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

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ABSTRACT

This paper seeks to measure industrial energy saving activities (ESAs) and identify their determinant factors via an empirical study of companies in Hyogo, Japan. The surveyed companies exhibit high participation ratios in the pre-listed ESAs, especially those related to managerial measures. The classified factors are partly confirmed by econometric analysis. Whereas external pressures do not appear to alter the level of involvement of a company in ESAs, internal factors show a significant and positive influence. These findings point to the need for higher levels of support for industry as a whole from policy makers and industrial associations, to enhance energy saving practices within industry.

1. Introduction

Under the Kyoto Protocol, Japan is obligated to reduce its greenhouse gases (GHG) emissions by 6% between 2008 and 2012 from 1990 levels. As the medium-term target, Japan pledged to reduce GHG emissions by 25% from 1990 levels by 2020 based on the proviso that aggressive reduction targets were also achieved by all other major emitting countries. The long-term climate target of Japan is to reduce GHG emissions by 80% from 1990 levels by 2050. Accordingly, the country 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 industry, the 'GHG Accounting and Reporting System' mandates the large 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' (Keidanren: 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 the 1990 level by 2010. Sub-industries declared their voluntary reduction targets in the form of absolute amounts or relative intensities. 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 of 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).

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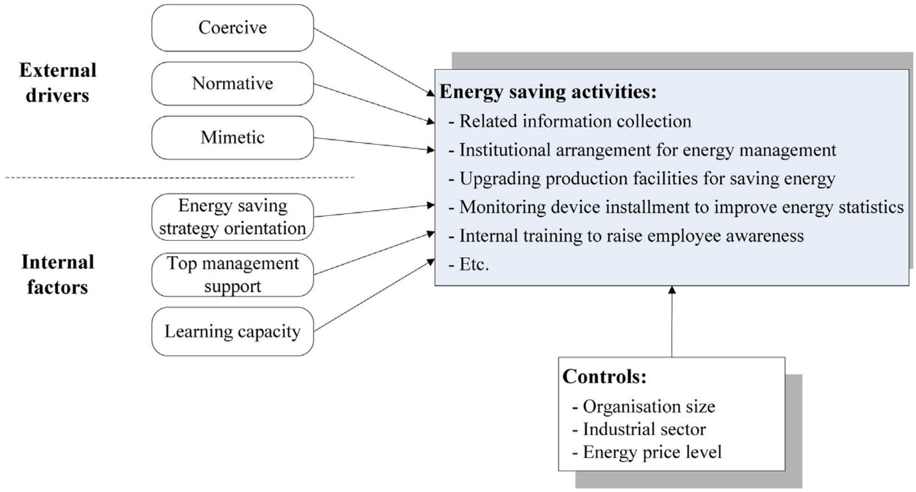

Fig. 1. Analytical framework of the study.

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. Even considering the wide scope of literatures, the existing research is limited to the identification of barriers hindering the improvement of industrial energy efficiency. There is a lack of comprehensive and theoretical linkage mechanism that can account for various factors affecting energy saving practices of individual companies (Liu et al., 2012a). Aiming to close the conceptual and empirical research gaps, we authors carried out a series of surveys in the three major economies in Northeast Asia, including China, the Republic of Korea and Japan, during 2010–2012. The survey in China was arranged in 2010 and sampled 125 SMEs in Taicang city of Jiangsu Province and confirmed the competition pressure and internal training as the factors significantly influencing the company's involvements in energy saving (Liu et al., 2012a). In the same year, the survey in the Republic of Korea sampled 66 large energy-consuming companies and revealed the internal factors rather than external pressures in significantly determining a company's energy saving practices (Suk et al., 2013). This paper describes the case study of Japanese companies in 2012 using a similar analytical framework as previous studies in China and the Republic of Korea. Hyogo Prefecture, the base of our research centre, was selected as the study area due to the ease of securing cooperation from companies for the survey. We had two major objectives in this study. One was to measure the extent to which companies had embraced energy saving activities (ESAs) in Japan; the other was to identify the determinant factors, external and internal, which indicate strong linkages with the level of Japanese company's ESAs.

