グループ別発表 6
発表 2

「包括的な交通手段の実現:
社会的弱者を考慮した完全自動運転」

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特任助教

Achieving Inclusive Transportation:
Fully Automated Vehicles with Social Support

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Introduction (1)

Source: https://marketrealist.com/ (Accessed 2020/12/7)

Source: https://marketrealist.com/ (Accessed 2021/10/5)

Will Socially Excluded People Choose Fully Automated Vehicles?

Introduction (2)

Social Supports encourage Disaster Victims?

Why Disaster Victims?

1. Disaster Victims are not yet studied while previous works focus on elders, females, low-income group and ethnic minorities.
2. Risk perceptions
3. Increased number of natural disasters

Introduction (3)

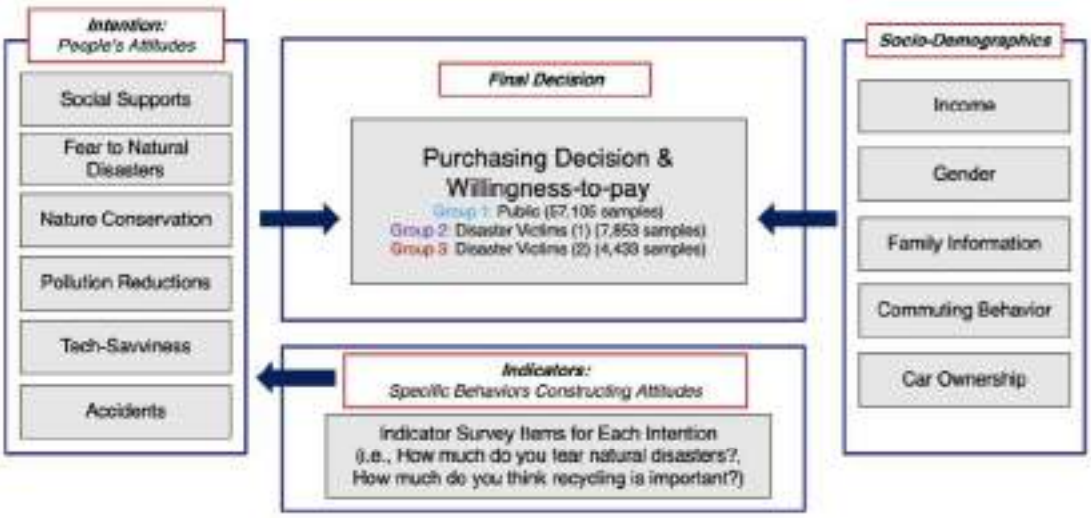


Figure 1: Study Structure

Previous Works

Table 1: List of Previous Works

▪ High risk refrains new technology choices	Mitchell (1999), Chen et al., (2021), Murray and Tuite (2014), Mairean (2020), Agahababaei (2010) For FAV contexts: DeMeulenaere 2020, Zhang 2019, Xu 2018.
▪Socially excluded people (i.e., elders, females, low-incomes) not choosing FAVs	Faber 2020, Kovacs et al., (2020), Lee (2018) and Dannimiller (2021).
▪ Disaster victims are not likely to choose new technologies, due to their increased fears	Sanbonmatsu 2018, Nunes 2018.
▪Social supports help disaster victims choose new technologies.	Han et al (2016), Joshi et al (2014), Murphy et al (2018), Lawrence et al., (2014), Brown (2018) and McGuire (2018).

Gaps from the previous research:
Disaster Victims, Social Supports, and FAVs.
(Possibly due to the lack of data)

Research Contribution

- Understand demand patterns and the provision of policies designed to encourage inclusive transportation modes, which goes beyond discussions on FAVs.
- Illuminate whether socially excluded accept fully automated vehicles.
- Social support as a buffer of natural disaster.

What is FAV?

