

Public Acceptance of CO₂ Capture and Storage: Exploratory Factor Analyses on a Public Survey

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Objective

- To assess potential acceptability of public on CCS.
- To find factors which influence public acceptance on CCS.
- To obtain information to make a effective public communication plan.

Design of questionnaire

- Structure

- Part 1 Demographic questions
- Part 2 Current recognition on CCS
- Part 3 Education + 5 level rating scale questions on respondents' perception and opinion on CCS (66 questions for factor analysis)

↓
Find Factors

Regression Analysis

- Part 4 Question on yes / no about CCS → Answers

Design of questionnaire

- Two different education versions
 - Limited education version (2 pages)
 - 1page summary of characteristics of CCS including risks and effects with illustrative figures
 - Full education version (8 pages)
 - Limited education version
 - + background
 - (climate change and mitigation measures)
 - + risk by type of CCS
 - + experiences (Norway and EOR)

Implementation of the survey and respondents' characteristics

- December 2003
- N=1006 (acceptance ratio 64%)
- Sampling
Method: multistage stratified sampling

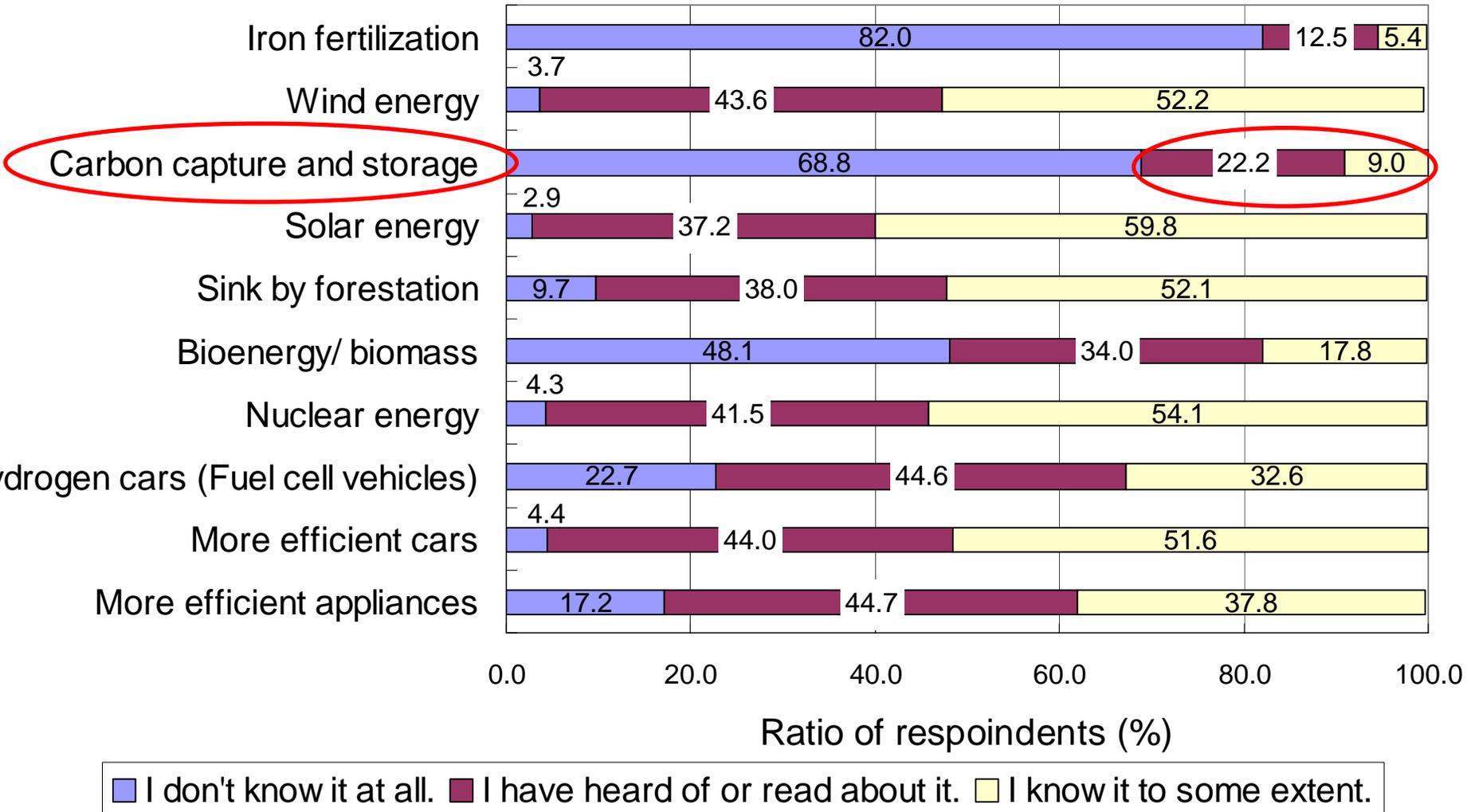
Venue:

Tokyo n=504	Sapporo n=502
Summer :hot and humid Winter: mild climate	Summer : pleasant climate Winter: severe climate

- Age :mean=47.3 yeas old Sex :female=50.6%

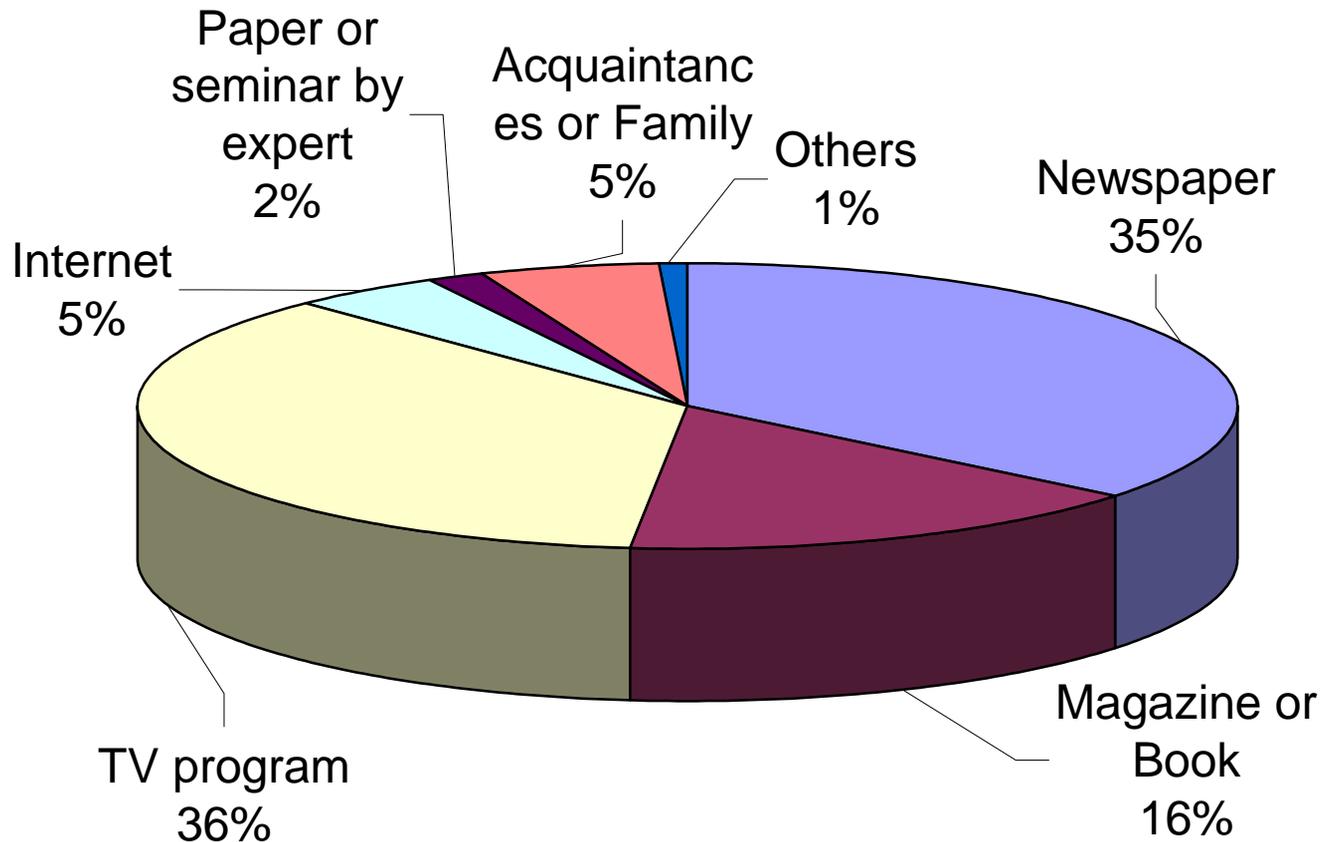
To what extent Public know CCS

- About 30% have heard of CCS.