2. Literature review

In the earlier paper analyzing the factors determining the energy saving practices of Chinese companies, we conducted a review of literatures, with most of them published during 2001–2010, to clarify the research progress related to industrial energy efficiency (Liu et al., 2012a). Based on the overview, 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 common means for promoting energy efficiency of industry. Various drivers, such as cost saving potential, and barriers, like 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. (see section 2 of Liu et al. (2012a) for the details).

This section summarizes the publications related to industrial energy efficiency in more recent years. Abdelaziz et al. (2011) present a comprehensive review covering industrial energy saving realized through management, technology and policy measures. Payback periods of various energy saving approaches were 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 conclude that future energy efficiency programmes should explicitly target the promotion of technological progress and address the informational and behaviour-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) analyzed 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 the lack of resources and the 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) analyzed 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 also 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

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Fig. 2. Geographical location of Hyogo prefecture.

company, as well as a management receptive of such issues, constituted additional drivers. Gulbrandsen and Stenqvist (2013) examined to what extent the EU-ETS has influenced the climate strategies of two Nordic pulp and 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 any meaningful exploration of innovative low-carbon solutions.

There are several studies analyzing the determinants of industrial energy efficiency in developing countries. Besides our own research in China mentioned in earlier (Liu et al., 2012a), Kostka et al. (2013) surveyed 480 SMEs in Zhejiang Province of China and confirmed that only a minority of them actively perform energy saving practices at a significant level. The information barriers are the core bottleneck inhibiting energy efficiency improvements in China's SME sector. Financial and organizational barriers influence a company's energy saving practices. Their study reveals that Chinese government could play a more active role in fostering the dissemination of energy-efficiency related information for SMEs (Kostka et al., 2013). Hasanbeigi et al. (2010) investigated barriers to and drivers for energy efficiency in Thai industry and

Table 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)

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Table 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	Optimize 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 organizations		

found that the management is concerned about production and other matters rather than energy efficiency. Reducing production cost is confirmed to be the main driver for energy efficiency investment. Apeaning and Thollander (2013) studied the barriers to and driving forces for energy efficiency measures in Ghana's industrial area. Their results indicated poor energy management in various industries and confirmed economic barriers, like 'lack of budget funding' and 'access to capital', as the most important factors impeding the implementation of energy efficiency technologies, which are linked with the lack of adequate government framework.

The research represented by the wide range of literature reviewed above, however, still fails to comprehensively clarify the factors determining industrial energy efficiency. This paper attempts to further bridge this knowledge gap, by qualitatively measuring the level of ESAs of Japanese companies and identifying the corresponding determinant factors. It shall be mentioned that the tool of MIND (Method for analysis of INDustrial energy systems), based on Mixed Integer Linear Programming (MILP), has been constructed to support the analyses of complex industrial energy systems and has extensive applications for energy-intensive

Table 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)					

sectors (Karlsson, 2011). We did not adopt this model due to the different objective of this analysis.

3. Analytical framework for this study

The analytical framework of this study is shown in Fig. 1, and draws on a paper analyzing the driving mechanism of proactive corporate environmental management in China (Liu et al., 2010). As such, the model we used considers the externally coercive, normative and mimetic pressures as important sociological factors acting within industry (DiMaggio and Powell, 1983). Gunningham et al. (2003), however, argued that this institutional theory fails to explain, at a fundamental level, why companies subjected to the same external pressures behave and perform differently, inferring that instead companies might operate heterogeneously according to how they perceive objective external pressures. 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). The use of this kind of comprehensive analytical framework has also been confirmed in analyses of business behaviour 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 implementation of an environmental management system and 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) analyzed 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 power within the company structure. When assessing the function of a competitor's environmental management on a certain company, Hofer et al. (2012) found that the company's characteristics, such as market leadership, size and profitability, are all highly significant. Company's ESAs in this paper

