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Influential information and factors for social acceptance of CCS: the 2nd round survey of public opinion in Japan

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Abstract

A public survey was conducted concerning carbon capture and storage technology (CCS) in the months of February and April 2007 in Japan, Previously another CCS survey took place in December 2003, and a set of the questions asked in the 2007 survey were purposely the same as that used in the 2003 survey, Japanese adults were randomly selected to answer a questionnaire either in printed format or in online format. Several versions of the questionnaire were used, and each contained a different educational part, imparting relevant CCS information. 334 people successfully responded to our paper survey in Tokyo and Sapporo while 2156 people completed our online survey across the nation. The questionnaire for the survey contained 5 sets of different information package on CCS and questions asking pros and cons on CCS implementation to analyze influence of information provided on CCS.

Based on the results of survey we found: that not many people still know about CCS. Those who have knowledge on CCS show a preference for CCS implementation, however; preference was decreased after obtaining information which we considered was neutral on CCS. These results suggest a possibility that information on negative aspects of CCS (risks, etc.) would not be well known in the general public. We also found that preference for CSS decreased slightly after providing different information on CCS to respondents in the group with the newspaper articles which we considered neutral in comparison with other groups. The newspaper articles contained the information on negative opinions against CCS besides risk-related information as well as information based on an IPCC Special Report: it is assumed that such negative opinions may have influenced opinion formation of respondents. Since CCS is new technology, information about how other people or entities evaluate CCS would influence public opinion. In the sub-sample provided with industrial and natural analogues of preference on geological storage, the views were slightly more positive about CSS in comparison with reported opinions of other groups. This implies information on natural or industrial analogue would help manage perception of risk in a positive way.

The result of path analysis to data of a public survey identified four factors, (1) risks and leakage, (2) effectiveness of CCS, (3) responsibility, and (4) fossil fuel use. We found that the factor of understanding the effectiveness of CCS is most positively influential for general acceptance of CCS. I Implementation of geological storage and the factor of risks and leakage become much more influential negatively in the implementation of geological storage compared to general acceptance of CCS, implying that implementation of CC2 geological storage also needs careful communication of risk.

Keywords: carbon capture and storage; public survey; public opinion

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1. Introduction

CO2 capture and storage technology (CCS) has been attracting attention as an emerging technology that has large potential for CO2 emission mitigation. However, there are some unknown aspects about its social acceptance since characteristics of this technology substantially differ from other available CO2 mitigation technologies, such as leakage risk of CO2 from storage sites. Given this situation, the authors designed a survey questionnaire for assessing Japanese public opinion, which was conducted in February and March 2007 to investigate the extent of recognition and latent social acceptance on global warming mitigation measures including CCS, as well as the kind of factors/that would influence their views. The survey in 2007 was designed to provide different kind of information on CCS to subsamples. This allowed analysis of the variance of acceptance level depending on available information can be analyzed, which is the focus of this report.

2. Implementation of the survey

The public survey was conducted in February and March 2007 in (1) in Tokyo and City of Sapporo by door-to-door method using printed format and (2) across the nation via the Internet using an online format. Respondents were selected by area sampling for the door-to-door survey and by stratified random sampling from registrants of a survey company's panel for the Internet survey. Itaoka, et al. (2004, 2006) earlier reported on the results of a door-to-door survey in Tokyo and City of Sapporo in December 2003; the questions in this survey were largely replicated in the two 2007 surveys. Table 1 shows attributes of the samples of the 2007's door-to-door and Internet surveys as well as the 2003's door-to-door survey. The response rates of 2007 door-to-door survey were 37% and 30% for the one administered via the Internet..

Table 1. Characteristics of respondent

	Sample	Dec 2003 (Paper, Door-to-door)	Feb-Mar 2007 (Paper, Door-to-door)	Feb-Mar 2007 (Internet)
	Venue	Sapporo&Tokyo	Sapporo&Tokyo	Nation
	No. of valid sample	1006	334	2156
	Collection rate	64%	37%	30%
Age	20s	15%	18%	16%
	30s	18%	22%	20%
	40s	23%	16%	17%
	50s	21%	19%	20%
	60s-70s	23%	16%	28%
	over 80	0%	8%	0%
	Average	47	46	48
Sex	Male	49%	49%	49%
	Female	51%	51%	51%
Year of Education	Junior high. (9 yrs)	8%	10%	5%
	High school (12 yrs)	41%	42%	35%
	2-year college/ vocational school (14	22%	20%	23%
	University (16 yrs)	28%	28%	35%
	Post graduate (18 yrs)	1%	1%	3%
	Average	13.4	13.3	13.9

