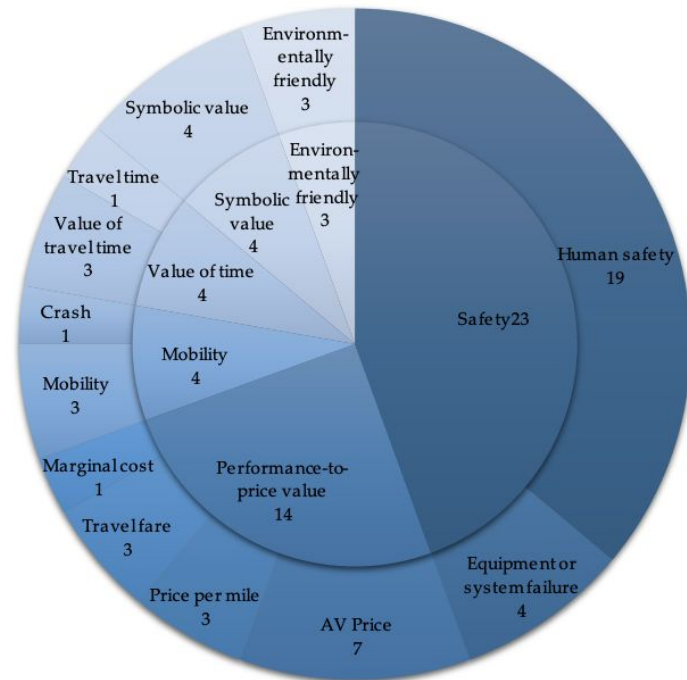# Traditional Rideshare vs. Robotaxi (AV) Ridership

John Bolaji, Mihir Thakar, John Thompson, Sarah Thorson

Objective/Motivation

- What factors determine rideshare preferences between AVs and human driven vehicles?
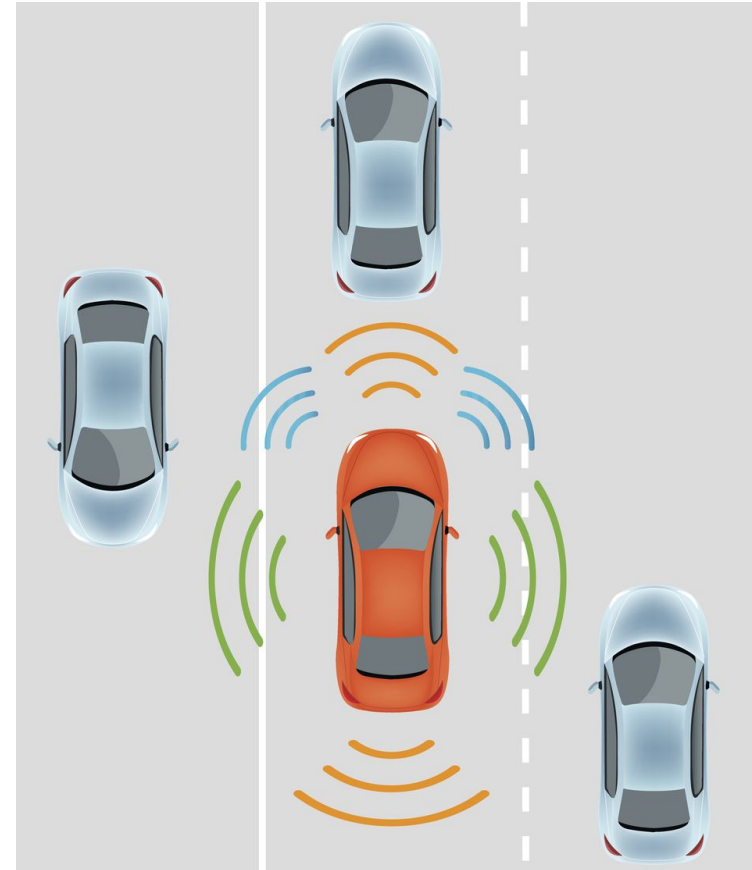
Target Insights

- Factors of importance for manufacturers
- Incentives for AVs

Literature Review

- People are *comfortable* with AV ridership

- Demographic breakdown of preferences

Survey Methodology

- Stated preference survey
  - Personal: Income, Reason Use Case, Routine Use Case

