector ended and the maximum allowance auction rate was raised to 10% from 5%. The third phase of EU-ETS is from 2013 to 2020, the goal of which is a 21% emissions reduction by programme target sectors from 2005 levels. A progressive move towards auctioning of allowances will further enhance the effectiveness of this scheme (Guo et al., 2011).

EU-ETS has since inspired other countries, including Korea, to consider cap and trade schemes of their own. Discussions on introducing domestic GHG ETS in Korea were started under the 'Framework Act on Low Carbon Green Growth' passed in 2010. Several studies analysed the economic effects and impacts of GHG ETS on Korean industry and concluded that this scheme would be more cost-effective (reduce costs by 44–68%) compared to mandatory regulations for achieving the 2020 national reduction

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target (PCGG, 2011; Kim, 2010; Lee, 2009). The latest version of Korea's GHG ETS bill, approved on 2 May 2012 and due to enter force on 1 January 2015, is aimed at the largest energy-consuming or GHG-emitting entities heading the list of TMS targets. The legislation provides for allowances to be allocated fully for free in the first phase (2015–2017), at 95–97% for the second phase (2018–2020) and at 90% for the third phase (2021–2025). It also allows the government to intervene in the market to stabilise credit prices. For companies failing to achieve their GHG reduction targets penalties will be levied at less than triple the average market price of carbon credits (PCGG, 2012).

A direct tax on the carbon content of fossil fuels (carbon tax) has also been reviewed in Korea as a possible measure to mitigate GHG in recent years. During 2008 to 2010, the Korea Institute for Public Finance (KIPF) studied green fiscal reform by addressing the negative externalities of the existing taxation system, and proposed a carbon tax policy to start in 2013, with a tax rate of 25 Euro/t-CO_2 and tax revenue equalling 1% of Korean GDP, to replace the transportation-energy-environment tax slated to end in 2012 (Kim et al., 2008). According to its 2009 report estimation, energy prices would hike by 4.10%, 37.90%, 4.39% and 6.05% respectively for oil, coal, gas and electricity due to this proposed carbon tax. KIPF later revised this proposal and recommended initial tax rates of 1/8 the above levels to make the policy more acceptable and to minimise negative economic impact (Kim and Kim, 2010). A recent proposal further reduces the above figure to 1/10 the original rate, and to start in 2016—equivalent to around 3000 KRW/t-CO_2 (about 2.7 USD/t-CO_2) (Shim, 2013). Kim (2013) extrapolated the policy effect of this carbon tax bill using 2009 input–output data into a maximum mitigation rate of 3.59% for GHG emissions.

In the context of recent developments in policy, an earlier survey conducted by the authors found that small and medium-sized enterprises (SMEs) of Korea tend to practice institutional and managerial energy saving activities, which incur relatively lower costs and efforts, rather than carry out research and development of energy efficient products. This is assumed to be because strategic cooperation with external business partners is absent, i.e., not factored into the business cycles for such SMEs, implying that Korean SMEs are still at an early stage in responding to governmental climate and energy saving countermeasures (Suk et al., 2013). In reality, there exists strong resistance from industry in Korea for the introduction of carbon pricing policies, including GHG ETS and carbon taxing (Liu et al., 2011, 2012). Based on the general consensus that Korea's economy is export-oriented and dominated by energy-intensive industries, the industrial sector is thus highly sensitive to any potential loss of international competitiveness that may result from increased energy costs due to carbon pricing policies. Further, Korea fails to see why it alone needs to change, considering other major economies such as the U.S. and Japan have shelved their GHG ETS plans, and the general lack of real progress in climate negotiations at the global level (Liu et al., 2012).

Discussions revealed that, on a practical level, the acceptance level of policy targets for industry is a key factor affecting progress and a successful outcome for carbon pricing policies. Previous researches have mainly focused on the question of how economic climate policies would affect Korean industries (Kang et al., 2011; Kim et al., 2010; Kim, 2009a; Kim, 2009b; Kim, 2008b)—few studies have actually tested the affordability of energy cost increases due to the introduction of MBIs from the perspective of individual companies in Korea. To overcome this policy practice gap this research estimates the affordability of Korean companies for energy cost increases based on a phase-in of market-based climate policies. Three energy-intensive sectors—iron & steel, cement and petrochemical industries—were selected as survey targets, since they were major CO_2 emitters and accounted for over 75% of emissions from the manufacturing industry in 2007 (MOE, 2011a), as detailed in Section 2.

Two topics are discussed in this paper. One is how the affordability for companies in the target sectors regarding energy cost increases can be estimated; the other is how the external and internal determinant factors can be identified, to clarify the relationships between affordability levels and company characteristics. The remainder of this paper is structured as follows. Section 2 gives an overview of the three target sectors in terms of their overall status and energy efficiency; Section 3 explains the methodology, including the models for estimating affordability of companies on energy cost increases by multiple-bounded discrete choice (MBDC) data, the analytical frame identifying the determinants of the estimated affordability and an outline of the questionnaire survey, and Section 4 discusses the results of affordability estimations and econometric analysis. Section 5 concludes the research findings.