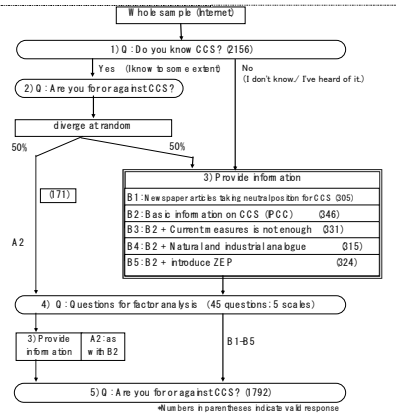


Figure 1. respondents' characteristics

3. Questionnaire design

3.1 Structure of the questionnaire

The structure of the questionnaire for the Internet survey is shown in Figure 1. The first question asked respondents to self-identify themselves based on their recognition of CCS. Specifically, respondents were grouped into one of two categories: (a) "I know to some extent." and (b) "I don't know" or "I've heard of it." To those who responded as "I know to some extent," another question was given to ask about their views for or against CCS implementation in the second question. In the third question, information on CCS was provided to all respondents. This then corresponded to45 questions in the fourth set of questions that contributed to conducting a factor analysis on respondents' views on CCS and global warming. The third and fourth parts of the survey were administered in reverse order to Group A2 (far left in Figure 1) that comprised roughly a half of the "I know to some extent" respondents. Finally, the fifth question asked the same question as the first one to assess any changes in opinion for

or against CCS implementation based on new information provided about the application of this technology.

3.2 Internal tests and external tests

The questionnaire was designed to conduct internal and external tests to examine effects of the information provided to respondents. As Figure 1 shows, the questions designed to probe about respondent views for or against CCS implementation were given two times before and after providing information about this technology to those who responded as "I know it to some extent" in the first question of the survey. Internal tests were conducted by examining the mean change of responses between the two questions.

The other respondents who responded as "I've heard of it" and "I don't know" in the first question were only asked about their views for or against CCS implementation at the end of the survey following their receipt of information about the technology.

All of the respondents were eventually provided with one of five different information packages on CCS in the questionnaire. External test were conducted by comparing the answers to the questions of five subsamples which were provided with different information package.

3.3 Information treatment

We prepared five type s of information about CCS for resp9ondents. B1 quotes newspaper articles on CCS. B2 and A2 give technological explanations and describe major characteristics of CCS as reported in the IPCC Special Report on CCS. B3-B5 add three types of supplemental information to the IPCC information in B2: Specifically, B3 offered a message from distinguished scientists to raise public awareness, saying that existing mitigation measures cannot achieve sufficient reduction of CO2 emissions; B4 contained analogue information (industrial activities and natural phenomenon that are similar to CCS); and B5 describes the CCS introduction plan in Europe (The EU Flagship Programme for CO Capture and Storage (CCS) ZEP). For technological explanation on CCS, the questionnaire discussed four methods of CO2 storage were included (ocean storage types and geological storage types). For samples of door-to-door survey (n=334), we used the same questionnaire form as Subsample B2.

4. Analysis

4.1 Public recognition of CCS

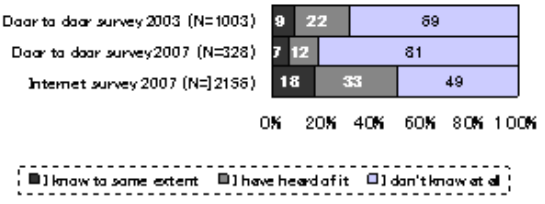


Figure 2 shows the result of the first question about recognition on CCS,. It was designed with three ordinal scales: (1) I know to some extent; I2) I've heard of it; and (3) I don't know. Public recognition of CCS in the 2003 survey administered to the general public in Tokyo and Sapporo revealed that 9% of respondents knew to some extent and another 22% "reporting that they have heard of it.. These respective rates in the 2007 door-to-door survey are 7% and 12% and 18% and 33% for the Internet survey. There is statistical significance ($P < 0.01$) in recognition rates between the samples of door-to-door and Internet surveys; Internet panel registrants show higher recognition rates than general public in Tokyo and Sapporo.