  - Demographic: Age, Gender, Political Leaning Introversion-Extroversion Scale

Survey Methodology

- Stated preference survey
    - Alternative Table

Variable	AV Taxi	AV Taxi with Human Pilot	Traditional Rideshare Service
Waiting Time (mins)	3/5/10	3/5/10	3/5/10
Ride Duration (mins)	10/15/25/30/40/45	10/15/25/30/40/45	10/15/25/30/40/45
Cost ($)	10/15/20/30/45	10/15/20/30/45	10/15/20/30/45
Are you Carpooling?	Yes/No	Yes/No	Yes/No

Model Methodology

- Multinomial Logit

- Nested Logit
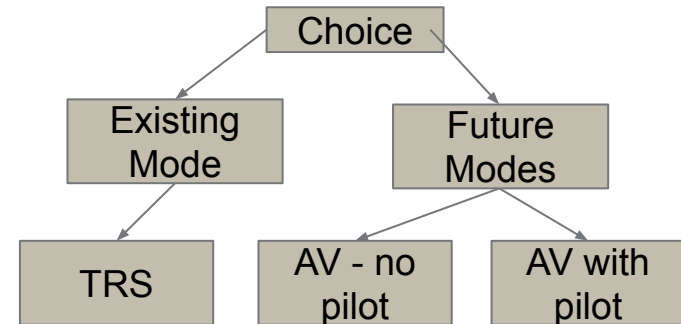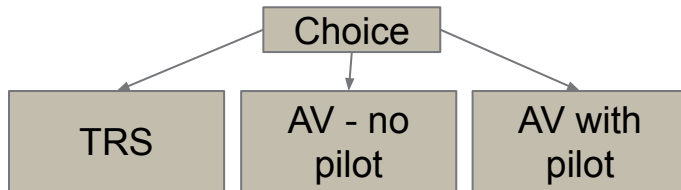
Results - MNL

Below are high-level results from our Multinomial Logit Model Regression (R-square: 0.173):

Variable	Coefficient	Z-Score
AV Taxi with and without Pilot	-0.1096	-0.251
Total Time	-0.0312	-3.857
Cost	-0.0486	-5.470
Fare/Income AV Taxi w/ and w/out Pilot	-0.0921	-0.934

- Respondents prefer traditional rideshare to AVs and AVs with human pilot*

- As expected, utility decreases as travel time and cost increase

- As the fare/income ratio increases, meaning that the fare is more substantial for those who earn less, utility decreases*

*Not statistically significant at the 90% level

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Results - MNL (cont.)

Below are key results from our Multinomial Logit Model Regression (R-square: 0.173):

Variable	Coefficient	Z-Score*
Carpool (AV Taxi)	-0.3550	-1.377
Carpool (AV Taxi + Pilot)	-0.0915	-0.364
Carpool (Traditional Taxi)	-0.0784	-0.267
Social Level (AV Solo)	0.1671	1.22e–08
Social Level (AV + Pilot)	-0.0251	-1.83e–09
Social Level (Trad. Rideshare)	-0.1420	-1.04e–08
Time of Day - Late Night AV	0.1264	0.420

- Respondents were less likely to choose an AV taxi if carpooling, as compared to AV taxi w/pilot or traditional taxi*

- Those who identify as more extroverted were more apt to choose a solo AV ride, which was opposite of our a-priori expectations*

- During late night hours (10pm-3am), respondents were more likely to take an AV

*All coefficients except for total time and cost (not shown here, see Appendix) were not statistically significant at the 90% level

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Results - Nested Logit

Below are key results from our Nested Logit Model Regression (R-square: 0.183):

Variable	Coefficient	Z-Score*
Future Modes	31.5564	2.77e-12
Existing Modes	0/0**	nan**
Carpool (AV Taxi)	-0.2811	-1.074
Carpool (AV Taxi + Pilot)	-0.2062	-0.681
Carpool (Traditional Taxi)	-0.0911	-0.304
Social Level (AV Solo)	0.2407	4.06e–08
Social Level (AV + Pilot)	-0.1057	-1.78e–08
Social Level (Trad. Rideshare)	-0.1350	-2.28e–08
Time of Day - Late Night AV	0.1344	0.437

- Respondents prefer riding alone over carpooling, and are less likely to carpool for an AV taxi