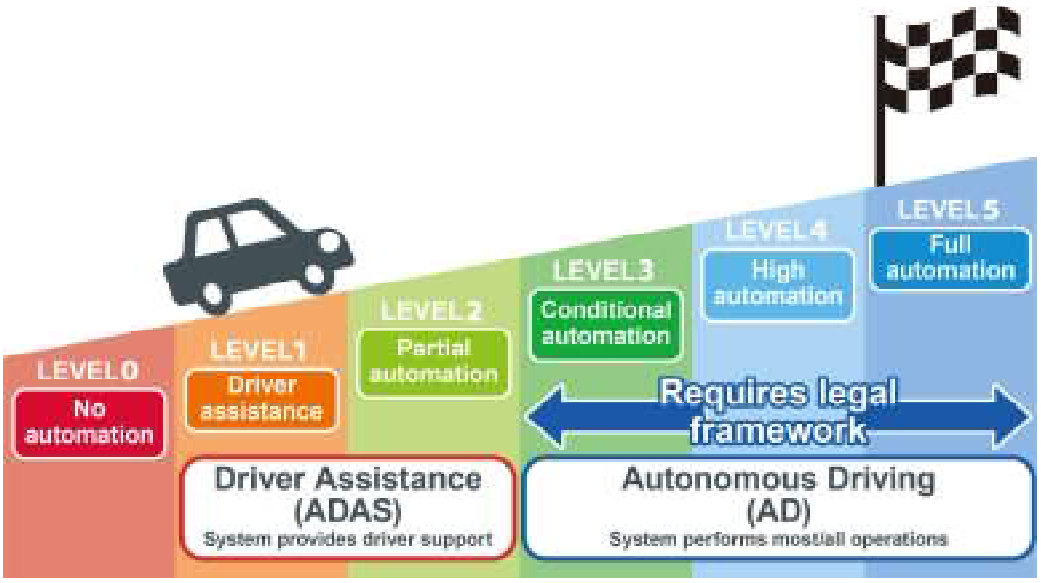


Figure 2: A Graphical Explanation of Automation Levels

Survey Design

- 2015-2017 Panel Survey Data

1) Identify Disaster Victim Groups

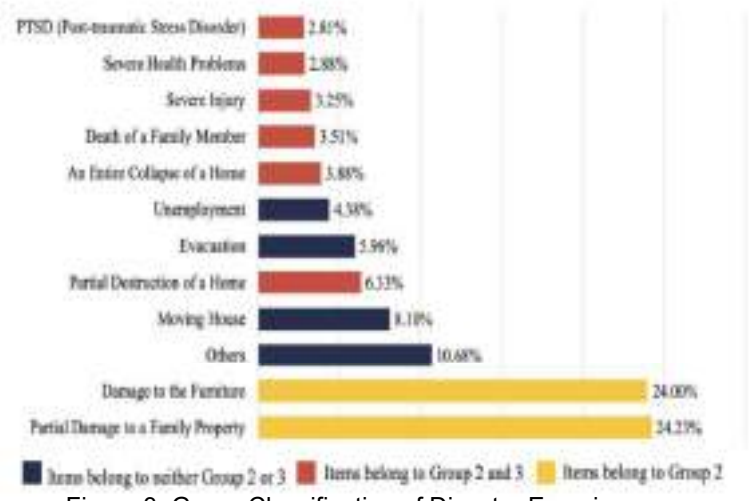


Figure 3: Group Classification of Disaster Experiences

2) FAV-related Questions

- Willingness-to-pay (Open Question)
- Willingness-to-buy (0, 1)

3) Socio-Economic Variables

- Income
- Gender
- Education levels
- The Number of Family Members
- Car Ownership
- Commuting Hour, Cost (if commutes)

Descriptive Statistics

Table 2: Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max	Variable	Mean	Std. Dev.	Min	Max
All Samples (n=69,391)					**Group 2 (n=7,853)**				
WTB (=1 if purchase FAVs)	0.488	0.500	0	1	WTB (=1 if purchase FAVs)	0.533	0.499	0	1
WTP (10,000 JPY)	67.618	131.359	0	999	WTP (10,000 JPY)	69.327	131.588	0	999
Female (=1 if female)	0.307	0.461	0	1	Female (=1 if female)	0.264	0.441	0	1
Annual Income (10,000 JPY)	511.958	420.924	100	3,50	Annual Income (10,000 JPY)	514.326	422.616	100	3,500
Age	0.486	0.506	0	3.25	Age	52.450	11.430	17	96
Commuting Time (Hours)	50.002	11.264	17	99	Commuting Time (Hours)	0.459	0.502	0	3.25
Household Members	2.785	1.315	1	10	Household Members	2.815	1.300	1	10
Household Members: Preschoolers	0.132	0.432	0	5	Household Members: Preschoolers	0.117	0.415	0	5
Commuting Cost (1,000 JPY)	0.620	2.360	0	999	Commuting Cost (1,000 JPY)	0.591	2.239	0	80
Car Ownership	0.802	0.398	0.00	1	Car Ownership	0.849	0.358	0	1
Group 1 (n=57,105)					**Group 3 (n=4,433)**				
WTB (=1 if purchase FAVs)	0.477	0.499	0	1	WTB (=1 if purchase FAVs)	0.547	0.498	0	1
WTP (10,000 JPY)	65.883	128.386	0	999	WTP (10,000 JPY)	86.803	165.358	0	999
Female (=1 if female)	0.315	0.465	0	1	Female (=1 if female)	0.285	0.452	0	1
Annual Income (10,000 JPY)	511.001	415.594	100	3,50	Annual Income (10,000 JPY)	520.088	481.752	100	3,500
Age	49.747	11.170	17	99	Age	48.958	11.614	17	99
Commuting Time (Hours)	0.487	0.505	0	3.25	Commuting Time (Hours)	0.515	0.521	0	3.25
Household Members	2.784	1.313	1	10	Household Members	2.754	1.366	1	10
Household Members: Preschoolers	0.134	0.433	0	5	Household Members: Preschoolers	0.139	0.452	0	5
Commuting Cost (1,000 JPY)	0.614	2.309	0	99	Commuting Cost (1,000 JPY)	0.736	3.097	0	80
Car Ownership	0.796	0.403	0	1	Car Ownership	0.801	0.399	0	1