The result shows that information on CCS is becoming more available among people who have good information literacy such as the registrants of the Internet panel.

4.2 Public opinion about CCS implementation

The question about CCS implementation has three items and was designed with six variations in total. In the first question, 1A, we asked respondents' views about being for or against implementing CCS as a part of climate policy portfolio using a 5-level Likert scale from 1 (No) to 5 (Yes). Question 1B was as a follow-up of 1A and asked those other than the group who reported a 5 (Yes) on the first question if they were "fundamentally no" or whether it "depends on conditions." In the second item, we asked respondents to assess their views for or against CCS implementation, again using a5-level Likert scale. As with 1A, we did this for each of the four technologies: (1) ocean dilution type, (2) ocean lake type, (3) geological onshore and (4) geological offshore. The results are shown in

Figures 3 and 4.

As for the question that probed respondents to state whether they were for or against CCS implementation by technology type, the mean value for each technology is consistent with what was found with the 2003 surveys. "Ocean dilution type" is most preferred followed by "ocean lake type." "Geological onshore" is the third most popular choice and "geological offshore" is the least favorable choice.

(1) Current opinions of those who have knowledge on CCS

As reported earlier, Question 1A asked respondents about their knowledge of implementing CCS as a part of a larger climate policy portfolio. In this second analysis, we restricted the survey to only those who reported some familiarity with CSS. Before respondents were provided with technical information, the mean results (on a 5-[point Likert scale) about their support for the technology equaled were 3.86 for those in the door-to-door survey and 4.11 for those responding to the Internet survey., These results show that over two-thirds of these self-identified knowledgeable respondents had positive opinions about CSS (see legend A0 in Figure 3). Put simply, people with some knowledge on CCS y tend to have a favorable opinion on implementing CCS as a part of a larger climate policy portfolio.

Second, in the question to the same respondents on their support for the four CCS technologies (Question 2) (legend A0 in Figure 3), the mean results in door-to-door survey were 3 or more (3.00-3.39) for all technologies. Thus, the public either was neutral or positive about their implementation. By contrast, those polled in the Internet survey had mean results that ranged from 2.88 to 3.73, indicating a large difference in their level of acceptability of the four types of CSS technology: Other than ocean dilution, respondents held positive opinions, with 60% supporting the two geological types of CSS. The result shows that people with knowledge on CCS in the Internet survey often tend to make their choice dependent upon the specific technological type..

(2) Changes in opinions of those who have knowledge on CCS, before and after providing information (internal test)

This section describes opinions of those who have knowledge on CCS after providing information mainly quoted from questions (1) and (2), including IPCC Special Report (seen in Legend A0 and A in Figures 3). As for implementing CCS as a part of climate policy portfolio (Question 1A), there is no major observed change: respondents tend to choose a more positive view after receiving information. This was true in both door-to-door surveys (statistically insignificant mean change from 3.86 to 4.11) and in the Internet surveys (; with a statistically significant change of mean value from 4.11 to 4.02, $P < 0.1$).

As for the question on CCS implementation by technology (Question 2), there was a change to somewhat negative direction with the door-to-door survey as the mean value equal to 3 or below for the two ocean storage types (statistically significant in mean value for ocean dilution type only, $P < 0.1$). By contrast, respondents prefer the two geological storage types with a mean value of 3 or more observed for the door-to-door survey (a scarce decrease was noted that is not statistically significant). By comparison, participants to the Internet survey expressed opinions that correlated with a slight shift tin a negative direction observed for all of the four technologies (the two ocean storage types are statistically significant in mean values, $P < 0.1$ respectively). These results show that people with knowledge on CCS have strong opinions that are not much affected with information temporarily provided in the questionnaire.

(3) Comparison of opinions between those who have and who do not have knowledge on CCS, after providing information (external test)

Somewhat characteristic in the 2007 survey was the difference in opinions between those who have and who do not have knowledge on CCS (Figures 4). Basically, those who have knowledge on CCS are more likely to choose "Yes" than those who do not have such knowledge for not only implementing CCS as a part of climate policy portfolio but also for implementation of each CCS technology (regarding the four technologies, no statistical significance was observed in the door-to-door survey while a statistical significance of $P < 0.01$ noted for the Internet survey).