- Those who identify as more extroverted were still more apt to choose a solo AV ride

- There was very little change in the coefficient of respondents more likely to take an AV during late night hours

- **Future Mode and Existing Mode Issues related to lack of scale parameter acquired from Biogeme package

*All coefficients except for total time and cost (not shown here, see Appendix) were not statistically significant at the 90% level

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Marginal Rates of Substitution - MNML

$$MRS(value\ of\ time) = \frac{\frac{\delta U_{in}}{\delta_{travel\ time}}}{\frac{\delta U_{in}}{\delta_{cost}}} = \frac{\delta_{cost}}{\delta_{travel\ time}} = \frac{-0.0486}{-0.0312} = \frac{\$1.5577}{min} = \frac{\$93.46}{hr}$$

$$\delta_{travel\ time} = -0.0312$$
$$\delta_{cost} = -0.0486$$

$$MRS(value\ of\ perceived\ safety) = \frac{\frac{\delta U_{in}}{\delta_{ASC}}}{\frac{\delta U_{in}}{\delta_{cost}}} = \frac{\delta_{cost}}{\delta_{ASC}} = \frac{-0.0486}{-0.0196} = \$2.4796$$

$$\delta_{AV\ Taxi\ (with\ and\ without\ pilot)} = -0.0196$$
$$\delta_{cost} = -0.0486$$

Marginal Rates of Substitution - Nested Logit

$$MRS(value\ of\ time) = \frac{\frac{\delta U_{in}}{\delta travel\ time}}{\frac{\delta U_{in}}{\delta cost}} = \frac{\delta cost}{\delta travel\ time} = \frac{-0.0486}{-0.0313} = \frac{\$1.5527}{min} = \frac{\$93.16}{hr}$$

$$\delta travel\ time = -0.0313$$
$$\delta cost = -0.0486$$

Forecasting Analysis MNML
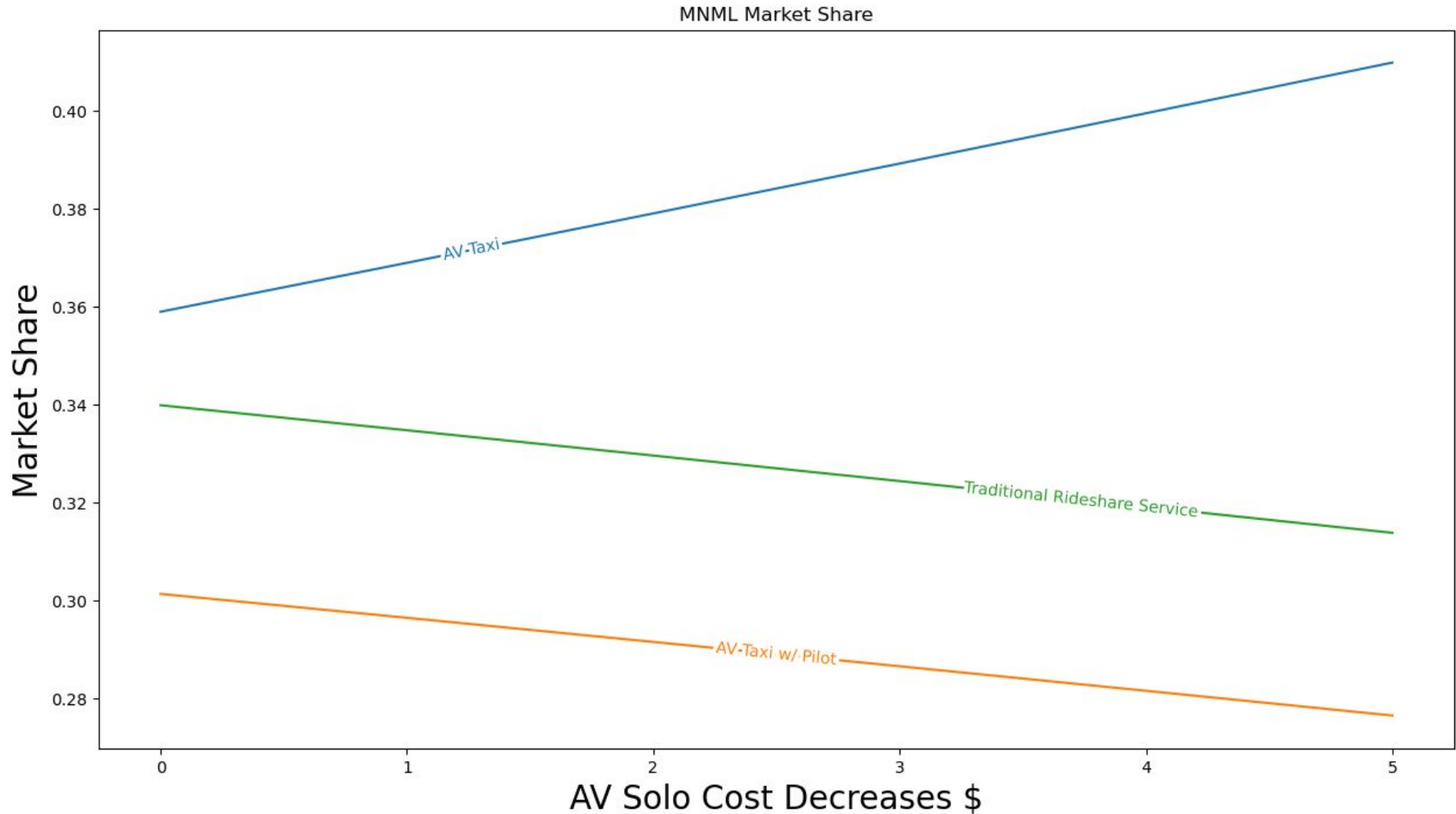
MNML Market Share