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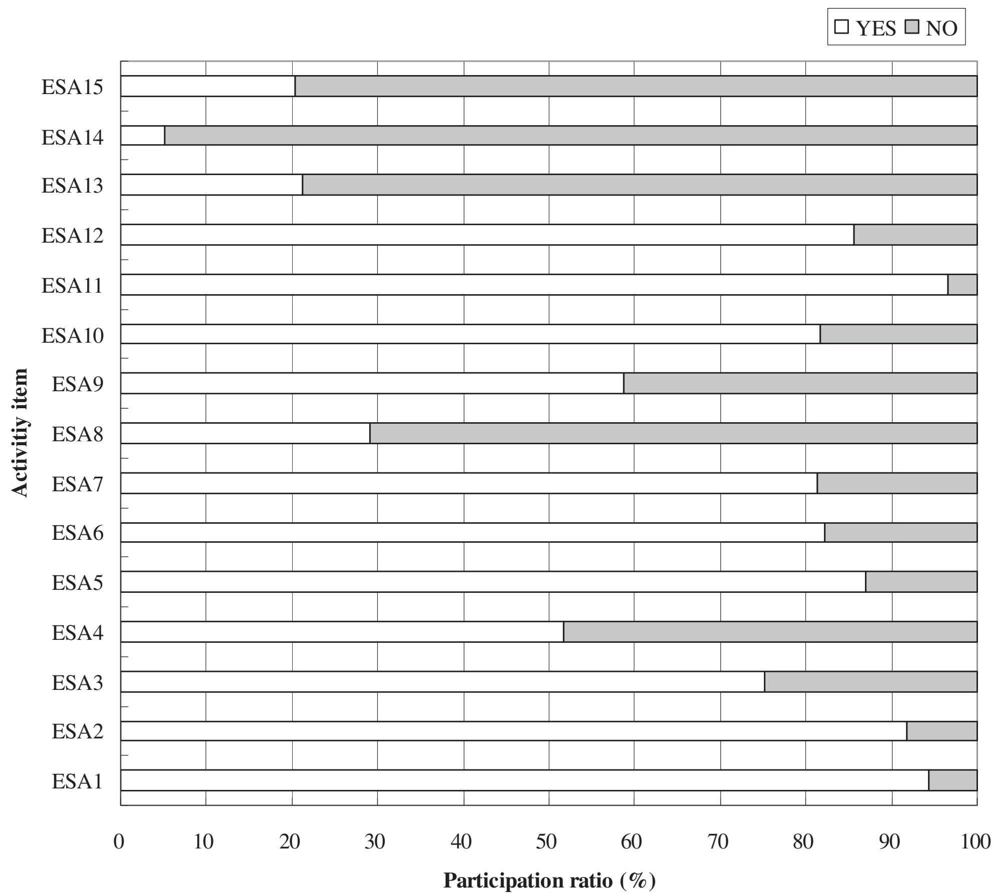

Fig. 3. Distribution of a company's energy saving activities ($N = 230$).

is one aspect of corporate environmental management. The comprehensive analytical framework analyzing the driving mechanism of business environmental behaviours in earlier studies may work well for this analysis. Our model thus supplemented the external pressures identified by institutional theory with three internal factors, including a company's orientation on energy saving strategy, top management support and learning capacity, to jointly explain a company's ESAs. Company characteristics are used as controls in the analytical frame.