This tendency was also observed in the 2003 survey, but it seems to have become stronger in the 2007 survey. In terms of geological storage, in particular, responses from those who have knowledge on CCS are above 3 in mean values, in both door-to-door and Internet surveys, showing that positive opinion to support CCS implementation is

getting stronger among people with knowledge on CCS at this stage.

Q1A
Yes / No about implementing CCS as a part of climate policy portfolio? (5 level rating scale)
Q1B
Fundamentally No or "It depends"?
(Dichotomous choice: 2 level rating scale)
Q2
Yes / No about implementation by type of CCS?
(5 level rating scale)

Ao: Respondents who chose "I know CCS to some extent." <before providing information>
A: Respondents who chose "I know CCS to some extent." <after providing information>
B: Respondents who chose "I've heard of CCS/ I don't know CCS." <after providing information>

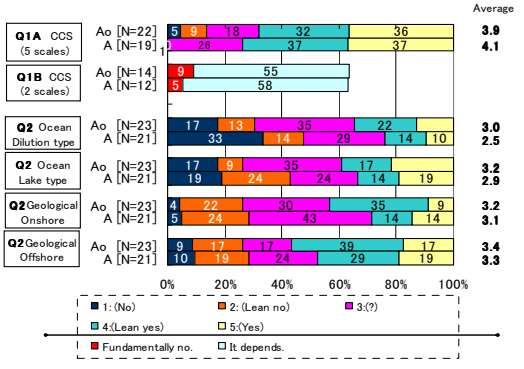


Figure3a. Changes in opinions of those who have knowledge on CCS, before and after providing information, door-to-door survey (2007)

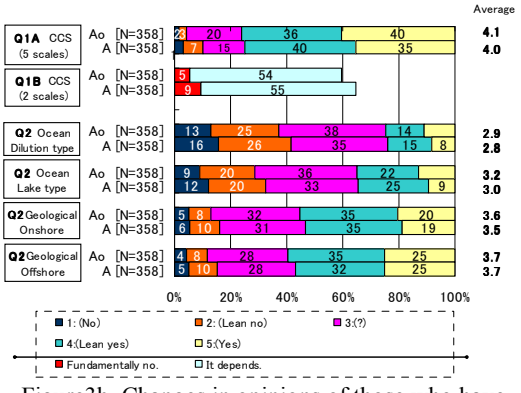


Figure3b. Changes in opinions of those who have knowledge on CCS, before and after providing information, Internet survey (2007)

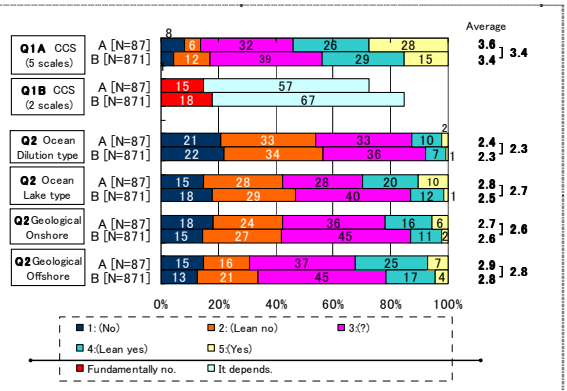


Figure4a. Comparison of opinions between those who have knowledge on CCS and those who do not, after providing information, door-to-door survey (2003)

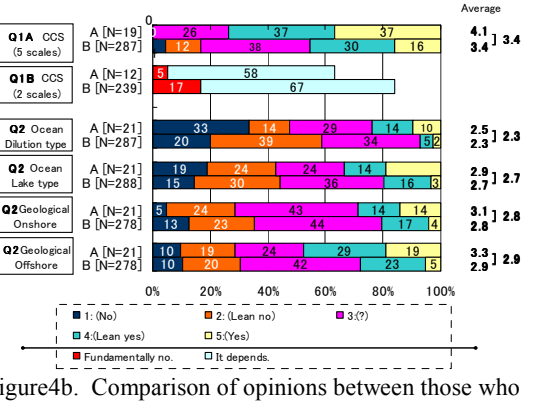


Figure4b. Comparison of opinions between those who have knowledge on CCS and those who do not, after providing information, door-to-door survey (2007)