2. Overview of the three target sectors

Korea's robust economic growth over the past half-century has chiefly been achieved through energy-intensive manufacturing industries—in particular, iron & steel, petrochemicals and cement (Kim et al., 2011). Exports of Korean energy-intensive industries amounted to 75.0 billion USD in 2007, 20.2% of the country's total of the same year (Park and Kim, 2009). Specifically, exports from the iron & steel industry increased from 4.2 billion USD in 1990 to 25 billion USD in 2010, for a share of 6.0% of total exports (source: http://www.kosa.or.kr). As a major product of the petrochemical industry, ethylene production ranked fifth in the world with a global share of 5.5% in 2007, and exports in 2009 amounted to 27.4 billion USD, accounting for 6.5% of total exports in the same year (source: http://kpia.or.kr/index.html). Korea currently has 10 cement companies, which produce about 6.2 million tons of cement per year, exported to the U.S., Japan and Africa (source: http://www.cement.or.kr).

In terms of energy use, the manufacturing industry consumed more than 55% of the country's total energy in 2008 (Kim et al., 2011). In comparison with the energy consumption (of energy-intensive industries in terms of total energy use) in OECD countries as a whole over the period 1997–2006, which dropped from 23% to 22%, that of Korea increased from 32% to 38% over the same period (Park and Kim, 2009). The three sectors in this study are major energy-consuming industries in Korea. In 2009, Korea's petrochemicals industry used 50.904 million TOE (tonnes of oil equivalent) of energy; of this, 83.1% was non-energy oil and second was electricity, with a share of 6.8% (KEEI, 2011). Bituminous coal is the largest energy source for the iron & steel industry. Of the total 19.35 million TOE of energy used by this sector in 2009, 75% was bituminous coal. Shares of electricity, city gas and oil were 15.6%, 7.5% and 1.8% individually. As in the iron & steel industry, energy use in the cement sector is dominated by bituminous coal; in 2010, cement consumed 3.966 million TOE of energy overall, of which bituminous coal had a share of 71.7% and electricity accounted for 27.8% (KEEI, 2011). During 1990–1997, energy efficiency in the three target sectors improved steadily: at an annual rate of 3% for petrochemicals, 1% for iron & steel and 0.9% for cement; however, this encouraging trend ended after the Asian financial crisis in 1997 (Park and Kim, 2009).

The three sectors under review are major emitters of CO_2 in Korea due to their heavy use of fossil fuels. Of the total 233 million tonnes of CO_2 emissions from the manufacturing industry in 2007, petrochemicals emitted 50.7 million, with a share of 21.7%. Iron & steel and cement emitted 86.0 and 42.2 million, with respective shares of 36.9% and 18.1%. Overall, these three sectors accounted for

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	☐	☐	☐	☐	✓

Fig. 1. A question and example response of MBDC format in this study.

more than 75% of CO_2 emissions from the manufacturing industry in 2007 (MOE, 2011a). Based on an MOE (2011b) estimate that BAU (business as usual) emissions from the petrochemicals sector would reach 63.47 million tonnes of CO_2 by 2020, this represents an increase of 25% from 2007. Accordingly, the BAU emissions of iron & steel and cement industries will be 121.35 and 41.48 million tonnes of CO_2 by 2020, an increase of 41.1% and a slight decrease of 1.7% from the 2007 levels, respectively. Aiming to realise the country's 30% mitigation goal, the sectors of petrochemicals, iron & steel and cement are therefore required to reduce their emissions by 7.5%, 6.5% and 8.5% compared with the projected BAU levels by 2020.

3. Methodology

3.1. Estimating affordability of energy cost increases for companies

3.1.1. Multiple-bounded discrete choice questionnaire

Contingent valuation (CV) is a survey-based economic technique and a stated preference model for placing a monetary value on a good. This approach is the only valuation technique capable of measuring non-use values and is well suited for public goods and non-market private goods. One problem in applying this method, however, is that it may present respondents with goods they are unfamiliar with and choices they would not normally face. The CV method has been widely used to estimate an individual's willingness-to-pay (WTP) for environmental improvements or willingness-to-accept (WTA) the compensation of ecological damage and pollution. Wang (1997) argued that uncertainty would be inherent in public valuations of commodities or services, i.e., that a distribution rather than a single number will result. The uncertainty of the CV method can be dealt with 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. The other is to request respondents 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 reveal the superiority of increasing the 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 developed method for CV estimation, the 'return potential' format, used by sociologists to measure the strength of social norms, was adapted for the MBDC questionnaire (Welsh and Bishop, 1993). The MBDC format is a two-dimensional matrix, in which one dimension delineates different levels of the commodity and the other elicits preference intensity. This approach contains elements of both the payment card (PC) and DC approaches widely used in CV research. Like the PC format, however, respondents are presented with an ordered sequence of thresholds, but rather than circling a single value or interval, the respondent is given a 'polychotomous choice' option, a format that allows respondents to vote on a wide range of referendums and express voting certainty for each. Therefore, the MBDC technique reinforces the quantity and quality of data to better approach real values.