Structural Equation Model（SEM）(1)

$$\begin{bmatrix} WTP_i \\ WTB_i \end{bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} & \alpha_{15} & \alpha_{16} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} & \alpha_{25} & \alpha_{26} \end{bmatrix} \begin{bmatrix} ND_i \\ SP_i \\ FE_i \\ MR_i \\ EP_i \\ EN_i \end{bmatrix} + \begin{bmatrix} \beta_{10} & 0 & \boldsymbol{\beta'_{1x}} \\ \beta_{20} & \beta_{21} & \boldsymbol{\beta'_{2x}} \end{bmatrix} \begin{bmatrix} 1 \\ WTP_i \\ \boldsymbol{x_i} \end{bmatrix} + \begin{bmatrix} \epsilon_{1i} \\ \epsilon_{2i} \end{bmatrix}$$

For individual i,
α: Correlation between each latent construct and WTP, WTB
$\beta_{10}$and β_{20} : Intercepts
β_{21}: Correlation between WTP and WTB
$\beta_{1x}$and β_{2x}: Correlation between WTP/WTB and a set of 12 individual characteristics x_i.

Structural Equation Model（SEM）(2)

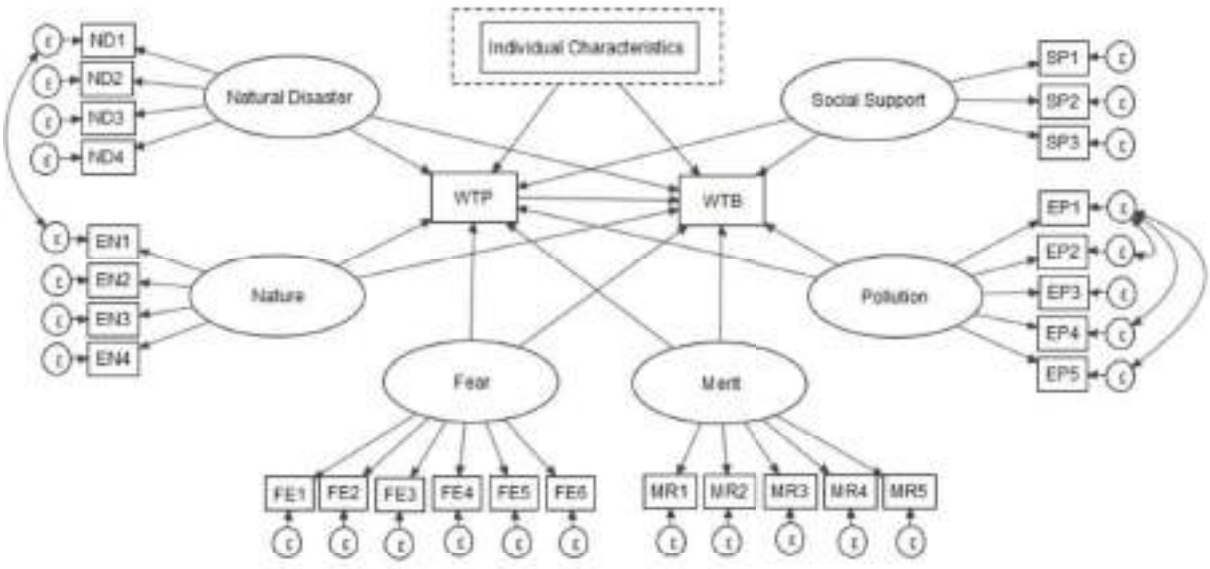


Figure 4: Model Structure

Result (1)