We focus on the subset of institutional actors that are most likely to influence a company's ESAs, including coercive pressure from organizations with mandatory power, normative pressure from industrial associations and mimetic pressure from competitors. The mandatory actors influencing a company's ESAs are government agencies acting at different levels and authorized to promulgate and enforce regulations on industrial energy efficiency, which therefore has a coercive influence on companies. In this study, the strength of government requirements of industrial energy saving is defined as the coercive driver. Normative pressure originates from norms of the institutions, such as industrial associations. Behaviours complying with these norms assist in forming legitimacy for company operations (Palmer et al., 1993). It is thus worth testing whether such behaviours and pressures that exist within a certain sector influence a company ESAs, which is why we use the degree of influence of industrial associations to represent normative pressure in this analysis. Further, in order to maintain competitiveness, companies are likely to mimic the practices of leading companies and business competitors in the same sector. The competition pressure was confirmed to significantly enhance

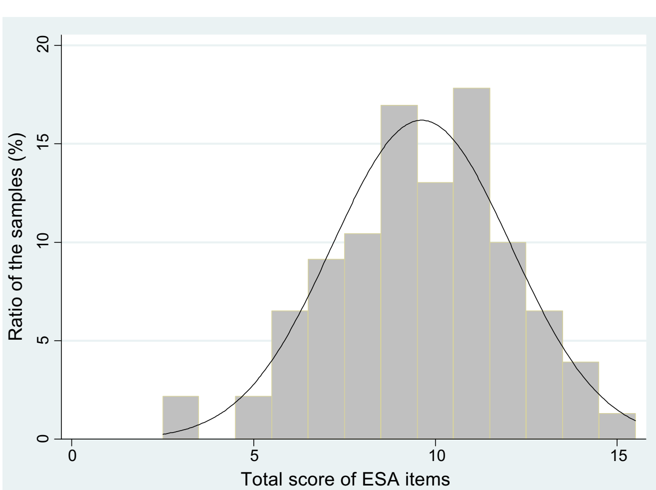

Fig. 4. Distribution of overall scores of energy saving activities ($N = 230$).

Table 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 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.

energy saving practices of Chinese SMEs (Liu et al., 2012a). The degree of competition of the sector's sales market is thus used to indicate the mimetic pressure perceived by companies in this analysis.

We selected a company's orientation in energy strategy, support from top management and learning capacity as internal factors for explaining a company's ESAs. Regarding the first factor (orientation of energy saving strategy), Prindle (2010) found that energy saving of the U.S. companies is driven by the commitment to reduce CO_2 emissions. A company's awareness of internal energy use and problems as well as willingness to improve energy efficiency is defined as proxies. Most of the companies in the survey area are SMEs and top management largely determines how such companies operate. Support from top management is necessary for such companies to follow proactive environmental practices. Our previous survey to Korean companies indicated the importance of top management support for the practices in energy saving (Suk et al., 2013). This variable is therefore selected as another internal factor. To a certain extent the energy efficiency of a company is never a fixed amount as it is related to the skills of the human resources (Hart, 1995). Lack of personnel with appropriate skills was confirmed as a common barrier for energy efficiency (Prindle, 2010). Thus the collective ability of a company to acquire knowledge in the field of ESAs needs to be factored in. To represent this, we use the frequency of internal training related to energy saving as a proxy for a company's learning capacity.

Previous studies have shown that large companies are more likely to be supervised by environmental authorities (Hettige et al., 1996), as evidenced by Japan's industrial energy efficiency policy which focuses on large GHG emitters. The energy-intensive sectors are more sensitive to energy prices due to their higher reliance on energy use and usually have more experience with energy efficiency programmes (Prindle, 2010). Christofferson et al. (2006) confirmed that electricity utilities emerge as the main source inspiring energy management. To analyze differences in ESAs of companies with differing characteristics, company size and sector, as well as domestic energy price level, are used as controls in this 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. The intermediating function of internal factors for external pressures in influencing a company's green supply chain management was confirmed in Liu et al. (2012b). Nevertheless, the model in Fig. 1 assumes no interactivity between such variables, as this deviates from the main purpose of this analysis: to identify the determinant factors behind company ESAs.