Inspired by the research of Wang and He (2010) on the public's WTP, an MBDC questionnaire was applied in this survey to estimate affordability of individual companies for energy cost increases due to the introduction of economic climate policies. Referring to Welsh and Poe (1998), the questions and format prepared for the surveyed companies and an example response from a cement company are shown in Fig. 1. The companies are presented with an ordered and ascending sequence of energy cost increase thresholds and multi-choice options, 'easily acceptable', 'acceptable', 'barely acceptable', 'rejection' and 'strong rejection'. Although it collects more information from each respondent, the MBDC approach is more difficult to implement than traditional survey approaches, as witnessed by the presence of some awkward responses, such as incomplete answers, in our survey.

3.1.2. Estimation models for affordability for companies

Various models have been proposed for the likelihood matrix data gathered by the MBDC questionnaire. The most prominent are those developed by Welsh and Poe (1998) and Alberini et al. (2003). Welsh and Poe (1998) employed information from the MBDC technique and conducted WTP analysis based on the multiple-bounded maximum likelihood interval modelling approach and found that their multi-bounded questions with 13 bids (14 intervals) could reduce the confidence bounds around estimates of WTP by over 60% relative to a single-bounded question with the same bid design. However, this model is straightforward and has an underlying assumption that all respondents share the same valuation distribution; but, the analysis actually makes full use of only one dimension of the information enrichment from the MBDC panel—the discrete choice of bid price levels. Alberini et al. (2003) extended the random valuation threshold model via a log-likelihood function to enable retaining all the response categories reflecting the different preference certainties of each respondent. This extended random valuation model permits the threshold to be individualised and offers the possibility to measure the degree of uncertainty of each individual. The disadvantage of this approach, however, is that estimation incorrectly treats the same individual's responses across the alternative bid values as independent (Vossler and Poe, 2005).

This study applied the two-stage estimation approach proposed by Wang and He (2010). The subjective verbal likelihoods presented by the respondents are encoded into numerical data for estimations. Taking the affordable cost increase rate of a company i as V_i, which is a random variable with a cumulative distribution function $F(r)$, the mean value of V_i is μ_i and the standard variance is σ_i. The cost affordability model can be written as,

$$V_i = \mu_i + \varepsilon_i \tag{1}$$

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

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

Once P_{ij}, the probability for the individual company i to agree with the increase rate 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,

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

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

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

At the first stage, 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 as the second step to analyse the factors determining the affordability. For instance, linear models can be expressed as,

$$\mu_i = \beta_0 + \beta X_i + \varepsilon \tag{5}$$

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.

As described in Wang and He (2010), this two-stage approach may provide a less biased estimation of the mean values and the variances of valuation distributions of individual companies since no econometric models are introduced at the first stage. The linear modelling results at the second stage can be easily compared with the results of the other CV approaches. The only bias that could be introduced comes from the WTP distribution assumption, which was confirmed as not being serious in Wang and Whittington (2005).

3.2. *Econometric analysis of the determinants of affordability for companies*

3.2.1. *Analytical framework and the determinants*

In this study, we 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. 2, and is similar to our previous analysis of the affordability of energy cost increases for Chinese companies (Liu et al., 2013). The determinant factors are described in detail in the following paragraphs.

The determinants of affordability of companies on energy cost increases are classified into external pressures and internal factors. Two external pressures were defined. One is the energy price pressure felt by companies—if a company felt energy prices to be already high, it would be hard for it to accept additional increases in energy costs. The other external pressure is the strength of market competition—a company would be reluctant to take on an additional cost burden to avoid the loss of competitiveness if competition in the sector was fierce.

Four internal factors were classified accordingly. One is the energy saving strategy of companies, indicating willingness to improve energy management. It is understandable that a company would more easily afford an energy cost increase if it were motivated to increase energy efficiency. The second is company awareness of energy saving technologies, both existing and new. Being aware of technological alternatives would enable a company to more accurately evaluate the measures dealing with business risks due to energy cost increases. Energy saving potential is categorised as the third internal factor. Companies with higher energy saving potential can more flexibly alleviate the energy cost burden by self reduction efforts. The last internal factor is a company's learning capacity. A company's energy efficiency is a kind of environmental performance, which is dynamic and related to the company's learning capacity (Hart, 1995). Raising the level of individual skills can help transform the skills of the organisation as a whole, but the learning process itself largely depends on interrelations among individuals and groups within the organisation (Lozano, 2008), and various factors influence the learning dynamic, such as manager integration power, external linkages and codification of experience (Chen et al., 2009). To simplify this analysis, the educational level of employees is used as a proxy for this factor as it is the basis of a company's learning capacity.

Regarding company characteristics, size, industrial sector and ownership were selected. The involvement status of TMS was added as another control for this analysis. As energy-intensive sectors are naturally more sensitive to changes in energy costs, proposals for carbon pricing policies often provide relief measures for energy-intensive sectors to overcome the resistance anticipated 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 in equation (4). The abbreviations, descriptions and valuations of determinant factors as independent variables and company characteristics as controls are listed in Table 1.