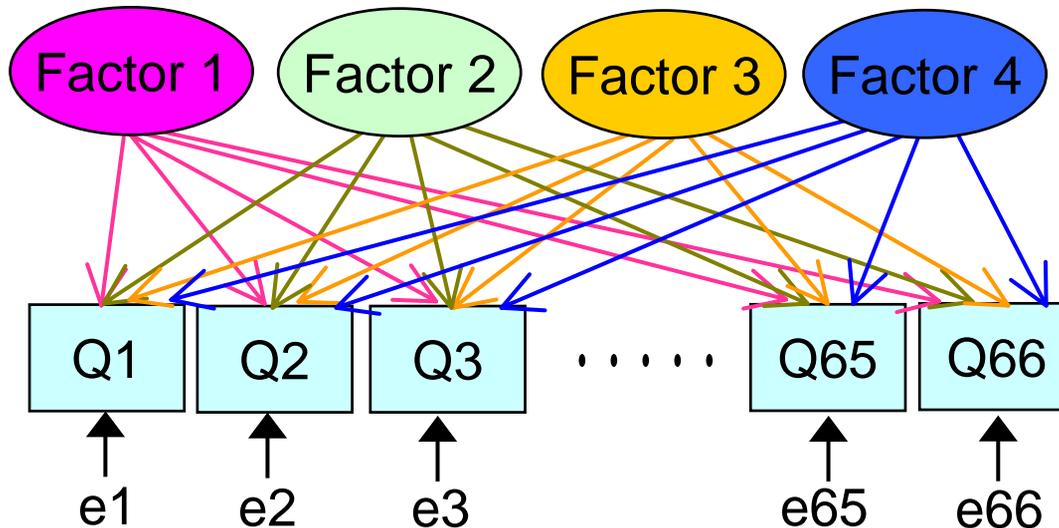
The sources of information on CCS

- TV and newspaper account for 1/3 respectively.



Theory of exploratory factor analysis

- To explore the underlying structure of a collection of observed variables.