Table 3: Estimation Result

	Model (1) (WTB)			Model (2) (WTP)		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
Panel A: Latent Variables						
SP	0.095***	0.088***	0.152***	0.060***	0.079***	0.126***
	(.005)	(.014)	(.016)	(.005)	(.014)	(.016)
ND	0.055***	0.038***	0.044**	0.071***	0.086***	0.095***
	(.004)	(.014)	(.018)	(.004)	(.013)	(.016)
FE	-0.077***	-0.103***	-0.113***	-0.077***	-0.102***	-0.106***
	(.009)	(.024)	(.032)	(.009)	(.024)	(.033)
MR	0.142***	0.150***	0.146***	0.217***	0.203***	0.231***
	(.009)	(.025)	(.033)	(.009)	(.025)	(.033)
EP	0.011	-0.027	-0.0388	0.026***	-0.048**	-0.052
	(.009)	(.026)	(.035)	(.009)	(.026)	(.033)
EN	0.054***	0.073***	0.106**	0.049***	0.112***	0.101**
	(.009)	(.026)	(.034)	(.009)	(.026)	(.034)
Observations	57,105	7,853	4,433	57,105	7,853	4,433
Panel C: Model Fit						
RMSEA		0.044			0.044	
CFI		0.913			0.913	
SRMR		0.06			0.06	

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

For simplicity, we omit other control variables.

SP>ND
Social support Buffers Natural Disaster

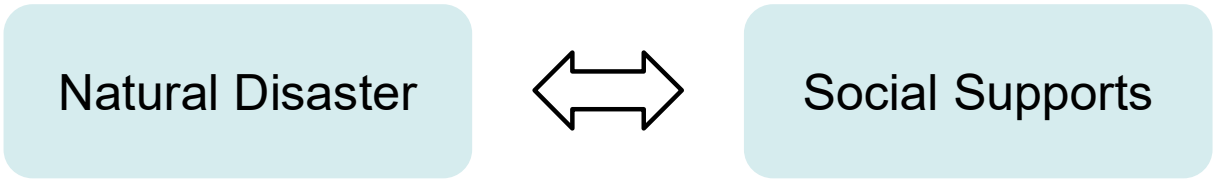
Result (2)

Table 4: Group Heterogeneity Test Result

	Group 1 vs. 2	Group 2 vs. 3	Group 1 vs. 3
Panel A: WTP			
SP	0.519	12.756***	13.524***
ND	1.629	0.286	0.228
FE	0.839	0.293	1.383
MR	0.013	0.096	0.102
EP	0.261	0.794	1.819
EN	0.383	0.946	2.393
Panel B: WTB			
SP	2.515	2.035	9.803***
ND	2.17	0.15	3.025*
FE	0.552	0.012	0.375
MR	0.329	0.756	0.189
EP	7.099***	0.015	3.382*
EN	4.886**	0.114	1.585

Note: Each value shows the chi-squared statistic with significance obtained from the Wald test.* p<0.1, ** p<0.05, *** p<0.01

Discussion



Policy Guidelines

- Providing a governmental (or local institutional) guidelines on the prior knowledge of FAVs
- Family and peer support can encourage disaster victims to adapt to new technologies or return to driving (Novack, 2010).

Conclusion

- Achieving inclusive transportation requires accommodating socially vulnerable people who are not able to drive unassisted.
- Social support is pivotal in motivating disaster victims to adopt and appreciate FAVs.
- Possible Limitation: Reverse Causality (SEM)

Appendix (1)

Table A1: Socioeconomic Distribution of the Respondents and the Japanese Population

		Sample (%) (n = 100,000)	Government Statistics (%)
Gender	Female	41	51.3
	Male	59	48.7
Education level	Junior high school or less	2.1	9.5
	High school	26.9	42.3
	Some college	22.6	15.6
	Bachelor / Master / Doctor	45.9	23.9
	Other	1.9	8.6
Age	18–19	0.2	2.3
	20–29	5.4	11.7
	30–39	18.1	13.3
	40–49	31.9	17.2
	50–64	25.8	22.1
	Over 65	10.7	33.4
Household income	<2 million JPY	7.8	18.3
	2–3 million JPY	8.9	17.2
	3–4 million JPY	11.9	15.3
	4–5 million JPY	12.3	12.2
	5–6 million JPY	11.9	9
	6–7 million JPY	9.6	6.9
	7–8 million JPY	9.1	5.8
	8–9 million JPY	6.9	4.1
	9–10 million JPY	6.7	3.4
	10–15 million JPY	10.5	6
	15–20 million JPY	2.7	1.1
	≥ 20 million JPY	1.7	0.7
	Don't know / don't want to answer	-	-
Region	Hokkaido	4.6	4.2
	Tohoku	5.9	6.8
	Kanto	38.2	34.4
	Chubu	16.6	16.8
	Kinki	20.1	17.7
	Chugoku	5.1	5.8
	Shikoku	2.5	2.9
	Kyushu/Okinawa	7.1	11.3
Household size	1	15.8	34.5
	2	30.1	27.9
	3	23.6	17.6
	4 and above	30.1	20