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

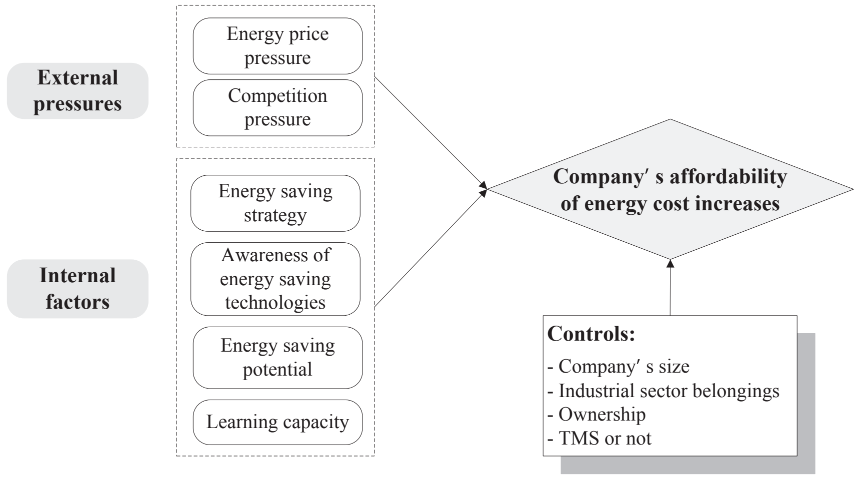

Fig. 2. Analytical framework for econometric analysis.

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. A five-level classification was applied, with '5' referring to a company having clear annual and internally decomposed energy saving targets; '4' as one having a specific annual target; '3' as one having a short- to medium-term target of 3–5 years; '2' as one having only a rough target in the long run, and '1' as one having no quantitative targets. The average educational level of employees, AVGEDU, was used to indicate the company's learning capacity. Five categories were used, with '1' = the rate 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%.

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

3.2.3. Econometric model

The regression 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.

$$\begin{aligned}\text{MEANAFFORD} = {} & \beta_0 + \beta_1\text{ENPRICE} + \beta_2\text{COMPETITION} \\ & + \beta_3\text{ENSTRATEGY} + \beta_4\text{EXISTINGTECH} \\ & + \beta_5\text{NEWTECH} + \beta_6\text{SAVPOTENTIAL} \\ & + \beta_7\text{AVGEDU} + \beta_8\text{SIZE} + \beta_9\text{SECTOR} \\ & + \beta_{10}\text{OWNERSHIP} + \beta_{11}\text{TMS} + \varepsilon \qquad (6)\end{aligned}$$

3.3. Outline of the survey and samples

Based on an understanding of the situation in Korea, a questionnaire was designed with the main objective of measuring the affordability of companies for energy cost increases due to the introduction of MBIs and identifying the corresponding determinants. The questionnaire consisted of four major components: company general information; company energy use and management status; the acceptability degrees to various rates of energy cost increases due to economic climate policies; and, the external pressures felt by the company and the company's internal factors, as shown in Table 1.

Data were collected by the questionnaire survey from January 25 to February 10, 2012. Questionnaires was sent via fax and email to a total of 205 companies—137 targeted by TMS and 68 non-TMS—intended to be filled out by environmental and energy managers. Of these, answers received from 62 companies were collected and confirmed to be valid. The distribution of the usable samples by company characteristics is summarised in Table 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 based on number of employees only, 27 were medium-sized companies having a staff of 50–300, two were small companies with a staff of less than 50, and 13 were large companies with a staff of over 1000. The remaining 20 were large medium-sized, i.e., between large and medium-size companies. Of the total 62 samples, 58 respondents were TMS targets.

4. Results and discussions

4.1. Energy use status of the samples

The surveyed companies were requested to elaborate on the types of energies and their corresponding rates in total energy use. The energy use structure of the samples overall and by sector is statistically summarised in Fig. 3.

The results confirm that electricity is the largest energy source for the surveyed companies as a whole, with an average share of 51% of total energy use; natural gas is second-largest and accounts for 17% of total energy use; and third is steam with a share of about 9%. Oil and coal share around 7% each, and renewables account for less 1% as a minor source. The remaining 8% is others, including LNG and Petro cokes.

Regarding the energy use structures of the three target sectors, several differences were found. Iron & steel and chemicals use electricity mostly, with a share of 64% and 51% respectively. The rate of electricity used by the surveyed 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 rate is less than 5% for the chemical and steel sectors. Steel companies in the survey use natural gas as the second largest energy source, accounting for about 25%. Natural gas and steam are used at the same

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Table 1
Abbreviations, descriptions and valuations 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	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	Level of energy saving potential of the company	
	AVGEDU	Average education level of the company's employees	
Controls	SIZE	Organisational size	
	SECTOR	Industrial sector to which the company belongs	
	OWNERSHIP	Company's ownership status	
	TMS	Status of TMS involvement	

rate of 15.5% as the second largest energy source for the chemical companies.

Fig. 4 shows the distribution of energy cost shares in total sales of the samples by sector. Rather than units of physical quantity, this rate represents energy intensity as an energy value. Overall, the samples have an even distribution of energy cost rates up to 20%. Nearly 30% of companies have an energy cost rate of 5–10%; companies with energy cost rates of less 5% and 10–20% individually have a similar share of around 25%. The remaining 16% of samples have an energy cost rate of 20–50%. The surveyed cement companies indicate high rates of energy costs in sales; around 55% have an energy cost rate of 20–50%, 9% of them have costs of over 50% of sales for energy use, and 27% answered their energy cost rates range from 10 to 20%. The remaining 9% have energy costs of 5–10% in total sales. For the chemical sector, almost 90% of the surveyed companies have an energy cost rate below 20%. The companies with energy cost rates of less 5%, 5–10% and 10–20% individually account for 31%, 37% and 23% of the total samples from this sector. Another 6% have energy cost rates of 20–50%. As in the chemical sector, most steel companies have energy cost rates below 20%. About 30% of steel companies have a rate of below 5% and 10–20%, respectively; 25% of them have an energy cost rate of 5–10%. The remaining 12.5% have an energy cost rate of 20–50%.