$$x_i = \mu + A \cdot f_i + e_i \quad (i = 1, 2, \dots, n)$$

i : Respondent number

x_i : Answers of questions

μ : Mean vector

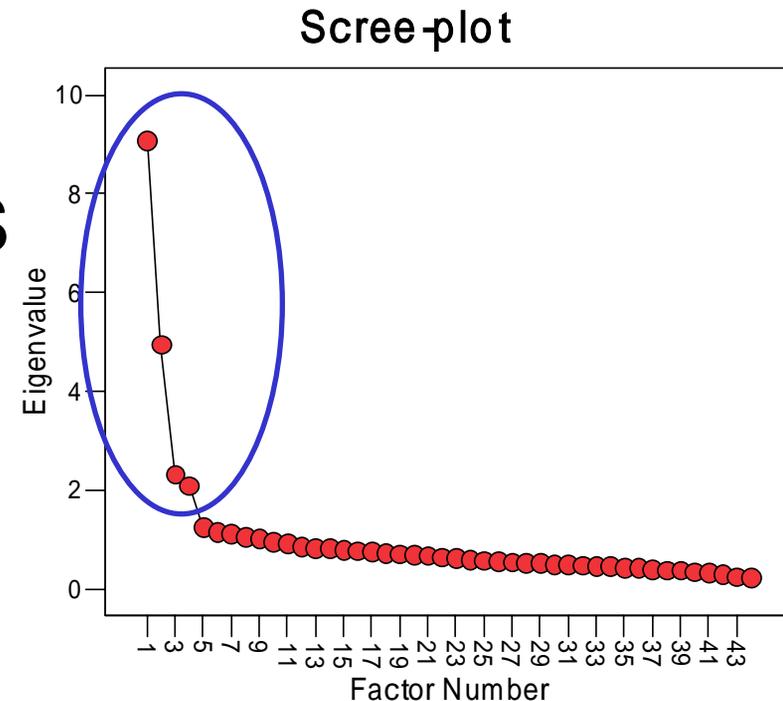
A : Factor loading matrix

f_i : Factor score vector

e_i : Unique factor vector

Influential factors on understanding CCS

- Factor 1: Risks and leakage
- Factor 2: Effectiveness of CCS
- Factor 3: Responsibility
- Factor 4: Use of fossil fuel



Estimation method: Varimax rotation, maximum likelihood solution

Influential factor 1

- Risk and leakage
 - Concern about environmental impacts and risks and possibility of leakage.

Factor loading matrix

Question	Factor1	Factor2	Factor3	Factor 4	Mean	S.D.
For CO2 geological storage, I'm concerned about the impacts on human health.	0.702	0.036	0.084	0.157	4.19	0.88
For CO2 geological storage, I'm concerned that we leave the risk to the future generation.	0.678	-0.081	0.279	0.127	4.33	0.81
For CO2 geological storage, I'm concerned about the impacts on underground organism.	0.672	-0.016	0.148	0.071	4.28	0.92
I feel uncomfortable with the idea itself that man injects something under the ground.	0.642	-0.148	0.096	0.257	4.07	1.02
I feel uncomfortable with the idea itself that man injects something into the sea.	0.636	-0.145	0.050	0.295	4.13	0.99

Influential factor 2

- Effectiveness

- Understanding of effectiveness of CCS as one of mitigation options of the climate change.

Factor loading matrix

Question	Factor1	Factor2	Factor3	Factor 4	Mean	S.D.
I think CO2 capture and storage is needed as an anti-global warming measure in developing countries where consumption of fossil fuel is increasing.	-0.084	0.733	0.088	-0.153	3.44	1.05
I think CO2 capture and storage is an effective means to deal with global warming issues.	-0.179	0.721	0.109	-0.242	3.24	1.04
I think CO2 capture and storage is the realistic option to reduce the amount of CO2 emission	-0.189	0.708	0.101	-0.217	3.32	1.07
CO2 capture and storage is the technology that we will definitely need in the future.	-0.025	0.674	0.055	-0.207	3.71	1.05
CO2 capture and storage is a good measure in terms of economic growth because it can deal with global warming by not changing current economic structure.	-0.258	0.642	0.083	-0.119	3.04	0.97

Influential factor 3

- Responsibility

- Awareness of responsibility for mitigation of CO₂ emission

Factor loading matrix

Question	Factor1	Factor2	Factor3	Factor 4	Mean	S.D.
Not implementing CO2 emission reduction measures means that we leave the burden to the future	0.127	0.079	0.640	0.078	4.52	0.79
Anti-global warming measures should be promoted rather	0.151	0.077	0.542	-0.061	4.51	0.74
Developed countries should be responsible to deal with global warming, since CO2 emission increased after the Industrial Revolution due to the economic	0.116	0.107	0.535	0.137	4.24	0.97
Major CO2 emission firms should voluntarily implement anti-global warming measures.	0.129	0.106	0.501	0.118	4.45	0.84
It would be unavoidable that we owe a certain amount of cost burden (tax raise) in order to promote anti-global warming measures.	0.015	0.159	0.427	-0.067	3.63	1.18

Influential factor 4

- Use of fossil fuel
 - Concern that CCS would allow us to keep using fossil fuel