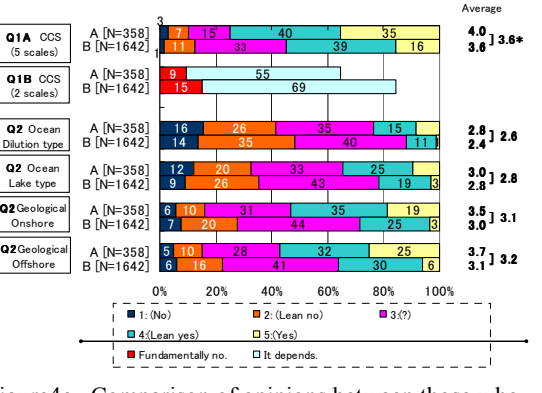


Figure4c. Comparison of opinions between those who have knowledge on CCS and those who do not, after providing information, Internet survey (2007)

(4) Comparison in opinions between 2003 and 2007 surveys, after providing information

In the 2003 survey, we provided the same package of information to all respondent and asked if they were for or against CCS implementation, since we had recognized respondents in general had little knowledge on CCS. This also was done in the 2007 survey. In this latter case, the basic information was provided to all respondent was eventually the same as in 2003. Therefore the results are comparable with the 2003 results. Efforts were taken to maintain scientific neutrality in terms of contents of the information provided in each survey, with an exception that the 2007 survey included the quotation from the IPCC Special Report. The mean values of all responses after providing information on CCS was 3.40 in the 2003 survey and 3.44 in the 2007 door-to-door survey and 3.65 in the 2007 Internet survey. No statistically significant change was observed in comparing the 2003 results to the 2007 door-to-door survey. By contrast, a positive, statistically significant difference was observed with greater acceptance for those participating in the 2007 Internet survey compared to those participating in the 2003 door-to-door survey.

As for the responses to Question 2 which asked opinions about implementation by technology type, some interesting observations were noted., Unlike Question 1A on implementing CCS as a part of climate policy portfolio, the mean value of each technology was below 3 in all other types than the two geological types in the 2007 Internet samples, showing that the overall response to implementation of specific technologies is in slightly negative direction. Such tendency is in consistent with the 2003 survey although with a slight shift to positive direction (statistically significant in mean values for all types of CCS technologies except for ocean dilution type, $P < 0.1$). In this context, it is noted that the 2007 Internet respondents show some preference in geological offshore type with the value of 3.2.

4.4 Analysis of influence to opinion formation depending on difference of information provided

(1) Changes in opinion of those who have knowledge on CCS before and after providing information (internal test)

Table 3 shows comparisons of changes in mean values of responses before and after receiving technical information of particular CCS types by subsample. The differences may not have been sufficiently detected in the subsample who received information by newspaper (Group B1) and those who received information through three supplemental information sources (B3-5) due to their relatively small size in number of the sample size. However, statistical significance was observed in the following cases: in all samples and in all questions. Public preference for CCS types was decreased by approx. 0.1 for the group receiving information about the technology on CCS. The group who received information from with newspaper articles, preference was largely decreased by 0.5 for the two ocean CCS types.

Table 3 Change before-and-after providing information on CCS to those who have knowledge on CCS

	B1-B5# (pooled)	B1	B2#-B5 (pooled)	B2#	B3	B4	B5
			Basic information based on IPCC special report				
	Whole sample	Newspaper	-	No other information	Current measures is not enough	Natural and industrial analogue	Plans by EU
Question \ N	324	30	294	200	35	32	27
Overall CCS (5 scales)	-0.1 ***	0.1	-0.1 ***	-0.2 ***	0.1	-0.1	-0.1
Overall CCS (2 scales)	-0.1 ***		-0.1 ***	-0.1 **		-0.1	-0.1
Ocean, Dilution type	-0.1 ***	-0.5 ***	-0.1 **	-0.1	-0.1	-0.2	-0.1
Ocean, Lake type	-0.1 ***	-0.5 ***	-0.1 *	-0.1	-0.4 **	0.0	-0.2
Geological, Onshore	-0.1 *	-0.2	-0.1	-0.1	-0.1	-0.1	0.1
Geological, Offshore	-0.1 *	0.0	-0.1 *	-0.1	-0.1	0.0	-0.3 **

***:P<1%, **:P<5%, *:P<10%

Note: The number in the table indicate difference in means :[mean after providing information]- [mean before providing information]

Both the information based on IPCC and that on newspaper articles commonly contained explanations on CCS technologies, effects and risk information. In addition, newspaper articles provided specific information that some organizations/countries have negative opinions on CCS. These were characterized from IPCC information with descriptions such as “there are concerns about impacts on ecosystems and about if CCS would discourage energy conservation” and “reluctance in developing countries that are keen to make steady effort for energy conservation, such as ‘issues of geological CCS should be carefully investigated. .