4.2. *Affordability of energy cost increases for companies*

The affordability of energy cost increases for companies was monitored by the MBDC format as shown in Fig. 1, which shows ten thresholds of energy cost increase. The reliability of this measurement was tested using Cronbach's alpha, which produced a result for all the samples of 0.9075. This figure is above 0.70, the criteria recommended by Nunnally and Bernstein (1994), and thus confirmed the reliability of the survey data construct.

Table 2
Distribution of usable respondents by company characteristics.

Company characteristics		Number of samples: Small	Medium	Large medium	Large	Number in total (percentage)
Number in total (Percentage)		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)
	Petrochemicals	–	13	13	9	35 (56.5)
TMS	TMS	2	26	17	13	58 (93.5)
	Non-TMS	–	1	3	–	4 (6.5)

4.2.1. *Statistics of cost affordability of the samples overall*

Table 3 lists the statistics of affordability of all the valid respondents to each energy cost increase rate presented in the MBDC format. A total of 36 companies fully circled the format and their answers were used for the 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. Another 55.6% of respondents expressed that it is no problem for them to afford this increase. The remaining 22.2% selected 'barely acceptable' for this increase rate. In summary, all the respondents could afford this increase. The share of companies with acceptance degrees of barely acceptable and beyond dropped to 94.4% at the increase rate of 0.5%, 80.6% at the rate of 1.0%, and 30.5% at the rate of 3.0%. The rates of companies with affordability degrees of 'barely acceptable' and over continue to decrease with growing energy cost increases. More than 91.6% of the companies viewed an increase of 10.0% to be high and answered with rejection or strong rejection. Energy cost increase rates of 20% and over are rejected or strongly rejected by all the surveyed companies.

Fig. 5 depicts the results of aggregated data listed in Table 3 and the simulation curves. Two groups of data, easily acceptable and acceptable, and barely acceptable and the beyond, are shown in the figure because they are meaningful for observing the rough range of energy cost increase rates acceptable of the sampled companies. A cumulative normal distribution model was applied for the regressions with the aggregative shares of the samples as a dependent variable and the energy cost rates as an independent variable. The R squared for regressions of the two sets of data is 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 rates of 0.6% and 2.3% on the two curves. The mean of energy cost increase rates affordable for the samples may be between 0.6% and 2.3%.

4.2.2. *Statistical summary of the affordability for iron & steel companies*

Table 4 lists the statistics of affordability for samples from the iron & steel industry. At the lowest rate of 0.1%, 36.4% of respondents indicated the increase to be too low and easily

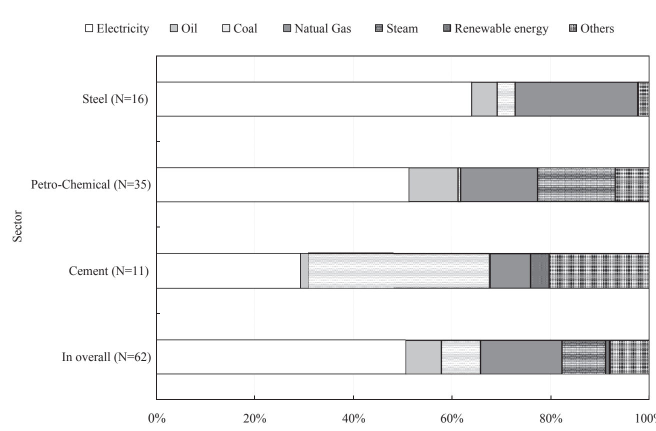

Fig. 3. Energy use structure of the samples by sector.

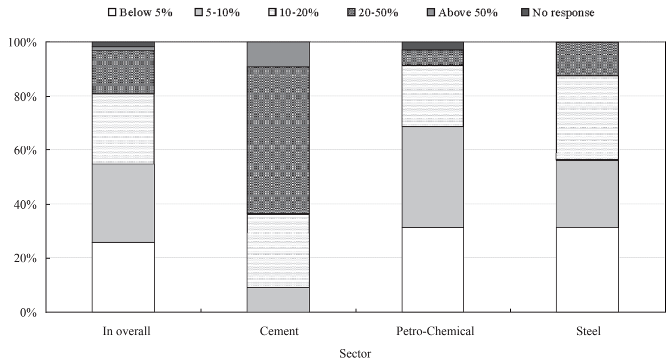

Fig. 4. Distribution of energy cost shares in total sales by sector.

acceptable, and 45.5% of the companies thought it was unproblematic to accept this increase. Another 18.2% selected 'barely acceptable' for this increase rate. Therefore, all the respondents could accept this rate. The share of samples with selections of barely acceptable and beyond dropped to 90.9% when energy cost increased by a rate of 1.0%. This number drastically fell to 18.2% at the rate of 3.0%, and 9.1% at the rate of 7.0%. Less than 10% of the companies thought they would accept an increase rate of 10.0%. All the surveyed companies rejected the energy cost increase rate of 20% and over.