Forecasting Analysis Nested Logit

Nested Logit Market Share

AV-Taxi

Traditional Rideshare Service

AV-Taxi w/ Pilot

Market Share

AV Solo Cost Decreases $
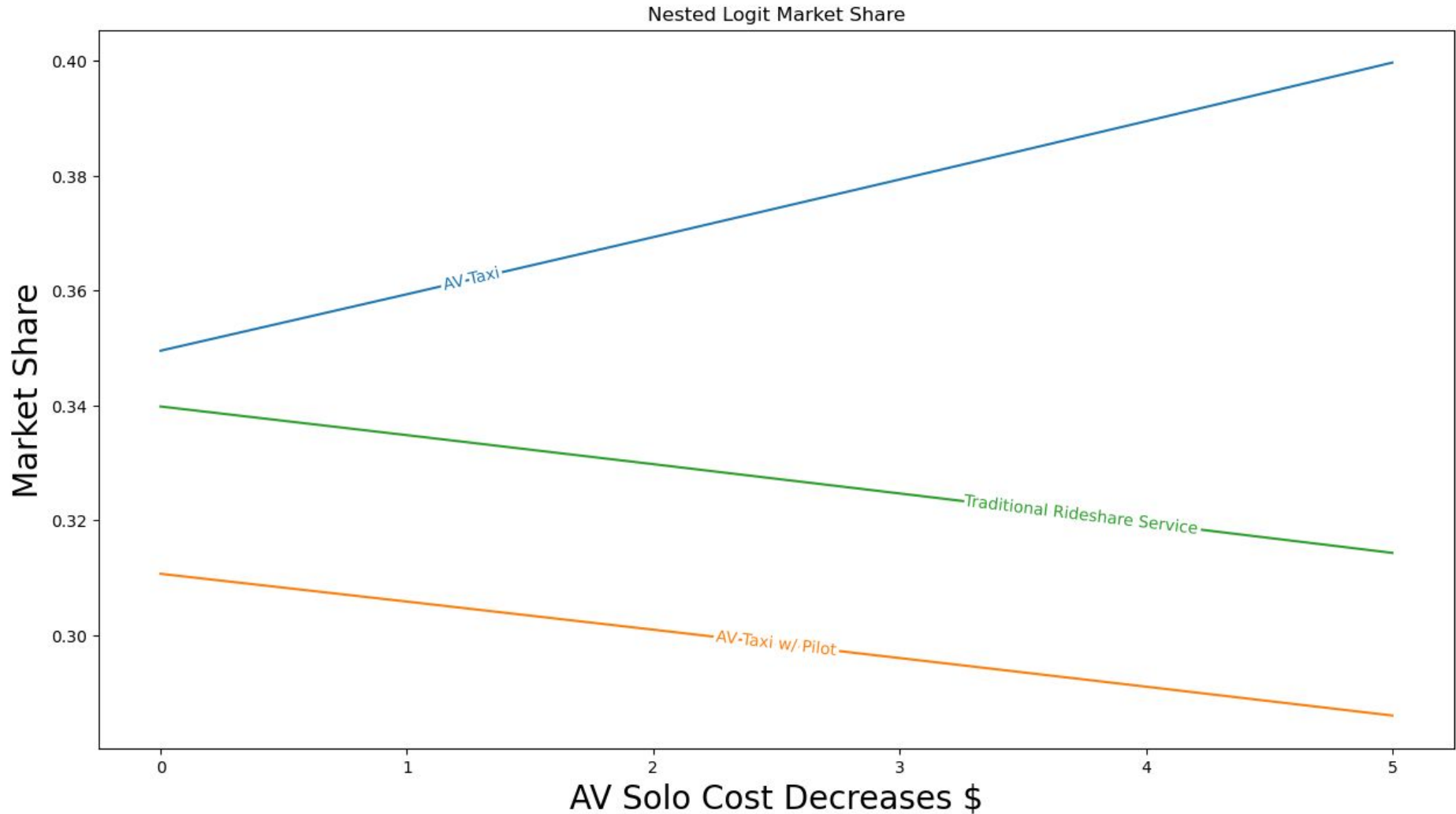
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Conclusions & Recommendations