Table 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

4. The survey area: Hyogo prefecture

This survey was carried out in Hyogo prefecture, with the geographical location depicted in Fig. 2. The prefecture has a land area of 8396.13 km^2. Its population was 5,572,724 and comprised of 2,280,354 households as of 1 November 2012. Most of the population inhabits the 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 than the previous year individually). First to third industries (Agriculture, forestry and fisheries; Mining, manufacturing and construction; Services) accounted for 0.55%, 27.99% and 71.46% of GDP of the prefecture 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. In 2009, there were 9555 industrial entities (mostly SMEs) with a total of 359,236 employees. Of the above entities, those with 4–299 employees numbered 9390 in 2009, 98.84% of the total. The remaining 1.16% (165 entities) are categorised as 'large companies'

Table 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–ESA10 and ESA13
ESA_{EX}	Practice level of ESAs in cooperation with external organizations	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

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Table 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
OTHERS							−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.

in Japan (with 300 or more employees). By sector for 2009, 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 fibre. These five sectors shared 49.1% of the total number of entities. The number of chemical and iron & steel companies was 302 and 251 in 2009, with respective shares of 3.2% and 2.6%. In terms of added value, the chemical sector generated the highest amount of 545.8 billion JPY in 2009, a share of 11.7% of the total. The second was food processing, at 531.7 billion JPY. The 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).

The overall GHG emissions of Hyogo were 63.494 Mt-CO_2 in 2009, reduced by 13.1% compared to the 1990 level. Emissions from the industrial sector were 41.53 Mt-CO_2 in 2009, a reduction of 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 and increased by 21.4% from 1990 (Hyogo Prefecture, 2011).

Hyogo issued its ‘Promotion Plan for Global Warming Prevention’ in July 2000 and revised the plan in July 2006. The plan targeted a 6% reduction of GHG emissions by 2010 from 1990. The prefecture has made efforts over past years to reduce the GHG emissions from the industry, especially from the large energy-consuming companies. Since July 1996, any newly established entity is required to conduct a global warming impact assessment if its incremental energy use exceeds 1500 kloe (kilolitres of oil equivalent). The notification must be submitted to Hyogo government before construction starts, and the company must take measures to control its emissions as the required. Since October 2003, existing entities with an annual energy use over 1500 kloe (about 580 entities in 2009) are mandated to report their plans of mitigating GHG emissions and the results of measures adopted. From 2007, guidance was provided for large entities (with annual energy use over 3000 kloe; 200 entities in 2009) to further reduce their CO_2 emissions. For SMEs that are not covered by the reporting system, guidance has been provided to prepare plans to mitigate their emissions since 2007.

Besides administrative measures, Hyogo government has also applied economic incentives to encourage the industry to reduce its GHG emissions. During 2009–2010, subsidies were provided for small businesses to establish solar power systems, energy saving facilities and heat insulation equipments. In 2011, energy saving projects of these businesses as models were recruited, and those selected were expected to promote climate awareness via dissemination activities, such as by seminars. To add flexibility into the CO_2 emissions reductions, the domestic carbon credit programme is used. With this innovative approach, large companies are encouraged to provide technological and financial assistance to their SME counterparts. The reductions achieved by this kind of cooperation are accredited to the large companies. In addition, Hyogo prefecture established the ‘Consultative Centre for CO_2 Mitigation Cooperation Project’, which provides comprehensive services such as consultation, guidance and project matching. In 2010, the centre launched a project to match the needs between large and small entities. The emissions reductions of several SMEs were combined and jointly transferred to the large companies, which have resulted in some successful matchups (Hyogo Prefecture, 2012b).

Table 9
Calculation results of marginal effects of factors affecting *TESA*.

Score of TESA	Marginal effects (%)					Predicted possibility (%)
	AWARENESS	WILLINGNESS	TOPSUPPORT	TRAINING	SME	
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

Table 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.

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 energy saving activities, awareness of various energy saving policies and the affordability of energy cost increases resulting from the start of MBIs. There are 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 paper analyses the energy saving practices and the factors affecting such practices (determinant factors) based on the collected data.