Factor loading matrix

Question	Factor1	Factor2	Factor3	Factor 4	Mean	S.D.
I think CO2 capture and storage technology is not useful because fossil fuels are limited and eventually run out.	0.101	-0.181	-0.069	0.534	2.87	1.00
I think implementing CO2 capture and storage will lead to grow oil companies.	0.044	0.105	0.014	0.529	2.96	0.98
I think CO2 capture and storage is no more than a makeshift solution.	0.234	-0.425	0.104	0.440	3.29	1.23
I think CO2 capture and storage will lead us to keep using fossil fuels.	0.147	-0.081	0.133	0.417	3.44	1.02
I think CO2 capture and storage will lead to stabilize economy of oil producing countries.	-0.081	0.257	0.047	0.411	2.99	0.94

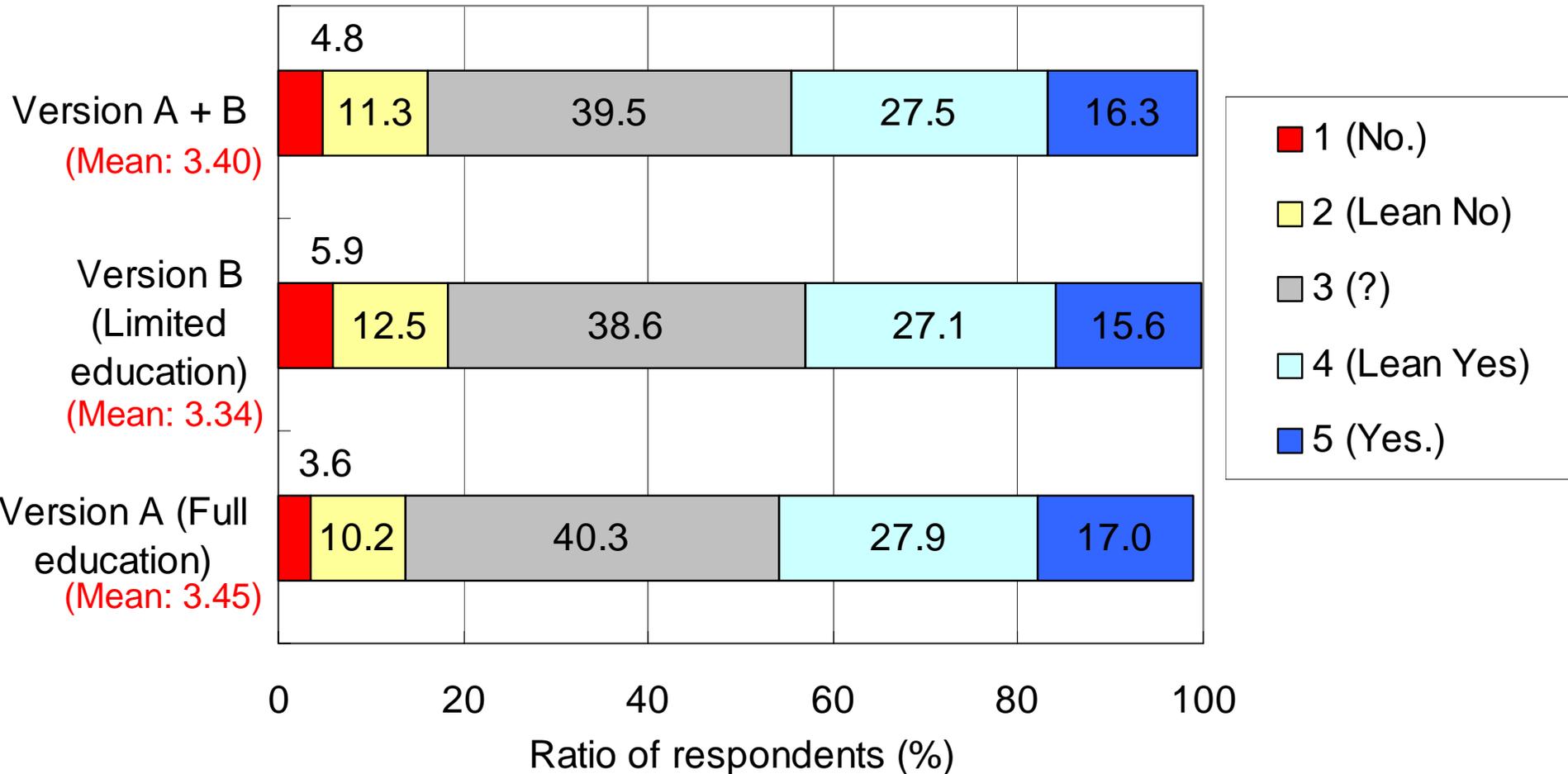
Assessment of acceptability of CCS

Yes / No about CCS

- Question 1
 - **Yes / No** about promoting CCS toward implementation as a part of climate policy portfolio?
(5 level rating scale)
- Question 2
 - Fundamentally **No** or **“It depends”**?
(Dichotomous choice: 2 level rating scale)
- Question 3
 - **Yes / No** about implementation by type of CCS?
(5 level rating scale)