- Subsidizing adoption of AVs
- Estimating market share and value of market over time
- Getting insight on actual costs and times associated with AV Taxi
- Strategic insights around business models

What we'd do next time

- **Use cross-nested logit model** to improve model accuracy- AV with human driver may overlap with both AV and traditional rideshare
- **Use best practices to get a more representative sample** - share more broadly with diverse socioeconomic groups that are representative of the Bay Area (as opposed to primarily students)
- **Add Survey Data Validation -** had to throw out ~20 responses because of incompletion
- **Nested Logit Specification -** Use biogeme package in order to get unconstrained scale parameter
- **Class Models -** focus on understanding differences in preferences and behaviors between different segments of the population

Questions?

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Appendix

Multinomial Logit Model

```
            Multinomial Logit Model Regression Results
===============================================================================
Dep. Variable:                    choice   No. Observations:             309
Model:           Multinomial Logit Model   Df Residuals:                 297
Method:                              MLE   Df Model:                      12
Date:                  Mon, 25 Apr 2022   Pseudo R-squ.:              0.173
Time:                         19:49:01   Pseudo R-bar-squ.:          0.138
AIC:                           585.529   Log-Likelihood:           -280.765
BIC:                           630.329   LL-Null:                  -339.471
===============================================================================
                                       coef   std err         z    P>|z|     [0.025     0.975]
-------------------------------------------------------------------------------------------------
AV Taxi with and without Pilot      -0.1096     0.437    -0.251    0.802     -0.966      0.747
Total Time, units: min              -0.0312     0.008    -3.857    0.000     -0.047     -0.015
Wait Time, units: min               -0.0247     0.024    -1.023    0.306     -0.072      0.023
Cost , units:$                      -0.0486     0.009    -5.470    0.000     -0.066     -0.031
Carpool (AV Taxi)                   -0.3550     0.258    -1.377    0.169     -0.860      0.150
Carpool (AV Taxi + Pilot)           -0.0915     0.251    -0.364    0.716     -0.584      0.401
Carpool (Traditional Taxi)          -0.0784     0.294    -0.267    0.790     -0.654      0.498
fare/income AV Taxi with and without Pilot  -0.0921  0.099  -0.934  0.350   -0.285      0.101
Social Level AV Solo                 0.1671   1.37e+07   1.22e-08   1.000   -2.68e+07   2.68e+07
Social Level AV with pilot          -0.0251   1.37e+07  -1.83e-09   1.000   -2.68e+07   2.68e+07
Social Level TRS                    -0.1420   1.37e+07  -1.04e-08   1.000   -2.68e+07   2.68e+07
Time of Day Use Late Night (10PM-3AM) AV Dummy  0.1264  0.301  0.420  0.675  -0.464    0.717
===============================================================================
```