Ideally, top management within the companies targeted was intended to fill out the questionnaire as they are the best representatives. However, due to past difficulties encountered in questionnaires conducted in China and Korea (Liu et al., 2012a; 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 should be highly knowledgeable on the subject. In fact, 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 organizations, 'Hyogo Environmental Protection Management Association' and 'Division of Global Warming Countermeasures, the Government of Hyogo', in order to obtain more active responses from the companies. Questionnaires were mailed to all 465 industrial companies with annual energy usages exceeding 1500 kloe, in Hyogo. Of these, 117 were environmental association members and the formats were sent to them 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 came from the other group, for a return rate of 49.5%. The distribution of valid samples by sector and size is shown in Table 1.

The samples from food processing, chemical, iron & steel and electronic industries individually account for 18.3%, 13.0%, 8.7% and 10.9% of the total, with the remaining 49.1% accounted for by

Table 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
OTHERS							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.

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Table 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
OTHERS							−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		

[a] Significant at 1% level.

various other minor sectors. Of the 230 samples, only four were small companies, with staffs 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 actions. However, trying to quantify a company's actual level of energy saving practices is problematic since it doesn't necessarily equal 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 practised ESAs may then be used as a proxy for a company's *TESA*. Table 2 lists 15 representative ESAs for companies, which are written as ESA1–ESA15 in sequence.

The items of ESAs in this study are almost the same as those in our previous surveys in China and the Republic of Korea (Liu et al., 2012a; Suk et al., 2013). These pre-listed ESAs reflect a company's energy saving in various aspects, including the practices by institutional arrangement (E.g., ESA2 and ESA3), technological measures (E.g., ESA5, ESA7 and ESA8), management approaches (E.g., ESA4, ESA6 and ESA9–ESA12) and joint activities with external organizations (E.g., ESA13–ESA15). The only different item with Liu et al. (2012a) is ESA1. This is due to our basic understanding of the samples in different surveys. Almost all the SMEs in Liu et al. (2012a) have no target in energy saving and GHG emissions mitigation. However, the large energy-consuming companies in Hyogo are requested to set up energy saving targets and have responsibility to report their energy use status to the government. ESA1 is thus included in this survey. The corresponding descriptions of these ESAs were used in the questionnaire to elicit whether the targeted Hyogo companies practised them or not. Since the relative importance of each activity for a company is difficult to quantify, the 15 activities in Table 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.

5.2.1.2. Independent variables. The proxies of independent variables as determinant factors are listed in panel A of Table 3. 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 of 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 1–3 times per year; '3' = 4–6 times per year; '4' = 7–12 times per year; and, '5' = over 12 times per year.

5.2.1.3. Control variables. As indicated in panel B of Table 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 small and medium-sized enterprises and large companies since the number of small respondents was only four. They are respectively named SME and LARGE. There are five types of sector: food processing, chemical, iron & steel, electronics and other. They are individually notated as 'FOOD', 'CHEMICALS', 'STEEL', 'ELECTRONICS' and 'OTHER'. Regarding the variable '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 price 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.

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

6. Results and discussions

6.1. Statistics of company ESAs

Stata10 was used for this analysis. Fig. 3 provides a summary of ESAs adopted by the surveyed Hyogo companies. Overall, the sampled companies actively practised 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 participation 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 technological and engineering, i.e., physical measures, therefore companies initially tend to adopt these ESAs due to the simplicity of doing so. This finding is consistent with our previous surveys of companies in China and Korea (Liu et al., 2012a; Suk et al., 2013).

Fig. 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 a participation ratio 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 items of ESAs 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 organizations) 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. This implies that the 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 the respondents (84.8% of the total) are manufacturing plants with headquarters, and research and development of energy efficient products, including eco-design, may be not the responsibility of such companies.

Fig. 4 further shows the distribution of *TESA*. Three of the 230 respondents (1.3%) practised all 15 activities. The companies, which 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 4 summarizes the independent and quantitative control variables in the equation of section 5.2.2. 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 improvement, 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, the sampled companies 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 1–3 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.

Regarding the categorical controls indicating a company's characteristics, most of the samples are SMEs, as listed in Table 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 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 would not occur until the correlation coefficient reached ± 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'.