Fig. 6 presents the aggregation results of observed data listed in Table 4 and the regression curves thereof. The R squared for the regressions of two sets of data is 0.9523 and 0.9708, respectively, confirming that the simulations are appropriate. The affordability of 50% corresponds to an energy cost increase rate 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.

4.2.3. Statistical summary of the affordability for chemical companies

Table 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 20. At the lowest rate 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 rate. This result confirms full acceptance of the respondents to this rate. The share of the samples with selections of barely acceptable and beyond dropped to 75.0% at the increase rate of 1.0%, and 35.0% at the rates of 3.0%. The affordability continues to decrease as the energy cost increase rates are raised. Five percent of the chemical companies believed that they would barely accept an increase rate of 10.0%. All of the chemical companies viewed an increase of 20.0% and over to be high and selected the answer of rejection and strong rejection.

Fig. 7 presents the aggregation results of observed data listed in Table 5 and the regression curves thereof 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 rate of 0.7% and 2.5% respectively on the two curves, which is almost same as that of all the samples and the iron & steel sector.

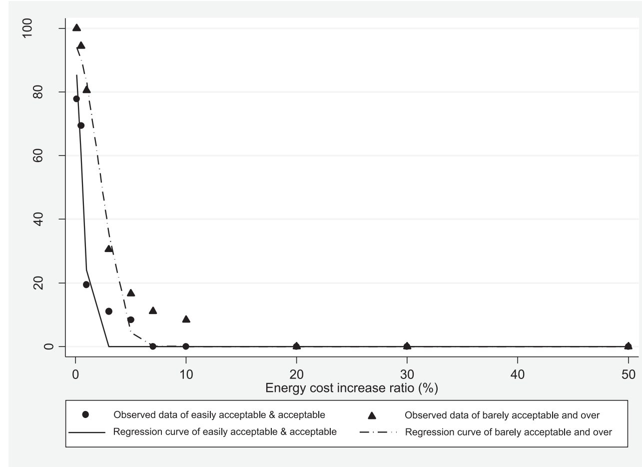

Fig. 5. Affordability of energy cost increases of all the samples ($N = 36$).

4.3. 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). As discussed earlier, numerical likelihood values of affording energy cost increase rates need to be assigned to the verbal expressions in MBDC format. 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 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 rates affordable for all the surveyed companies is 2.6%, which drops near the range of affordability, 0.6%–2.3%, preliminarily observed from Fig. 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

Table 3
Statistics of affordability responses of all the samples ($N = 36$).

Energy cost increase rate (%)	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

Table 4
Statistics of affordability responses of iron & steel companies ($N = 11$).

Energy cost increase rate (%)	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

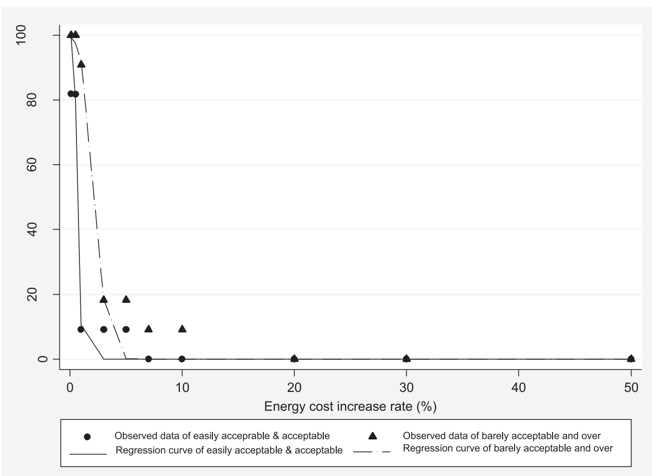

Fig. 6. Affordability of energy cost increases for the iron & steel industry ($N = 11$).

of energy cost increase rates 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 the same at 1.6%, which is almost the same as that of all the samples. The mean and medium value of energy cost increase affordability for the cement sector is 2.8% and 1.8%. In comparison with a similar 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 the perception of Korean companies in their limited energy saving potential, particularly for the energy-intensive industries targeted in this survey.

4.4. Statistics of the determinant factors and controls

Table 7 summarises the statistics of determinants as independent variables in Equation (6). 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. This 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, as EXISTINGTECH and NEWTECH achieved 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 a domestically advanced level and have limited potential for further improvement in energy efficiency. A mean of 2.43 for AVGEDU indicates that the company employee education level is not so high. Around 30% of the sampled companies have a share of 50% of employees with college level and above education.

Regarding the characteristics of companies, the distribution of samples by sector and size has been described in Section 4. The rates of samples with an ownership of domestically private and foreign-funded are 88.7% and 11.3%, respectively.

4.5. 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 8.

There is no indication for an unacceptable level of multicollinearity 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

Table 5
Statistics of affordability responses of chemical companies ($N = 20$).