(2) Influence of difference in information provided in the subsamples: all respondents (external test)

Since the B1 cohort was only provided with news paper article on CCS and other cohorts (B2-B5) were provided with CCS information from IPCC special report (plus different supplemental information), we pooled B2-B5 as a group sharing IPCC information, and then compared with the B1 cohort. The result is as shown in Figure 6. Between the two groups, a statistically significant difference was observed in the questions on implementing CCS on the two ocean types and on the geological offshore type. Regarding CCS implementation, the group with IPCC information for all questions showed opinions with higher preference than that for the other groups. These results imply that information included only in the article of a newspaper that is about concerns on CCS expressed by an expert and a country influenced people in forming of their opinion on CCS implementation.

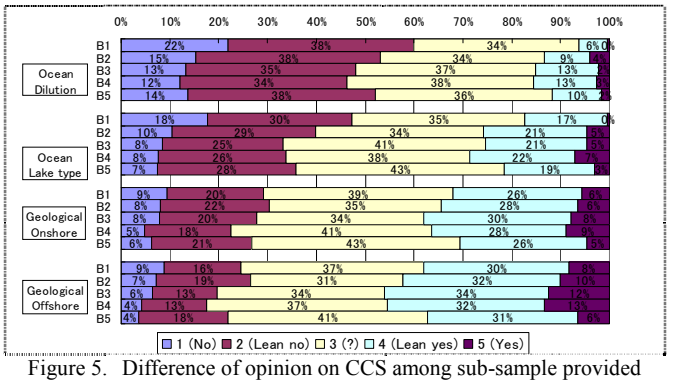
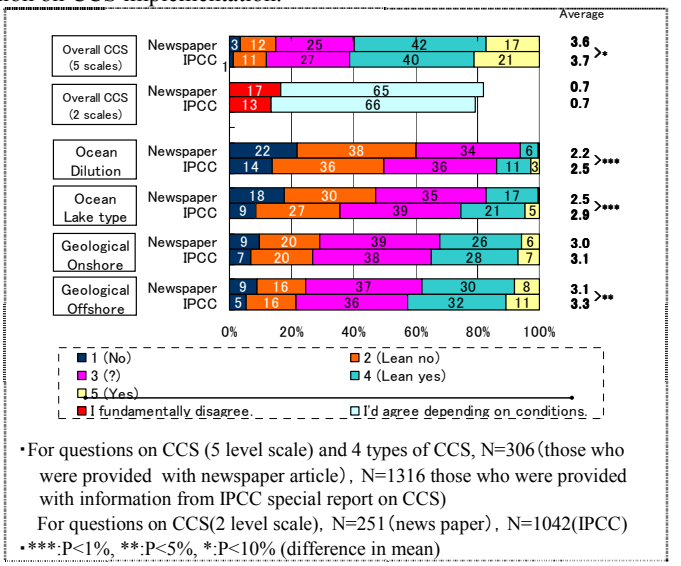


Figure 5. Difference of opinion on CCS among sub-sample provided with difference information on CCS (N =1620)

4.4 Influential factors on understanding CCS

Exploratory factor analysis was applied to results of 45 questions on respondents' views on CCS and global warming to identify the distinct influential factors attributed for respondent understanding of CCS. The four factors obtained by the factor analysis are interpreted below. The labels for each factors was determined based on subjective assessment of the similarities in the survey questions associated with each loading factor:



・For questions on CCS (5 level scale) and 4 types of CCS, N=306(those who were provided with newspaper article), N=1316 those who were provided with information from IPCC special report on CCS)
For questions on CCS(2 level scale), N=251(news paper), N=1042(IPCC)
・***:P<1%, **:P<5%, *:P<10% (difference in mean)