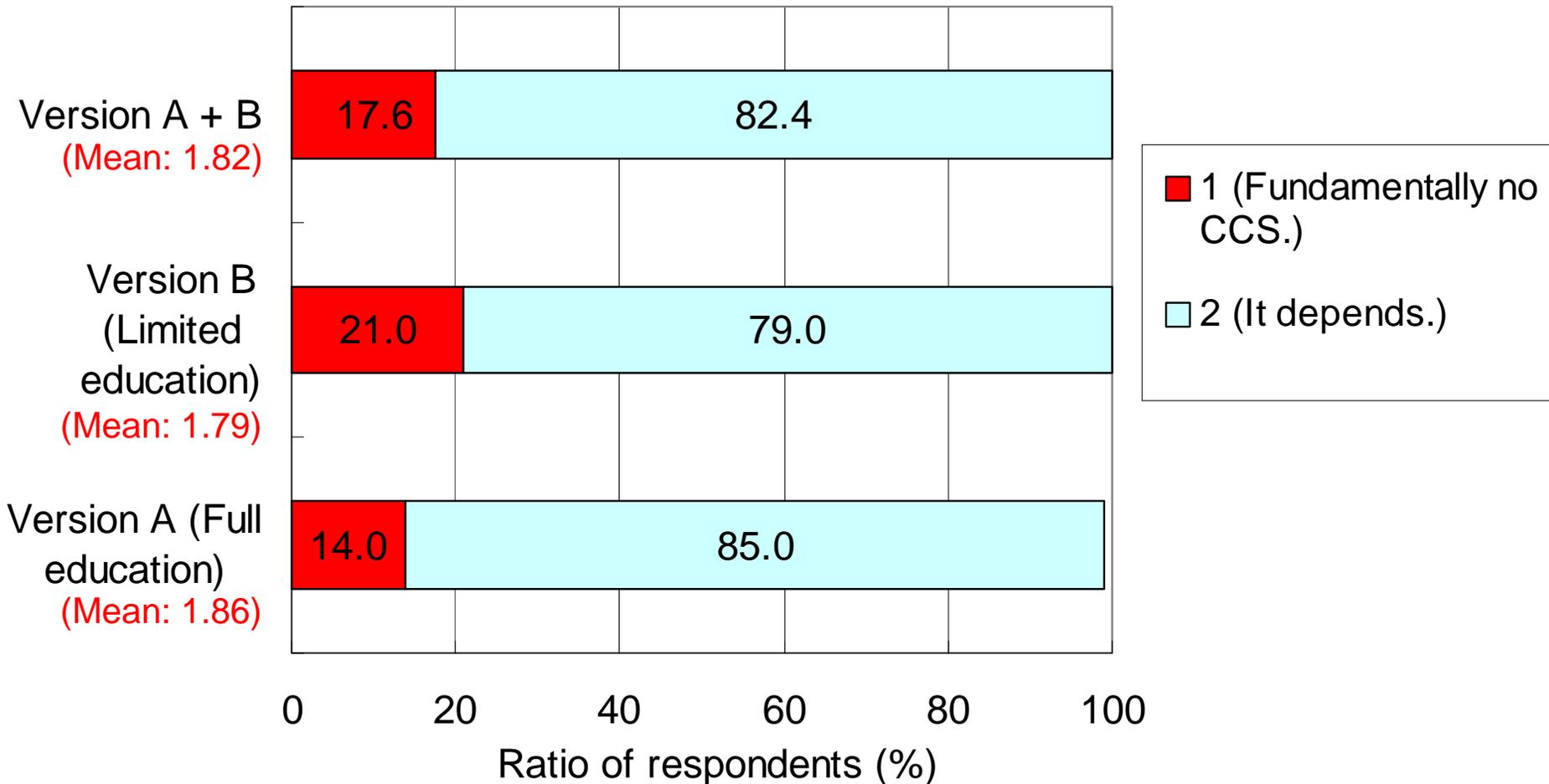
Yes / No about CCS

about promoting CCS toward implementation as a part of climate policy portfolio (5 level rating scale)