Energy cost increase rate (%)	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

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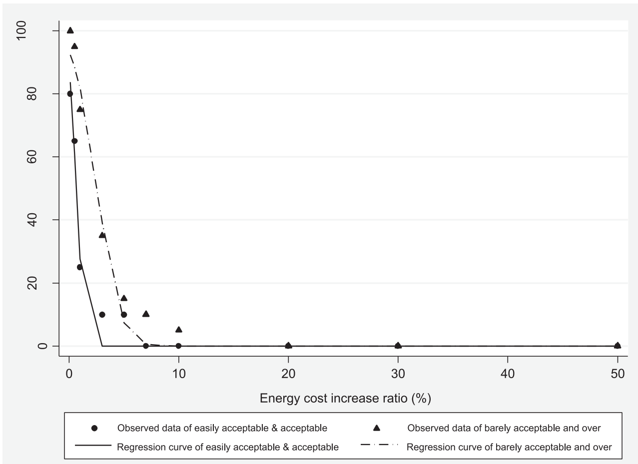

Fig. 7. Affordability of energy cost increases for the chemical industry ($N = 20$).

Table 6
Distribution of estimated individual company's cost affordability.

Variable	Percentile	Centile (%)	95% Conf. Interval (%)	
Panel A: All the samples ($N = 36$)				
Mean of μ: 2.6%	10	0.4	0.1	0.5
The std. dev. of μ: 3.9%	30	0.7	0.5	1.4
	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 ($N = 11$)				
Mean of μ: 2.5%	10	0.5	0.5	1.0
The std. dev. of μ: 3.8%	30	0.9	0.5	1.6
	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 ($N = 5$)				
Mean of μ: 2.8%	10	0.1	0.1	1.5
The std. dev. of μ: 4.3%	30	4.1	0.1	3.9
	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 ($N = 20$)				
Mean of μ: 2.6%	10	0.3	0.1	0.6
The std. dev. of μ: 3.8%	30	0.7	0.4	1.6
	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.

expected not to occur 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 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

4.6. Multivariate regression results of the estimated affordability

Table 9 presents the results of econometric analysis of the estimated affordability of the companies using equation (6). This analysis tests the validity and quality of the affordability estimations for individual companies since the estimated results track underlying economic factors and intuitive comprehension. In practice, econometric analysis can check the ordering effects of matrix design in the MBDC approach. As a referendum method, there may be an anchoring effect of the cost presentation sequence in the MBDC format. Considering the difficulty in requesting cooperation from companies, the questionnaire in this survey only used an identical matrix starting at the lowest cost increase rate, with all the other rate options ascending. Therefore, anchoring effects cannot be tested in this analysis.

The robustness of the analysis results was tested by repeating the regression with gradual introduction of the independent variables and controls. Three models were adopted: Model 1 only imports 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 of the determinants that have significant relationships with the estimated affordability. It is indicated that energy price level and ownership are significantly associated with affordability. Compared with domestically private companies, foreign-funded ones have relatively higher affordability for energy cost increases. If a company feels energy prices are already high, it would be more difficult for such company to afford additional energy price increases resulting from the pricing of carbon emissions. All other determinant factors and controls, including the company sector and size, reveal no significant effect on the estimated cost affordability.

4.7. Carbon price affordability for the companies by sector

According to carbon tax policy, costs are ascribed to CO_2 emissions based on a specific carbon tax rate, and the price of CO_2 emissions under GHG ETS is determined by supply and demand of emissions credits in the carbon market. Energy cost increases that a company or sector can afford on average, *MEANAFFORD*, equates to the affordable price of carbon in response to the introduction of carbon pricing policies, the relationship of which can be expressed as equation (7), where i means the energy type.

$$\mathrm{MEANAFFORD} = \frac{\sum_i \mathrm{Emission\ factor}_i \times \mathrm{Use\ amount}_i \times \mathrm{Affordable\ carbon\ price}}{\sum_i \mathrm{Energy\ price}_i \times \mathrm{Use\ amount}_i} = \frac{\sum_i \mathrm{Emission\ factor}_i \times \mathrm{Energy\ ratio}_i \times \mathrm{Affordable\ carbon\ price}}{\sum_i \mathrm{Energy\ price}_i \times \mathrm{Energy\ ratio}_i} \quad (7)$$

Table 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%.

To arrive at an affordable price for carbon for the respondents, equation (7) can be incorporated into the following equation (8), which uses the mean of affordable rates of energy cost increases, *MEANAFFORD*, and the surveyed rates of energy uses of the companies by type.

$$\text{Affordable carbon price} = \text{MEANAFFORD} \times \frac{\sum_i \text{Energy price}_i \times \text{Energy ratio}_i}{\sum_i \text{Emission factor}_i \times \text{Energy ratio}_i} \quad (8)$$

The data sources and calculation results are listed in Table 10. An underlying assumption for this calculation is that price increases of the secondary energies (including electricity and steam) due to the introduction of climate economic policies are fully passed on to the final energy users.