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. The rotated component matrix of the factor analysis and KMO values is shown in Table 6.

All the 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–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 constructs of ESAs can be categorized. The four sub-categories of ESAs and their valuations are listed in Table 7. ESA4–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 organizations. 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., 2012a). 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., 2012a). Further, ESA2, ESA3 and ESA12 in this study are the 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 practised 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.

6.5. Multivariate analysis with TESA as the dependent variable

As the dependent variable, *TESA*, derives from ordinal measurement, we carried out an ordered logistic regression, as shown in Table 8. The robustness of results was tested by repeated regressions and omitting certain variables. Three models were adopted. Model 1 excludes all controls, Model 2 adds the quantitative control 'ENPRICE', and Model 3 includes all the variables identified earlier. No obvious changes were found between the results of the three regressions. The total number of observations was 199 due to incomplete respondee data.

The results in Table 8 show that there are no significant relationships between *TESA* and the three external pressures. All the sampled companies have annual energy usages exceeding 1500 kloe and are mandated to calculate and report their GHG emissions to the government according to the 'GHG Accounting and Reporting System' of Japan. They felt pressure from the government and the variable of 'REGULATION' achieved a mean of 3.86 as in Table 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'. The regulative pressure failed to function as a driver for the 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. The insignificant role of coercive and normative pressures in determining the ESAs of the companies in Hyogo also bears out in our findings from the China and Korea surveys (Liu et al., 2012a; Suk et al., 2013). In our survey to SMEs in China, mimetic pressure was confirmed to significantly determine *TESA* (Liu et al., 2012a), which implies that 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. Their energy saving practices cannot be differentiated by competitive pressure.

All the internal factors, 'AWARENESS', 'WILLINGNESS', 'TOPSUPPORT' and 'TRAINING', indicate significant and positive relationships with *TESA*. The statistics of variables in Table 4 confirm that Hyogo companies have high awareness of their internal energy use and problems, as well as high willingness to improve their energy efficiency. The result in Table 8 reveals that strategy orientation within companies has led to actual energy saving practices. This finding contrasts with that of Liu et al. (2012a), which documented that willingness alone does not lead Chinese SMEs to take real energy saving practices due to capacity limitations. Nevertheless, this result is similar to Suk et al. (2013), confirming that Korean company's ESA involvement level would be partly attributed to their own strategy orientation. The questionnaire survey to nearly 100 U.S. companies achieved a similar conclusion that these firms' energy saving strategy is driven by their commitment to reduce CO_2 emissions (Prindle, 2010). Herrero Sola and Xavier (2007) verified the correlations between organizational factors and energy management of companies in Brazil and confirmed the determinants are linked with company's strategic vision. The significant and positive effect of 'TOPSUPPORT' on *TESA* confirms the usefulness of support from top managers in enhancing a company's energy saving, especially for SMEs in this survey. The 'split incentives' of different internal departments of a company create persistence to energy efficiency improvement (Prindle, 2010). Top management support is thus necessary to clear the 'split incentive' problem and improve the company's energy efficiency. Similarly to Liu et al. (2012a), the training of employees in the specific field of energy saving enhances the ability of Hyogo companies to practice ESAs and is significantly associated with *TESA*. The lack of information has been confirmed as a common barrier hindering the company's energy efficiency improvement (E.g., Christofferson et al., 2006; Cagno and Trianni, 2013). The training to employees fills up the information gap and enhances the company's involvements in ESAs.

As shown in Table 8, 'ENPRICE' is not significantly associated with *TESA*. This is different with the results of Fisher-Vanden et al. (2004), Prindle (2010) and Liu et al. (2012a), which confirmed that energy price pressure and motivation for energy cost reductions act as principal drivers for improving the energy efficiency of industry. The organization size is significantly associated with *TESA* in this analysis. Compared with large companies, SMEs demonstrated less involvement in energy saving practices, a result in line with the resource-based perspective and previous studies confirming that larger organizations are more likely to adopt proactive environmental practices (Sharma, 2000). This is consistent with Trianni et al. (2013), revealing that smaller companies indicate a greater perception of barrier than larger ones in energy efficiency. There is no significant difference in energy saving practices of companies from various sectors, probably because this survey targeted companies within a small area and the respondents from different industries exhibited similar levels of performance in energy saving.