Sources: MIC (2017, 2019a, 2019b)

Appendix (2)

Table A2: Proportion and Mean Value of Respondents' Evaluations for Each Latent Construct

Latent Category	All	Group 1	Group 2	Group 3
Latent Category 1: "Natural Disaster", 1-5 Point Scale		Mean Value		
ND1. Do you think your life will be in danger due to a large-scale natural disaster?	2.31	2.32	2.3	2.33
ND2. Do you think your property (household, household goods, automobiles, etc.) will be damaged by a large-scale natural disaster?	1.11	2.13	2.09	2
ND3. Do you think a large-scale natural disaster will isolate you from your surroundings?	2.34	2.35	2.34	2.34
ND4. Do you think you will need to evacuate from your home during a disaster to save your life?	2.73	2.74	2.72	2.84
Latent Category 2: "Social Support", 1-5 Point Scale		Mean Value		
SP1. I expect physical/mental support from the government, local authorities and public institutions.	2.38	2.39	2.41	2.49
SP2. I expect physical/mental support from family members and friends.	2.47	2.45	2.54	2.56
SP3. I expect physical/mental support from local volunteers and members of local communities.	2.37	2.36	2.43	2.46
Latent Category 3: "Merit", Multiple Choice		Evaluation (%)		
MR1. People can drive without a license.	12.31%	12.08%	13.74%	12.73%
MR2. Burdens on driving would be decreased.	38.45%	38.12%	40.85%	32.94%
MR3. Children can move the vehicle without a guardian.	5.04%	5.84%	4.68%	5.56%
MR4. Able to do other work while driving. (Multitask)	27.96%	27.69%	32.89%	24.91%
MR5. Able to avoid responsibility for traffic accidents.	12.01%	11.26%	13.83%	12.38%
Latent Category 4: "Fear", Multiple Choice		Evaluation (%)		
FE1. There is a possibility that children will be able to move vehicles on their own.	33.74%	36.02%	38.89%	35.52%
FE2. There is a possibility that the software is hacked. (Cyber security)	66.13%	63.74%	57.85%	51.26%
FE3. A malfunction may cause accidents.	68.25%	53.04%	58.76%	45.29%
FE4. It is unclear who is responsible for an accident due to AV technology.	78.83%	48.52%	53.84%	43.48%
FE5. Traffic volume and congestion might increase because those without a license can drive.	52.98%	25.05%	26.91%	24.13%
FE6. A malfunction may lead me to the wrong destination.	52.20%	25.02%	26.10%	24.13%
Latent Category 5: "Pollution", 1-5 Point Scale		Mean Value		
EP1. Recycling is important.	3.43	3.41	3.58	3.43
EP2. Cycle utilization rate, the percentage of the total amount of reusable and recycled materials to be injected into society, is important for preventing pollution.	3.34	3.31	3.48	3.35
EP3. I think water quality should be improved.	3.37	3.35	3.54	3.37
EP4. Alleviating particulate matter (PM) 2.5, pollution is critical for our society.	3.48	3.46	3.68	3.47
EP5. Resolving air pollution (particularly, photochemical smog) is important.	3.45	3.43	3.62	3.44
Latent Category 6: "Nature", 1-5 Point Scale		Mean Value		
EN1. Preserving endangered species is important.	2.94	2.92	3.04	3.01
EN2. Preserving living animals overall is important.	2.83	2.81	2.99	2.83
EN3. The ratio of green area within 1,500 meters of a house is important.	3.08	3.06	3.25	3.13
EN4. Green purchasing: When purchasing goods and services, I consider the environmental impact before purchasing.	3.02	3	3.15	3.09

Appendix (3)

Table A3: Correlation Matrix

	SP	ND	FE	MR	EP	EN
SP	1					
ND	0.049	1				
FE	-0.018	0.150	1			
MR	0.016	0.076	0.821	1		
EP	0.107	0.284	0.284	0.286	1	
EN	0.133	0.095	0.204	0.189	0.889	1