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Nested Logit Model

```
           Nested Logit Model Regression Results
================================================================================
Dep. Variable:               choice   No. Observations:            309
Model:            Nested Logit Model   Df Residuals:                294
Method:                         MLE    Df Model:                     15
Date:             Mon, 25 Apr 2022    Pseudo R-squ.:             0.183
Time:                     19:51:10    Pseudo R-bar-squ.:         0.139
AIC:                       590.384    Log-Likelihood:         -280.192
BIC:                       646.384    LL-Null:                -343.045
================================================================================
```

	coef	std err	z	P>|z|	[0.025	0.975]
Future Modes	31.5564	1.14e+13	2.77e-12	1.000	-2.23e+13	2.23e+13
Existing Modes	0	nan	nan	nan	nan	nan
AV Taxi	-0.2948	0.529	-0.557	0.577	-1.331	0.742
AV Taxi with Pilot	0.1010	0.542	0.186	0.852	-0.962	1.164
Total Time, units: min	-0.0313	0.009	-3.564	0.000	-0.049	-0.014
Wait Time, units: min	-0.0233	0.025	-0.942	0.346	-0.072	0.025
Cost , units:$	-0.0486	0.011	-4.582	0.000	-0.069	-0.028
Carpool (AV Taxi)	-0.2811	0.262	-1.074	0.283	-0.794	0.232
Carpool (AV Taxi + Pilot)	-0.2062	0.303	-0.681	0.496	-0.799	0.387
Carpool (Traditional Taxi)	-0.0911	0.300	-0.304	0.761	-0.679	0.497
fare/income AV with and without Pilot	-0.0917	0.130	-0.703	0.482	-0.348	0.164
Social Level AV Solo	0.2407	5.93e+06	4.06e-08	1.000	-1.16e+07	1.16e+07
Social Level AV with pilot	-0.1057	5.93e+06	-1.78e-08	1.000	-1.16e+07	1.16e+07
Social Level TRS	-0.1350	5.93e+06	-2.28e-08	1.000	-1.16e+07	1.16e+07
Time of Day Use Late Night (10PM-3AM) AV Dummy	0.1344	0.307	0.437	0.662	-0.468	0.737

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MRS Substitutions - Nested Logit

Nested Logit

$$MRS(value\ of\ time) = \frac{\frac{\delta U_{in}}{\delta_{travel\ time}}}{\frac{\delta U_{in}}{\delta_{cost}}} = \frac{\delta_{cost}}{\delta_{travel\ time}} = \frac{-0.0486}{-0.0313} = \frac{\$1.5527}{min} = \frac{\$93.16}{hr}$$

$$\delta_{travel\ time} = -0.0313$$
$$\delta_{cost} = -0.0486$$

$$MRS(value\ of\ perceiveds\ afety) = \frac{\frac{\delta U_{in}}{\delta_{ASC}}}{\frac{\delta U_{in}}{\delta_{cost}}} = \frac{\delta_{cost}}{\delta_{ASC}} = \frac{-0.0486}{-0.2948} = \$0.1649$$

$$\delta_{AV\ Taxi(upper\ nest)} = -0.2948$$
$$\delta_{cost} = -0.0486$$

$$MRS(value\ of\ perceived\ safety) = \frac{\frac{\delta U_{in}}{\delta_{ASC}}}{\frac{\delta U_{in}}{\delta_{cost}}} = \frac{\delta_{cost}}{\delta_{ASC}} = \frac{-0.0486}{-0.1948} = \$0.2495$$

$$\delta_{AV\ Taxi\ (with\ pilot)} = -0.1948$$
$$\delta_{cost} = -0.0486$$

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Team Background & Contributions

- **Diversity Statement:** John Thompson is in the Transportation Track of CEE in the MEng program, whereas John Bolaji and Sarah are pursuing the Systems Track, while Mihir is in the M.S Transportation program. We have teammates who identify as men and women. Our members also come from different ethnic backgrounds and geographic areas across the U.S, and have a unique collection of job experience prior to starting at UC Berkeley.