We calculated the marginal effects of determinant factors in influencing a company's *TESA*. As shown in Fig. 4, a total of 12 categories of scores are shown for *TESA*. Table 9 lists the marginal effects of related factors, including the four internal factors and the size, for each *TESA* value. The results reveal that the enhancement of internal factors ('AWARENESS', 'WILLINGNESS', 'TOPSUPPORT' and 'TRAINING') would decrease the possibilities for companies to practice nine or less ESA items but increase the possibilities of *TESA* of ten and over. In comparison with large companies, SMEs could be categorized as laggard performers of ESAs since they are more likely to practice ten or less ESA items. 'WILLINGNESS' indicates higher marginal effects in influencing a company's *TESA*, which implies that improvement in a company's willingness to save energy is more effective for enhancing their involvement in ESAs.

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 10–12, respectively. The result for $ESA_{T\&H}$ is not shown here since significant relationships between this ESA category and the identified factors were not found.

ESA_{IN} in Table 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 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 industry, which implies that energy-intensive companies are more motivated to seek the cooperation and support from external organizations such as the government in pursuit of higher energy efficiency. The results shown in Table 12 confirm that certain internal factors, especially 'AWARENESS' and 'WILLINGNESS', have significant and positive relationships with ESA_{PR}. On an intuitive level this would seem 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.

7. Conclusions

This paper identified the determinant factors for companies to practice ESAs by an empirical study in Hyogo, Japan. The pre-classified factors are partly confirmed by the econometric analysis. With the function of external pressures being not significant, the energy saving practices of the sampled companies are mainly attributed to the internal factors, such as their individual business strategies and energy saving motivations. The results of this analysis have meaningful implications for enhancing energy efficiency of Japanese companies. Overall, the samples in this survey perform internal energy management well. However, ESAs with high participations are the practices that may be carried out by the companies independently. The joint efforts with the external stakeholders are limited. This reveals the necessity for public organizations of Japan to act more actively for pushing the companies to operate with higher energy efficiency. So far, the industrial energy saving and carbon mitigation in Japan mainly rely on the voluntary action plan of the industry. The industrial associations shall enhance their energy saving programmes further, among which, long-term agreements (LTAs) have been confirmed effective for promoting energy efficiency in Europe and could be referred (Rietbergen et al., 2002). The governments at various levels need to work better in supporting energy saving of the industry. One important thing for the government is to actively disseminate energy saving information with the nature of public good to the companies, especially for the SMEs, to improve their practice capacities. Financial support from the government is useful to facilitate the company's access of capital for energy saving investments. The limited public budget shall address the innovation and demonstration of companies in energy efficient technologies since the promotion of eco-design and the research and development of energy efficient products of the samples are quite limited. The development of social mechanisms by setting up regional and/or local learning networks for the companies is another useful approach to motivate the improvement of energy efficiency, which has been confirmed successful in Switzerland and Germany (Jochem and Gruber, 2007).

Limitations to this study are that the survey relied on self-reporting of companies for data gathering. The number of samples is limited due to lack of cooperation from the companies approached. The geographical area covered by the survey is also small. These factors may lead to bias in the generalization of research findings. Similar surveys in other regions of Japan or including other sectors would highlight the regional or sector variations in the determinants. In addition, the model adopted may not be completely appropriate for the research question, and the proxies of variables require testing. In consideration of a simple format for the survey, a five-level method was generally applied. Such valuation of the independent variables may result in measurement errors and reduce analysis accuracy. The following research shall overcome these shortcomings and further clarify the policy direction to effectively improve the energy efficiency of companies in Japan.

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