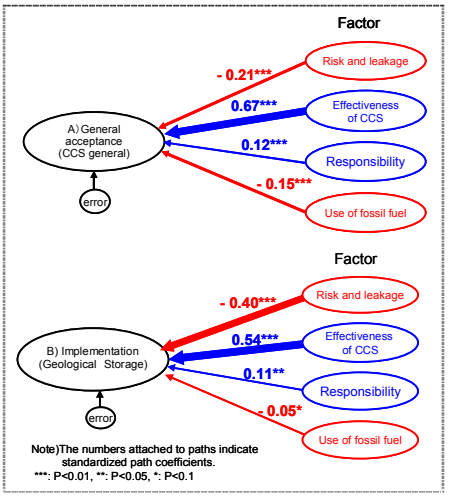
Figure 6. Difference of opinion among respondents who received IPCC information or newspaper information on CCS, 07 survey (Internet, whole sample: after providing information

Factor 1: risks and leakage (respondents' concern about environmental impacts and risks caused by injection of CO2 and possibility of leakage)

Factor 2: effectiveness of CCS (respondents' understanding of effectiveness of CCS as a mitigation option for climate change)

Factor 3: responsibility (respondent awareness of societal responsibility for mitigation of CO2)

Factor 4: fossil fuel use (respondent concern that CCS would allow continuation of current usage levels of fossil fuels)



Using the results of the exploratory factor analysis, we conducted a path analysis (i.e., structural equation modeling, SEM) to obtain a statistical acceptable structural model based on the presumed relationship between respondents' views on CCS and global warming (observed variables), the latent four influential factors, and the level of acceptability of CCS

(observed variables). We also assumed two latent variables ("General acceptance (CCS general)" and "Implementation (Geological storage)") between four factors and acceptance of CCS or geological storage (four observed variables) as constructs for understanding the acceptability of CCS or implementation of each type of geological storage in this model. Figure 7, illustrates the relationship between the four factors, and the two latent variables ("General acceptance (CCS general)." Implementation (Geological storage)," also was incorporated into the e path analysis.

According to the size of the standardized path coefficients, the "Effectiveness of CCS" factor consistently influences both the "General acceptance (CCS general)" and "Implementation (Geological storage)." Meanwhile, the negative influence of "Risks and leakage" on "Implementation (Geological storage)" is much larger than that on "General acceptance (CCS general)" as the path coefficient to "Implementation (Geological storage)" (-0.40) is twice as large as that on "General acceptance (CCS general)" (-0.21). On the contrary, the negative influence of the "Fossil fuel use" on the "General acceptance (CCS general)" is about two times as large as that on "Implementation (Geological storage)," as the path coefficients, (-0.15) and (-005) indicate.

In summary, understanding the effectiveness of CCS would be a key factor of positively influencing the public in both general CCS acceptance and geologic implementation. The factor for concern about the risks and leakage of CCS would mainly negatively influence public opinion regarding the implementation (Geological storage). Similarly, the factor for concern that CCS would allow continuation of current usage levels of fossil fuels would mainly negatively influence general CCS acceptance of CCS..

5. Conclusion

The Japanese public surveys regarding recognition status and opinions of CCS were conducted, and the following results were obtained. First, not many people still know about CCS. And second, those who have knowledge on CCS show a preference for CCS implementation; however; preference was decreased after obtaining information which we considered was neutral on CCS. These results suggest a possibility that information on negative aspects of CCS (risks, etc.) may not be well known in the general public.

We also found that after providing different information on CCS to respondents, in the group with the newspaper articles which we considered neutral, preference on CCS was slightly lower in comparison with other groups that received information from the IPCC Special Report. The newspaper articles contained the information on negative opinions against CCS that went beyond the information of risks provided in the PCC Special Report. It is assumed that such negative opinions may have influenced opinion formation of respondents. Since CCS is a new technology, information about how other people or entities evaluate CCS is a major influence. The views of those assigned to the sub-sample provided with industrial and natural analogue of preference on geological storage was slightly higher in comparison with other groups. This implies information on natural or industrial analogue would help communicate information on risk to the public in a positive way.

As the result of path analysis to data of a public survey, assuming four factors -- (1) risks and leakage, (2) effectiveness of CCS, (3) responsibility, and (4) fossil fuel use -- we found that the factor of understanding the effectiveness of CCS is the most positively influential for general acceptance of CCS and implementation of geological storage. The factor of risks and leakage became much more influential negatively in the implementation of geological storage compared to general acceptance of CCS. This implies implementation of CC2 geological storage needs careful communication of risk.

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