- **Author Contributions:**
    - John Bolaji: Formal Analysis; Writing - Original Draft;
    - Mihir Thakar: Software; Data Curation; Survey Creation & Model Development
    - John Thompson: Investigation (background research/literature review); Writing - Original Draft
    - Sarah Thorson: Formal Analysis; Writing - Original Draft
    - All: Conceptualization, Methodology

Detailed Survey (1/4)

With the rise of Autonomous Vehicles, our group is looking to study the behaviors behind a consumer's choice for rideshare taxi services. As companies such as Waymo, Cruise, and Zoox enter the market, we want to understand what parameters influence decision making when weighing these new alternatives against more traditional services such as Uber and Lyft.

In more detail a self-driving car (sometimes called an autonomous car or driverless car) is a vehicle that uses a combination of sensors, cameras, radar and artificial intelligence (AI) to control, navigate, and drive without a human operator.

For more information click here.

All survey inputs anonymous.

What is your annual income (or expected income upon graduation if you're a student?)

- ○ $0-$49,999
- ○ $50,000-$79,999
- ○ $80,000-$119,999
- ○ $120,000-$199,999
- ○ $200,000+

How frequently do you use rideshare services?

- ○ Multiple times a day
- ○ Once a day
- ○ 4-5 times a week
- ○ 2-3 times a week
- ○ Once a week
- ○ Once every 2 weeks
- ○ Once a month

Detailed Survey (2/4)

For what reasons would you take a Traditional Rideshare Service? Choose all that apply

- ☐ Office/School Commute
- ☐ Business Travel
- ☐ Shopping
- ☐ Leisure
- ☐ None

For what reasons would you take a Self Driving Taxi (Without a human safety driver)? Choose all that apply

- ☐ Office/School Commute
- ☐ Business Travel
- ☐ Shopping
- ☐ Leisure
- ☐ None

Choice Set 1

Please carefully review the options detailed below, then please answer the questions. If you are using a mobile device please rotate to landscape mode so you can see all the alternatives.

If you required Taxi Services from **8:00 AM – 5:00 PM** Which of these choices do you prefer?

*Ride Duration does **NOT** include Waiting Time*

Rank these alternatives from MOST attractive to LEAST attractive (1 to 3)

	RoboTaxi	RoboTaxi with Human Safety Driver	Traditional Rideshare Service
Waiting Time (mins)	10	10	10
Ride Duration (mins)	30	30	20
Cost ($)	20	20	45
Are you Carpooling?	Yes	No	No

Robotaxi

Robotaxi with Human Safety Driver

Traditional Rideshare Service

Detailed Survey (3/4)

Please carefully review the options detailed below, then please answer the questions. If you are using a mobile device please rotate to landscape mode so you can see all the alternatives

If you required Taxi Services from **5:00 PM – 10:00 PM** Which of these choices do you prefer?

*Ride Duration does **NOT** include Waiting Time*

Rank these alternatives from MOST attractive to LEAST attractive (1 to 3)

	RoboTaxi	RoboTaxi with Human Safety Driver	Traditional Rideshare Service
Waiting Time (mins)	10	3	3
Ride Duration (mins)	10	20	20
Cost ($)	20	45	25
Are you Carpooling?	Yes	No	Yes

Robotaxi

Robotaxi with Human Safety Driver

Traditional Rideshare Service

Choice Set 3

Please carefully review the options detailed below, then please answer the questions. If you are using a mobile device please rotate to landscape mode so you can see all the alternatives

If you required Taxi Services from **10:00 PM – 3:00 AM** Which of these choices do you prefer?

*Ride Duration does **NOT** include Waiting Time*

Rank these alternatives from MOST attractive to LEAST attractive (1 to 3)

	RoboTaxi	RoboTaxi with Human Safety Driver	Traditional Rideshare Service
Waiting Time (mins)	3	10	10
Ride Duration (mins)	20	45	20
Cost ($)	35	35	10
Are you Carpooling?	Yes	Yes	No

RoboTaxi

Robotaxi with Human Safety Driver

Traditional Rideshare Service

Detailed Survey (4/4)

What is your age?

○ 18-24

○ 25-35

○ 36-45

○ 46+

How would you assess your level of introversion or extroversion?

○ Strongly Introverted

○ Somewhat Introverted

○ Neutral

○ Somewhat extroverted

○ Strongly extroverted

Which gender do you most identify with?

○ Male

○ Female

○ Non-binary / third gender

○ Prefer not to say

Which political leaning do you most strongly align to?

○ Liberal

○ Conservative

○ Other

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THANK YOU

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