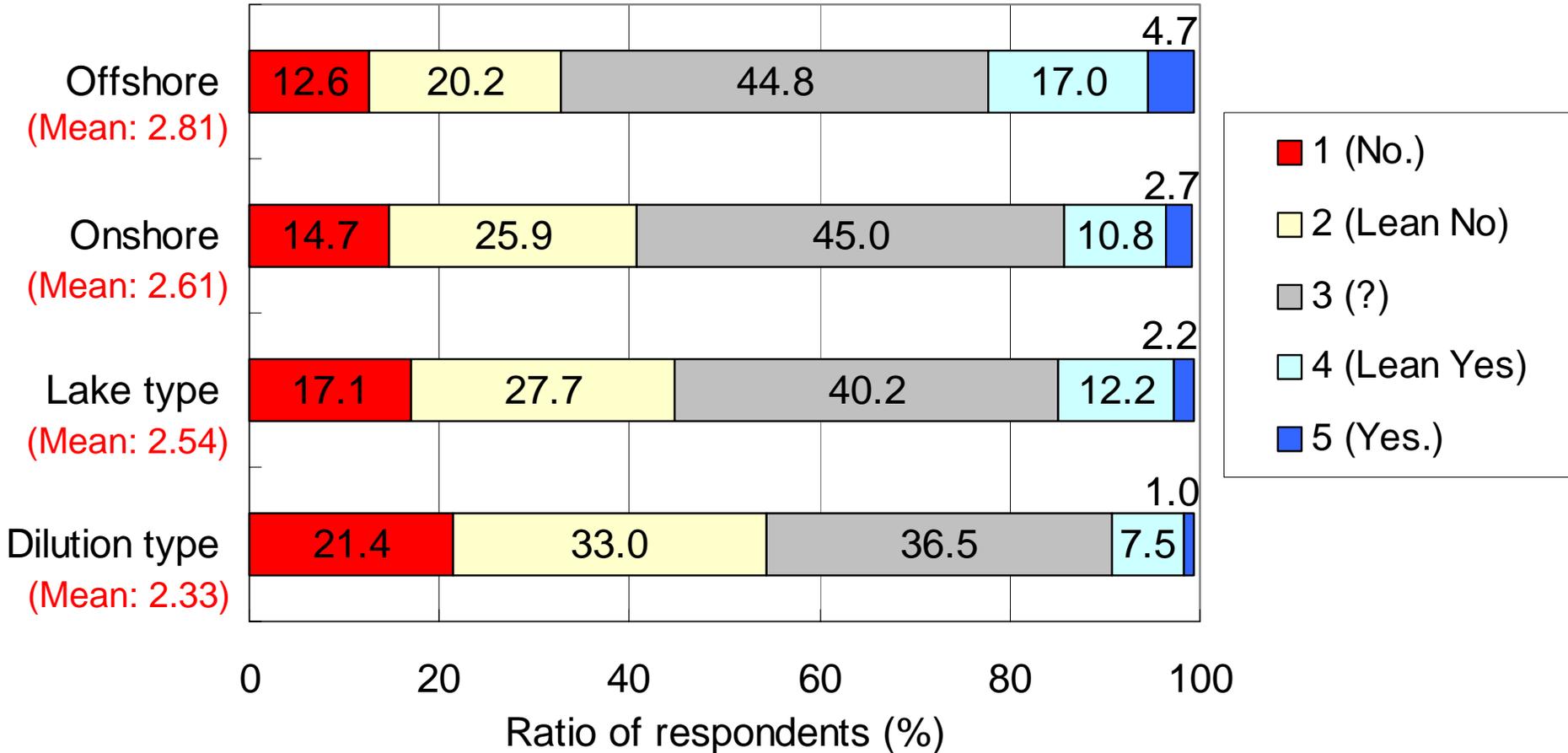
Yes / No about CCS

Fundamentally No or “It depends”?
(Dichotomous choice: 2 level rating scale)



Yes / No about CCS

about **implementation** by type of CCS?
(5 level rating scale)



Education influences public acceptance of CCS?

Mean and rank order test between the 2 education versions

	Mean					Rank order		
	Score		T-test			Mann-Whitney test		
	Full education	Limited education	T-value	P-value		Mann-Whitney U	P-value	
Yes and No (5 level rating scale)	3.45	3.34	1.647	0.100	*	1.187E+05	0.149	
Yes and No (2 level rating scale)	1.86	1.79	2.885	0.004	**	1.163E+05	0.004	**
Ocean: Dilution type	2.42	2.24	3.067	0.002	**	1.119E+05	0.003	**
Ocean: Lake type	2.62	2.47	2.363	0.018	**	1.162E+05	0.043	**
Geological: Onshore	2.65	2.57	1.299	0.194		1.211E+05	0.425	
Geological: Offshore	2.87	2.75	1.803	0.072	*	1.188E+05	0.171	

** : P-value < 5%, * : P-value < 10%

Influential factors on public acceptance of CCS

- Regression analyses

Variable	Yes and No (5 rating scale)		Yes and No (2 rating scale)		Ocean				Geologic			
					Dilution type		Lake type		Onshore		Offshore	
	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
Constant	3.407 ***	0.000	2.699 ***	0.000	2.484 ***	0.000	2.544 ***	0.000	2.652 ***	0.000	2.882 ***	0.000
Factor1 (Risks and leakage)	-0.230 ***	0.000	-0.858 ***	0.000	-0.392 ***	0.000	-0.443 ***	0.000	-0.378 ***	0.000	-0.447 ***	0.000
Factor2 (Effectiveness of CCS)	0.485 ***	0.000	1.324 ***	0.000	0.372 ***	0.000	0.427 ***	0.000	0.375 ***	0.000	0.448 ***	0.000