The calculation results indicate that a carbon price of 2500 to 4000 KRW/t-CO_2 (about 2.3–3.5 USD/t-CO_2) would be acceptable for the surveyed companies in Korea. These figures are much lower than the price level affordable for Chinese companies (which range from 6 to 12 USD/t-CO_2) in our previous survey (Liu et al., 2013). In comparison with the carbon tax policies actually practiced in Europe—20 Euro/t-CO_2 in 2010 for Finland (the first country to introduce the tax) and approx. 13 Euro/t-CO_2 for Denmark (since 2002)—the carbon price affordable for Korean companies is thus comparatively low. However, blanket agreement between the EU member states has not been reached and the current European Commission (EC) proposal is 4–30 Euro/t-CO_2 (SBS News, 2013).

There exists a large gap between the present cost affordability of Korean companies and the carbon price identified by macroeconomic modelling for realising the country's GHG mitigation target over the medium term. Kwon and Heo (2010) suggested that a carbon tax equivalent to 36,545 KRW/t-CO_2 (about 31 USD/t-CO_2) would be required to achieve Korea's 2020 mitigation target. Calvin et al. (2012) compared the Copenhagen pledges to the results from 23 different models, all of which participated in the Asia Modelling Exercise (AME), and found that of the nine models reporting results for Korea only two ever attain the pledged amount, with carbon prices of 30–50 USD/t-CO_2. Nevertheless, a recent KIPF report recommends that the carbon tax should be introduced in Korea at a lower rate initially, bearing in mind the short-term negative impact on industrial competitiveness and acceptance at the company level (Kim and Kim, 2010). Kim and Kim (2010) thus suggested a carbon tax rate at the level of 1/8 that of KIPF's first proposal which was 25 EURO/t-CO_2, equivalent to 31,328 KRW/t-CO_2 and 28.2 USD/t-CO_2 (Kim et al., 2008). Therefore, the estimated carbon price affordable for companies in this survey is at a level comparable with the tax rate proposed by KIPF, which confirms that KIPF's latest carbon tax proposal, in terms of the tax rate, would be acceptable for the Korean companies surveyed.

5. Conclusions

This study extended application of the MBDC technique to estimate the affordability of Korean companies in energy-intensive industries for energy cost increases due to possible introduction

Table 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
	LMEDIUM			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%.

Table 10
Estimations of affordable carbon prices by sector.

Energy type	Energy use rates (%)			Current energy price[a]	Emission factor [c]
	Iron & steel	Cement	Chemical		
Electricity	64.0	29.3	51.3	73.69 KRW/KWh	1.428t-C/TOE[d]
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 [b]	0.3231t-C/TOE
MEANAFFORD	2.5%	2.8%	2.6%		
Affordable carbon price KRW(USD)/t-CO_2	3770 (3.3)	2600 (2.3)	3950 (3.5)		

Data sources: As of August 2013, exchange rate was: KRW1,000 = USD0.9.
[a] IEA (2010).
[b] International Journal.
[c] IPCC.
[d] Kim (2006).

of market-based climate policies. The results indicate that a mean energy cost increase of 2.6% is acceptable for the respondents as a whole. Further, this affordability is relatively consistent across the three sectors, with the range of acceptable energy cost increases being 2.5–2.8%. Econometric analysis confirms the current energy price level and company ownership as the determinants significantly affecting the cost affordability of the companies. The calculations of the affordable carbon prices for companies may be referred for the development of carbon tax policy and the establishment of a domestic GHG ETS in Korea. In contrast with policy practices in Europe, progress in the pricing of carbon emissions is laggard in major Asian economies, including Japan, China and Korea (Liu et al., 2011). This analysis shows the limited cost affordability of Korean companies, confirming that introducing effective carbon pricing policies in this country is highly difficult. In practice, levying of taxes on carbon emissions for companies in Korea would thus need be introduced gradually and start with low rates, as practiced for Japan's environmental tax which started October 2012 (Liu et al., 2011). As described earlier, domestic GHG ETS for Korea will be formally launched at the beginning of 2015; however, this scheme would not exert a real economic burden on the target entities since the allowances will be allocated fully for free in the initial phase and the rates by auction will be very limited in the following two phases. Therefore, Korea will have to rely on regulatory measures, e.g., TMS, to achieve its GHG mitigation target in the medium term. Nevertheless, such modification of the policy mix, which permits more leeway for economic measures, is a step in the right direction towards reducing GHG emissions in a cost-effective way. Korea's government intends to continue enhancing the awareness of and support from industry for carbon pricing policies, so that introduction thereof may be implemented smoothly.

This research does suffer several shortcomings, as follows. The survey relied on self-reporting by companies, only a very limited number of samples of which were gathered for the analysis. Companies were particularly reluctant to provide internal quantitative data, and less than 60% of the samples provided full answers for the MBDC format. This small sample size may lead to bias in the estimations and thus limit the general scope of applicability based on the research findings. Further studies would close these gaps by expanding the surveys in sample scale and number of sectors, as companies in less energy-intensive industries may respond to climate policies differently; such research efforts may facilitate a more comprehensive understanding of the level of business acceptability of policy costs in Korea. In addition, the real policy acceptance of companies needs to be jointly determined by the costs and non-economic aspects, such as the complexity, transparency and flexibility of the policies. Subsequent research should also account for perspectives from the side of the companies themselves as regards these factors. All such empirical input would help in the formulation of effective and equitable climate policies for Korea.

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