Factor3 (Responsibility)									-0.067 **	0.027		
Factor4 (Use of fossil fuel)	-0.373 ***	0.000	-0.958 ***	0.000	-0.233 ***	0.000	-0.307 ***	0.000	-0.222 ***	0.000	-0.372 ***	0.000
Factor1*Education			0.455 *	0.074								
Factor2*Education												
Factor3*Education	0.113 **	0.017			-0.087 **	0.039						
Factor4*Education					0.150 ***	0.007	0.104 *	0.063			0.162 ***	0.005
Education dummy					0.132 ***	0.008						
Female dummy			-0.364 *	0.093					-0.088 *	0.089		
Age					-0.006 ***	0.001						
Children dummy			-0.380 *	0.089							-0.096 *	0.059
Academic years												
Tokyo dummy					0.084 *	0.086						
University dummy												
R-squared	0.375		0.427		0.361		0.437		0.355		0.451	

(Nagelkerke R2)

***: P-value<0.01, **: P-value<0.05, *: P-value<0.1

Implications

- Japanese public would not have extreme opinions on CCS.
- “Concern about risks and leakage” and “Understanding of effectiveness” and “Concern about use of fossil fuel” would influence public acceptance.
- Providing more education would increase acceptability and reduce fundamental opposition.
 - Education to increase awareness of responsibility for mitigation of CO₂ emission would not necessarily enhance acceptability of CCS.
 - Education to help understanding on issues related to keeping use of fossil fuel would enhance acceptability of CCS.
- Onshore geologic sequestration needs careful communication strategy.

Questions or comment

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